ISSN 0102–3616

SBOT
SOCIEDADE BRASILEIRA DE ORTOPEDIA E TRAUMATOLOGIA

RBO
REVISTA BRASILEIRA DE ORTOPEDIA

VOLUME 59 • ISSUE 5 • SEPTEMBER/OCTOBER 2024

New Graft Choices for ACL Reconstruction: Update Article
Chronic Compartment Syndrome in Athletes
Thermography as a Supporting Tool for the Diagnosis of Patellar Tendon Dysfunctions: A Systematic Review
Comparison of External Circular Fixation and Plate and Screw Fixation Methods in Tibial Pilon Fractures
Doctor, Will My Surgical Hardware Set Off Metal Detector in the Airport?
Ankle Sprains in Brazilian Professional Soccer: Epidemiological Analysis of 126,357 Match Hours
Convolutional Neural Networks in the Diagnosis of Cervical Myelopathy
Causes of Revision of Total Knee Arthroplasties in a Tertiary Hospital in Brazil
Meniscal Ramp Injury Diagnosis
Precision of Magnetic Resonance Imaging in Detection of Anterior Cruciate Ligament and Posterior Cruciate Ligament Ruptures and Subsequent Arthroscopic Correlations: An Investigation
Comparison between Atasoy-Kleinert V-Y Advancement Flap and Figueiredo Techniques for the Treatment of Transverse and Dorsal Oblique Fingertip Injuries
Arthroscopy Treatment of Scaphoid Pseudarthrosis: Description of the Technique and Case Series
Percutaneous Surgery for Tailor's Bunion: A Comparative Study
Three-dimensional Evaluation of Gait: Kinetics, Kinematics, and Electromyographic in Patients with Mucopolysacharidosis Types IV and VI
Periprosthetic Fractures of the Femur during the Operation of Primary Total Hip Arthroplasties
A Retrospective Cohort Study of the Effects of Canal Filling Ratio and Femoral Bone Density Change on the Outcomes of Anatomical and Double-tapered Wedge Stems
Proximal Biceps Tenodesis – Biomechanical Analysis in Sheep: Comparison between Metallic Anchor, Onlay Bioabsorbable Knotless Anchor, and Interference Screw
Validation of the Brazilian Portuguese Version of the Western Ontario Shoulder Instability Index (WOSI) Questionnaire
Comparative Clinical Evaluation of Two Techniques in the Arthroscopic Treatment of Partial Articular Rotator Cuff Tears after Six Years of Follow-up
Polypropylene Prosthesis in the Treatment of Extended Injuries and Coverage of Graft-free Donor Areas: Case Series
Shanz-assisted Closed Reduction (SACR): A Novel Reduction Technique for Elastic Stable Intramedullary Nailing of Pediatric Forearm Fractures
Kapandji-assisted Closed Reduction and Percutaneous K-wire Fixation for Proximal Humerus Fractures in Adolescents: A Technical Note
Long-term Survival of Hip Cement Spacer: A Case Report
Van Neck-Odelberg Disease — A Rare or Underdiagnosed Condition?
Total Duplication of the Femur: Case Report with 23 Years Follow-up

OPEN ACCESS

Thieme

ISSN 0102-3616

Brazilian Orthopaedic Journal

Indexed in PubMed/PubMed Central (2015), SciELO (2007), Scopus™ (2011), LILACS (1981) and affiliated to Associação Brasileira de Editores Científicos (ABEC).

Editor-in-Chief

Geraldo da Rocha Motta Filho
(https://orcid.org/0000-0002-5187-2787)
Instituto Nacional de Traumatologia e Ortopedia - INTO, Rio de Janeiro, RJ, Brasil

Emeritus Editor

Achilles Ribeiro de Araújo (In memoriam)

Márcio Ibrahim de Carvalho (In memoriam)

Donato D´Angelo (In memoriam)

Carlos Giesta
(https://orcid.org/0000-0002-3242-900X)
Universidade Federal do Estado do Rio de Janeiro, Rio de Janeiro, RJ, Brasil

Gilberto Luís Camanho
(https://orcid.org/0000-0001-8656-5552)
Instituto de Ortopedia e Traumatologia da FMUSP, Departamento de Ortopedia e Traumatologia HCFMUSP, São Paulo, SP, Brasil

Sergio Luiz Checchia
(https://orcid.org/0000-0002-9086-734X)
Faculdade de Ciências Médicas da Santa Casa de Misericórdia São Paulo, SP, Brazil

Associated Editors

Helton Luiz Aparecido Defino
(https://orcid.org/0000-0003-4274-0130)
Depto. Biomec. Med. Ap. Locom. Fac. Med. Rib. Preto Ribeirão Preto, SP, Brasil

João Carlos Belloti
(https://orcid.org/0000-0003-3396-479X)
Depto. Ortop. Traumatol. Univ. Federal de São Paulo - UNIFESP São Paulo, SP, Brazil

Raphael Martus Marcon
(https://orcid.org/0000-0001-5958-5646)
Inst. Ortop. Traumatol. Hosp. Clin. Fac. Med. Univ. São Paulo São Paulo, SP, Brasil

Area Editor

João Carlos Belloti
(https://orcid.org/0000-0003-3396-479X)
Depto. Ortop. Traumatol. Univ. Federal de São Paulo - UNIFESP São Paulo, SP, Brazil

Junior Editor

José Leonardo Rocha de Faria
(https://orcid.org/0000-0003-2635-1469)
Instituto Nacional de Traumatologia e Ortopedia - INTO/MS
Rio de Janeiro, RJ, Brasil

International Editors

A Lee Osterman
(https://orcid.org/0000-0002-2641-7360)
Thomas Jefferson University, Woodbury, Estados Unidos da América

Alessandro Castagna
(https://orcid.org/0000-0002-2029-3539)
Humanitas University, Pieve Emanuele, Italy

Boris Zelle
(https://orcid.org/0000-0002-9420-6995)
The University of Texas at Austin, Austin, Estados Unidos da América

César De César Iowa
(https://orcid.org/0000-0001-6037-0685)
University of Iowa, Department of Orthopaedics and Rehabilitation, Iowa City, Estados Unidos da América

David Ring
(https://orcid.org/0000-0002-6506-4879)
The University of Texas at Austin, Austin, Estados Unidos da América

Deborah Eastwood
(https://orcid.org/0000-0002-6191-4768)
Royal National Orthopaedic Hospital NHS Trust, London, England

Eiji Itoi
(http://orcid.org/0000-0002-9859-6791)
Tohoku Rosai Hospital, Sendai, Japan

Enrique Guerado
(http://orcid.org/0000-0002-8711-5307)
Universidade de Málaga, Malaga, Spain

Gehrke Thorsten
(https://orcid.org/0000-0002-4124-1682)
Helios ENDO-Clinic Hamburgo, New Hamburg, Germany,

George S. Athwal
(https://orcid.org/0000-0002-5174-219X)
Western University, Ontario, Canadá

Jason Pui Yin Cheung
(https://orcid.org/0000-0002-7052-0875)
University of Hong Kong, Hong Kong, China

Jeff Wang
(https://orcid.org/0000-0002-6297-7410)
USC Spine Center, Beverly Hills, Estados Unidos da América

Luis Alberto Aponte-Tinao
(https://orcid.org/0000-0002-2096-7206)
Hospital Italiano de Buenos Aires, Buenos Aires, Argentina

Marc Sinclair
(https://orcid.org/0000-0001-9870-4054)
King's College Hospital Dubai, Dubai, Emirados Árabes Unidos

Olufemi R. Ayeni
(https://orcid.org/0000-0003-4219-8564)
McMaster University, Hamilton, Canada

Javad Parvizi
(https://orcid.org/0000-0002-6985-5870)
Thomas Jefferson Univerity, Philadelphia, Estados Unidos da América

Philippe Hernigou
(https://orcid.org/0000-0002-8475-279X)
University of Paris East, Paris, France

Rami Mosheiff
(https://orcid.org/0000-0002-3867-1972)
Hadassah-Hebrew University Medical School, Jerusalém, Israel

Robert F. LaPrade
(https://orcid.org/0000-0002-9823-2306)
Twin Cities Orthopedics, Edina, Estados Unidos da América

Editorial Board

Alan de Paula Mozella
(https://orcid.org/0000-0001-5855-5808)
Inst. Nac. Traumatol. Ortop. (INTO) Rio de Janeiro, RJ, Brazil

Alex Guedes
(https://orcid.org/0000-0001-7013-7107)
Fac. Med. Bahia - Univ. Federal da Bahia Salvador, BA, Brazil

Alexandre Fogaça Cristante
(https://orcid.org/0000-0002-7797-5274)
Inst. Ortop. Traumatol. Hosp. Clin. Fac. Med. Univ. São Paulo, São Paulo, SP, Brasil

Alexandre Leme Godoy dos Santos
(https://orcid.org/0000-0002-6672-1869)
Inst. Ortop. Traumatol. Hosp. Clin. Fac. Med. Univ. São Paulo, São Paulo, SP, Brazil

Benno Ejnisman
(https://orcid.org/0000-0002-3301-1457)
Depto. Ortop. Traumatol. UNIFESP/EPM São Paulo, SP, Brazil

Carlos Henrique Fernandes
(https://orcid.org/0000-0003-0146-6091)
Depto. Ortop. Traumatol. Univ. Federal de São Paulo – UNIFESP São Paulo, SP, Brazil

Carlos Roberto Schwartsmann
(https://orcid.org/0000-0002-9318-1642)
Universidade Federal de Ciências da Saúde de Porto Alegre, Porto Alegre, RS, Brazil

Cláudio Santili
(https://orcid.org/0000-0003-0645-5500)
Santa Casa de Misericórdia de São Paulo, Departamento de Ortopedia Traumatologia, São Paulo, SP, Brazil

Eduardo Angeli Malavolta
(https://orcid.org/0000-0003-1956-6445)
Inst. Ortop. Traumatol. Hosp. Clin. Fac. Med. Univ. São Paulo
São Paulo, SP, Brazil

Fernando Baldy dos Reis
(https://orcid.org/0000-0003-2431-2634)
Universidade Federal de São Paulo – UNIFESP, Departamento de Ortopedia Traumatologia, São Paulo, SP, Brazil

João Antonio Matheus Guimarães
(https://orcid.org/0000-0002-5647-2248)
Instituto Nacional de Traumatologia e Ortopedia – INTO, Rio de Janeiro, RJ, Brazil

João Maurício Barretto
(https://orcid.org/0000-0003-3654-2031)
Santa Casa de Misericórdia do Rio de Janeiro, Departamento de Ortopedia Traumatologia, Rio de Janeiro, RJ, Brazil

José Ricardo Pécora
Inst. Ortop. Traumatol. Hosp. Clín. Fac. Med. Univ. São Paulo São Paulo, SP, Brasil

Julio Cesar Gali
Centro Ciênc. Med. Biol. PUC-SP - Fac. Med. Sorocaba Sorocaba, SP, Brasil

Luiz Antonio Munhoz da Cunha
(https://orcid.org/0000-0002-1808-5749)
Universidade Federal do Paraná, Curitiba, PR, Brazil

Marcel Jun Sugawara Tamaoki
(https://orcid.org/0000-0002-9539-454)
Depto. Ortop. Traumatol. Univ. Federal de São Paulo – UNIFESP São Paulo, SP, Brazil

Marcelo Pires Prado
(https://orcid.org/0000-0003-0325-8050)
Hospital Israelita Albert Einstein
São Paulo, SP, Brazil

Marcelo Rosa de Rezende
(https://orcid.org/0000-0003-3441-8117)
Inst. Ortop. Traumatol. Hosp. Clin. Fac. Med. Univ. São Paulo São Paulo, SP, Brazil

Marcelo Tomanik Mercadante
(https://orcid.org/0000-0002-3140-7562)
Santa Casa de Misericórdia de São Paulo, Departamento de Ortopedia Traumatologia, São Paulo, SP, Brazil

Marco Antônio Percope de Andrade
(https://orcid.org/0000-0001-6284-213X)
Faculdade de Medicina da Universidade Federal de Minas Gerais – UFMG, Belo Horizonte, MG, Brazil

Marcus Vinícius Malheiros Luzo
(https://orcid.org/0000-0003-1345-6915)
Depto. Ortop. Traumatol. Univ. Federal de São Paulo – UNIFESP São Paulo, SP, Brazil

Moisés Cohen
(https://orcid.org/0000-0001-7671-8113)
Universidade Federal de São Paulo – UNIFESP, Departamento de Ortopedia Traumatologia, São Paulo, SP, Brazil

Olavo Pires de Camargo
(https://orcid.org/0000-0002-1128-7292)
Faculdade de Medicina da Universidade de São Paulo – FMUSP, Departamento de Ortopedia Traumatologia, São Paulo, SP, Brazil

Paulo Santoro Belangero
(https://orcid.org/0000-0003-4441-4742)
Depto. Ortop. Traumatol. Univ. Federal de São Paulo – UNIFESP
São Paulo, SP, Brazil

Patrícia Maria de Moraes Barros Fucs
(https://orcid.org/0000-0001-7081-987X)
Santa Casa de Misericórdia de São Paulo, Departamento de Ortopedia Traumatologia, São Paulo, SP, Brazil

Pedro José Labronici
(https://orcid.org/0000-0003-4967-7576)
Universidade Federal Fluminense – UFF,Petrópolis, RJ, Brazil

Raphael Martus Marcon
(https://orcid.org/0000-0001-5958-5646)
Inst. Ortop. Traumatol. Hosp. Clin. Fac. Med. Univ. São Paulo São Paulo, SP, Brazil

Tarcísio Eloy P. de Barros Filho
(https://orcid.org/0000-0002-7969-7845)
Faculdade de Medicina da Universidade de São Paulo – FMUSP, Departamento de Ortopedia Traumatologia, São Paulo, SP, Brazil

Willian Dias Belangero
(https://orcid.org/0000-0003-1838-1473)
Universidade Estadual de Campinas, Campinas, SP, Brazil

Consultant Board

Adalberto Visco
(https://orcid.org/0000-0001-5069-9049)
Clínica de Fraturas Ortopédicas, Salvador, BA, Brazil

Adriana Macedo Dell'Aquila
Hospital do Servidor Público Estadual – IAMSPE São Paulo, SP, Brazil

Adriano Fernando Mendes Junior
(https://orcid.org/0000-0003-1877-8155)
Hospital Universitário da Universidade Federal de Juiz de Fora -UFJF (HU-UFJF/EBSERH), Juiz de Fora, MG, Brazil

Adriano Marques de Almeida
(https://orcid.org/0000-0003-2507-3786)
Instituto de Ortopedia e Traumatologia da FMUSP, Departamento de Ortopedia e Traumatologia HCFMUSP, São Paulo, SP, Brazil

Alberto Naoki Miyazaki
(https://orcid.org/0000-0002-3121-463X)
Santa Casa de Misericórdia de São Paulo, Departamento de Ortopedia Traumatologia,
São Paulo, SP, Brazil

Alberto Tesconi Croci
(https://orcid.org/0000-0003-3047-2757)
Faculdade de Medicina da Universidade de São Paulo – FMUSP, Departamento de Ortopedia Traumatologia, São Paulo, SP, Brazil

Alejandro Enzo Cassone
(https://orcid.org/0009-0008-4834-4589)
Depto. Ortop. Traumatol. Fundação Centro Méd. Campinas Campinas, SP, Brazil

Alfredo dos Santos Netto
(https://orcid.org/0000-0003-1472-7174)
Santa Casa de Misericórdia de São Paulo, Departamento de Ortopedia Traumatologia, São Paulo, SP, Brazil

Alexandre Francisco de Lourenço
(https://orcid.org/0000-0002-0557-9176)
Universidade Federal de São Paulo – UNIFESP, Departamento de Ortopedia Traumatologia, São Paulo, SP, Brazil

Álvaro Baik Cho
(https://orcid.org/0000-0002-3099-4750)
Instituto de Ortopedia e Traumatologia da FMUSP, Departamento de Ortopedia e Traumatologia HCFMUSP, São Paulo, SP, Brazil

Américo Zoppi Filho
(https://orcid.org/0000-0002-8704-8378)
Instituto de Ortopedia e Traumatologia da FMUSP, Departamento de Ortopedia e Traumatologia HCFMUSP, São Paulo, SP, Brazil

Ana Carolina Leal Oliveira
(https://orcid.org/0000-0002-2556-3446)
Instituto Nacional de Traumatologia e Ortopedia - INTO, Rio de Janeiro, RJ, Brasil

Ana Carolina Pauleto
(https://orcid.org/0000-0001-5296-63310000-0001-5296-6331)
Complexo Pequeno Príncipe
Curitiba, PR, Brasil

Ana Lucia Lei Munhoz Lima
(https://orcid.org/0000-0002-2396-9880)
Hospital das Clínicas – Faculdade de Medicina da Universidade de São Paulo – FMUSP, São Paulo, SP, Brazil

Ana Paula Simões Ferreira
(https://orcid.org/0000-0001-8196-6349)
Santa Casa de Misericórdia de São Paulo, Departamento de Ortopedia Traumatologia, São Paulo, SP, Brazil

André Couto Godinho
(https://orcid.org/0000-0001-9996-7729)
Hospital Ortopédico de Belo Horizonte, Belo Horizonte, MG, Brazil

André Luiz Passos Cardoso
(https://orcid.org/0000-0002-6881-9085)
Hospital das Clínicas da Universidade Federal de Goiás – HCUFG, Goiânia, GO, Brazil

André Pedrinelli
(https://orcid.org/0000 0002 8449 7493)
Instituto de Ortopedia e Traumatologia da FMUSP, Departamento de Ortopedia e Traumatologia HCFMUSP, São Paulo, SP, Brazil

André Perin Shecaira
(https://orcid.org/0000-0003-3397-5982)
Hospital Universitario Clementino Fraga Filho Rio de Janeiro, RJ, Brazil

André Vitor Kerber Cavalcanti Lemos
(https://orcid.org/0000-0001-8974-5815)
Universidade Federal de São Paulo – UNIFESP, São Paulo, SP, Brazil

Antonio Carlos da Costa
(https://orcid.org/0000-0003-4499-5233)
Santa Casa de Misericórdia de São Paulo, Departamento de Ortopedia Traumatologia, São Paulo, SP, Brazil

Antonio Egydio de Carvalho Júnior
Depto. Ortop. Traumatol. Hosp. Clin. Fac. Med. Univ. São Paulo
São Paulo, SP, Brazil

Antonio Marcelo Gonçalves de Souza
(https://orcid.org/0000-0003-3771-9628)
Universidade Federal de Pernambuco
Recife, PE, Brazil

Antonio Marcos Ferracini
(https://orcid.org/0009-0008-7973-6403)
Universidade Federal da Bahia
Salvador, BA, Brazil

Arildo Eustaquio Paim
(https://orcid.org/0000-0002-2878-1027)
Santa Casa de Belo Horizonte, Departamento de Ortopedia, Belo Horizonte, MG, Brazil

Arnaldo Amado Ferreira Neto
(https://orcid.org/0000-0001-5097-9542)
Instituto de Ortopedia e Traumatologia da FMUSP, Departamento de Ortopedia e Traumatologia HCFMUSP, São Paulo, SP, Brazil

Ayres Fernando Rodrigues
(https://orcid.org/0000-0001-7598-4102)
Universidade Nove de Julho, São Paulo, SP, Brazil

Bruno Air Machado da Silva
(https://orcid.org/0000-0002-3008-460X)
Hospital de Urgências de Aparecida de Goiânia, Goiânia, GO, Brazil

Bruno Dutra Roos
(https://orcid.org/0000-0002-4001-834X)
Instituto Ortopédico de Passo Fundo, Passo Fundo, RS, Brazil

Bruno Lobo Brandão
(https://orcid.org/0000-0003-4361-6115)
Instituto Nacional de Traumatologia e Ortopedia – INTO, Rio de Janeiro, RJ, Brazil

Caio Santos Checchia
(https://orcid.org/0000 -0003-1562-9795)
Santa Casa de Misericórdia de São Paulo, Faculdade de Ciências Médicas, Departamento de Ortopedia Traumatologia, São Paulo, SP, Brazil

Caio Zamboni
(https://orcid.org/0000-0001-9256-4150)
Santa Casa de Misericórdia de São Paulo, Departamento de Ortopedia Traumatologia, São Paulo, SP, Brazil

Camila Cohen Kaleka
(https://orcid.org/0000-0002-3381-5009)
Hospital Israelita Albert Einstein
São Paulo, SP, Brasil

Camilo Partezani Helito
(https://orcid.org/0000-0003-1139-2524)
Instituto de Ortopedia e Traumatologia da FMUSP, Departamento de Ortopedia e Traumatologia HCFMUSP, São Paulo, SP, Brazil

Carina Cohen Grynbaum
(https://orcid.org/0000-0002-9980-8733)
Universidade Federal de São Paulo – UNIFESP, Departamento de Ortopedia Traumatologia, São Paulo, SP, Brazil

Carlos Augusto de Mattos
(https://orcid.org/0000-0003-3482-5265)
Pontifícia Universidade Católica de Campinas – PUCAMP, Campinas, SP, Brazil

Carlos Cesar Vassalo
(https://orcid.org/0000-0001-7390-7744)
Hospital Madre Teresa
Belo Horizonte, MG, Brazil

Carlos Ernesto Ferreira Starling
(https://orcid.org/0000-0002-9330-5676)
Faculdade de Saúde e Ecologia Humana de Vespasiano, São Paulo, SP, Brazil

Carlos Górios
(https://orcid.org/0000-0003-0840-124X)
Centro Universitário São Camilo, São Paulo, SP, Brazil

Carlos Henrique Ramos
(https://orcid.org/0000-0002-5616-4288)
Hospital Santa Casa de Curitiba, Curitiba, PR, Brazil

Carlos Roberto Galia
(https://orcid.org/0000-0003-1731-4543)
Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil

Carlos Rodrigo de Mello Roesler
(https://orcid.org/0000-0002-9430-7059)
Universidade Federal de Santa Catarina Joinville, SC, Brasil

Carlos Vicente Andreoli
(https://orcid.org/0000-0003-3761-0745)
Universidade Federal de São Paulo – UNIFESP, Departamento de Ortopedia Traumatologia, São Paulo, SP, Brazil

Cecília Bento de Mello Richard Ferreira
(https://orcid.org/0000-0003-2260-6559)
Centro de Pesquisa de Osteoporose do Rio de Janeiro – CEPOR, Rio de Janeiro, RJ, Brazil

Cristiano Frota de Souza Laurino
(https://orcid.org/0000-0002-3845-5575)
Instituto de Saúde, Prevenção, Ortopedia, Reabilitação e Treinamento – INSPORT, São Paulo, SP, Brazil

Cristiano Magalhães Menezes
(https://orcid.org/0000-0001-6670-5159)
Fundação Hospitalar São Francisco de Assis, Belo Horizonte, MG, Brazil

Dan Viola
(https://orcid.org/0000-0002-6173-8004)
Universidade Federal de São Paulo – UNIFESP, Departamento de Ortopedia T raumatologia, São Paulo, SP, Brazil

Daniel Soares Baumfeld
(https://orcid.org/0000-0001-5404-2132)
Universidade Federal de Minas Gerais – UFMG, Belo Horizonte, MG, Brazil

David Sadigursky
(https://orcid.org/0000-0003-3437-6180)
Hospital COT, Salvador, BA, Brasil

Dennis Sansanovicz
(https://orcid.org/0000-0002-4891-7227)
Universidade de Santo Amaro, São Paulo, SP, Brazil

Diego Figueira Falcochio
(https://orcid.org/0000-0002-3833-5397)
Irmandade da Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brazil

Edie Benedito Caetano
(https://orcid.org/0000-0003-4572-3854)
Pontifícia Universidade Católica de São Paulo – PUC, Sorocaba, SP, Brazil

Edilson Forlin
(https://orcid.org/0000-0002-3083-2735)
Hospital Infantil Pequeno Príncipe, Curitiba, PR, Brazil

Edison Noboru Fujiki
(https://orcid.org/0000-0002-7604-3141)
Faculdade de Medicina do ABC, Departamento de Ortopedia Traumatologia, Santo André, SP, Brazil

Edson Pudles
(https://orcid.org/0000-0001-9816-2945)
Hospital Universitário Evangélico de Curitiba, Curitiba, PR, Brazil

Eduardo Barros Puertas
(https://orcid.org/0000-0002-0834-4970)
Universidade Federal de São Paulo – UNIFESP, Departamento de Ortopedia Traumatologia, São Paulo, SP, Brazil

Eduardo da Frota Carrera
(https://orcid.org/0000-0002-7703-7122)
Depto. Ortop. Traumatol. Univ. Federal de São Paulo – UNIFESP
São Paulo, SP, Brazil

Eduardo Murilo Novak
(https://orcid.org/0000-0002-2480-0737)
Pontifícia Universidade Católica do Paraná -PUC-PR, Curitiba, PR, Paraná, Brazil

Eduardo Sadao Yonamine
(https://orcid.org/0000-0001-6924-2647)
Irmandade da Santa Casa de Misericórdia de São Paulo, São Paulo, PR, Brazil

Elmano de Araújo Loures
(https://orcid.org/0000-0003-3691-013X)
Hospital Universitário da Universidade Federal de Juiz de Fora, Juiz de Fora, MG, Brazil

Emiliano Neves Vialle
(https://orcid.org/0000-0003-1157-4889)
Hospital Universitário Cajuru, Pontifícia Universidade Católica – PUCPR, Curitiba, PR, Brazi

Emilio Carlos Curcelli
(https://orcid.org/0000-0003-0582-2903)
Faculdade de Medicina de Botucatú - UNESP Botucatú, SP, Brazil

Emílio Cezar Mamede Murade
(https://orcid.org/0000-0002-1372-5057)
Faculdade de Medicina de Marília – FAMEMA, Marília, SP, Brazil

Fabiano Kupczik
(https://orcid.org/0000-0003-1850-9238)
Hospital Universitário Cajuru, Pontifícia Universidade Católica – PUCPR, Curitiba, PR, Brazil

Fabio Farina Dal Molin
(https://orcid.org/0000-0003-0328-2237)
Hospital Moinhos de Vento de Porto Alegre, Porto Alegre, RS, Brazil

Fábio Krebs Gonçalves
(https://orcid.org/0000-0003-4156-4550)
Hospital Mãe de Deus, Porto Alegre, RS, Brazil

Fábio Lucas Rodrigues
(https://orcid.org/0000-0001-9786-9789)
Depto. Ortop. Traumatol. Fac. Medicina do ABC, Santo André, SP, Brazil

Fabio Teruo Matsunaga
Escola Paulista de Medicina - UNIFESP São Paulo, SP, Brasil

Fernando Antônio Mendes Façanha Filho
(https://orcid.org/0000-0003-3774-2342)
Instituto Dr. José Frota, Departamento de Ortopedia, Fortaleza, CE, Brazil

Francisco Carlos Salles Nogueira
(https://orcid.org/0000-0002-3828-6425)
Hospital Mater Dei
Belo Horizonte, MG, Brazil

Geraldo Sergio de Mello Granata Jr.
(https://orcid.org/0000-0003-0601-0712)
Universidade Federal de São Paulo – UNIFESP, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil

Giana Silveira Giostri
(https://orcid.org/0000-0001-9184-3828)
Pontifícia Universidade Católica do Paraná – PUCPR, Paraná, PR, Brazil

Gilberto Francisco Brandão
(https://orcid.org/0000-0002-3033-4832)
Universidade Federal de Minas Gerais – UFMG, Minas Gerais, MG, Brazil

Gracielle Silva Cardoso
(https://orcid.org/0000-0003-2956-6625)
Hospital Governador Celso Ramos, Florianópolis, SC, Brazil

Guilherme Moreira de Abreu e Silva
(https://orcid.org/0000-0002-3869-8606)
Universidade Federal de Minas Gerais – UFMG, Faculdade de Medicina, Belo Horizonte, MG, Brazil

Guilherme Pelosini Gaiarsa
(https://orcid.org/0000-0003-1481-3048)
Instituto de Ortopedia e Traumatologia da FMUSP, Departamento de Ortopedia e Traumatologia HCFMUSP, São Paulo, SP, Brazil

Gustavo Pacheco Martins Ferreira
(https://orcid.org/0000-0003-1887-0058)
Universidade Federal de Minas Gerais – UFMG, Hospital das Clínicas, Belo Horizonte, MG, Brazil

Guydo Marques Horta Duarte
(https://orcid.org/0000-0002-2154-2832)
Hospital Ortopédico de Belo Horizonte, Belo Horizonte, MG, Brazil

Hamilton da Rosa Pereira
(https://orcid.org/0000-0001-7456-1036)
Universidade Estadual de São Paulo – UNESP, Faculdade de Medicina de Botucatu, São Paulo, SP, Brazil

Hélio Jorge Alvachian Fernandes
(https://orcid.org/0000-0002-6913-6243)
Depto. Ortop. Traumatol. UNIFESP/EPM São Paulo, SP, Brazil

Helton Luiz A. Defino
(https://orcid.org/0000-0003-4274-0130)
Depto. Biomec. Med. Ap. Locom. Fac. Med. Rib. Preto Ribeirão Preto, SP, Brazil

Henrique A. Berwanger Cabrita
(https://orcid.org/0000-0003-2752-2397)
Instituto de Ortopedia e Traumatologia da FMUSP, Departamento de Ortopedia e Traumatologia HCFMUSP, São Paulo, SP, Brazil

Henrique Ayzemberg
(https://orcid.org/0000-0002-4302-8287)
Hospital Municipal São José – HMSJ, Departamento Ortopedia Traumatologia, Joinvile, SC, Brazil

Henrique Mansur Gonçalves
(https://orcid.org/0000-0001-7527-969X)
Universidade de Brasília – UNB, Brasília, DF, Brazil

Henrique Melo Campos Gurgel
(https://orcid.org/0000-0002-2005-0553)
Instituto de Ortopedia e Traumatologia da FMUSP, Departamento de Ortopedia e Traumatologia HCFMUSP, São Paulo, SP, Brazil

Hugo Alexandre de A. Barros Cobra
(https://orcid.org/0000-0002-7315-0961)
Instituto Nacional de Traumatologia e Ortopedia – INTO, Rio de Janeiro, RJ, Brazil

Ivan Chakkour
(https://orcid.org/0000-0003-3870-0523)
Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brazil

Jairo de Andrade Lima
Universidade Federal de Pernambuco Pernambuco, PE, Brazil

Jair Simmer Filho ((https://orcid.org/0000-0002-1571-1855)
Hospital Santa Rita Vitória, ES, Brazil

Jan Willem Cerf Sprey
(https://orcid.org/0000-0002-9239-1736)
Santa Casa de Misericórdia de São Paulo, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil

João Batista de Miranda
(https://orcid.org/0000-0001-9128-0295)
Universidade Estadual de Campinas – UNICAMP, Faculdade de Ciências Médicas –FCM, Campinas, SP, Brazil

João Carlos Belloti
(https://orcid.org/0000-0003-3396-479X)
Departamento de Ortopedia e Traumatologia da Universidade Federal de São Paulo - UNIFESP, São Paulo, SP, Brazil

João Carlos Nakamoto
(https://orcid.org/0000-0003-4780-827X)
Universidade Estadual de Campinas – UNICAMP, Departamento Ortopedia Traumatologia, Campinas, SP, Brazil

João Damasceno Lopes Filho
(https://orcid.org/0000-0001-8761-7887)
Fundação Faculdade Regional de Medicina de São José do Rio Preto e Faculdade de Medicina de São José do Rio Preto – FUNFARME/FAMERP, Departamento Ortopedia Traumatologia, São José do Rio Preto, SP, Brazil

João José Sabongi Neto
(https://orcid.org/0000-0002-0554-1426)
Pontifícia Universidade Católica – PUC, Soracaba, SP, Brazil

João Valverde Filho
(https://orcid.org/0000-0002-5214-2831)
Hospital Sírio Libanês São Paulo São Paulo, SP, Brazil

Joel Murachovsky
(https://orcid.org/0000-0003-1812-8566)
Faculdade de medicina do ABC – FMABC, São Paulo, SP, Brazil

Jordanna Maria Pereira Bergamasco
(https://orcid.org/0000-0002-5280-1673)
Santa Casa de Misericórdia de São Paulo, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil

Jorge Mitsuo Mizusaki
(https://orcid.org/0000.0001.6039.4599)
Casa de Saúde Santa Marcelina, São Paulo, SP, Brazil

José Antonio Veiga Sanhudo
(https://orcid.org/0000-0002-6321-9566)
Hospital Moinhos de Vento, Porto Alegre, RS, Brazil

José Carlos Cohen
(https://orcid.org/0000-0001-9323-476X)
Universidade Federal do Rio de Janeiro – UFRJ, Rio de Janeiro, RJ, Brazil

José Carlos Souza Vilela
(https://orcid.org/0000-0002-3700-1838)
Hospital Unimed Belo Horizonte, Belo Horizonte, MG, Brazil

José Leonardo Rocha de Faria
(https://orcid.org/0000-0003-2635-1469)
Instituto Nacional de Traumatologia e Ortopedia - INTO/MS Rio de Janeiro, RJ, Brasil

José Maurício de Morais Carmo
(https://orcid.org/0000-0002-5688-7013)
Hosp. Universitário Pedro Ernesto da Univ. Est. do Rio de Janeiro
Rio de Janeiro, RJ, Brazil

José Octávio Soares Hungria
(https://orcid.org/0000-0003-2215-9103)
Santa Casa de Misericórdia de São Paulo, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil

José Sérgio Franco
(https://orcid.org/0000-0002-4964-0979)
Universidade Federal do Rio de Janeiro, Faculdade de Medicina, Departamento de Ortopedia Traumatologia, Rio de Janeiro, RJ, Brazil

José Vicente Pansini
(https://orcid.org/0000-0003-1445-9464)
Santa Casa de Misericórdia de São Paulo, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil

Karen Voltan Garofo
(https://orcid.org/0000-0001-5025-0823"0000-0001-5025-0823)
Hospital de Clínicas da Universidade Estadual de Campinas São Paulo, SP, Brasil
Kelly Cristina Stefani
(https://orcid.org/0000-0003-1534-9654)
Universidade de São Paulo – USP, Hospital das Clínicas da Faculdade de Medicina da USP, São Paulo, SP, Brazil
Leandro Alves de Oliveira
(https://orcid.org/0000-0002-2231-8947)
Universidade Federal de Goiás, Hospital das Clínicas, Goiânia, GO, Brazil
Leandro Emilio Nascimento Santos
(https://orcid.org/0000-0001-6449-7077)
Hospital Felício Rocho, Belo Horizonte, MG, Brazil
Leandro Lemgruber Kropf
(https://orcid.org/0000-0002-1306-9010)
Universidade do Rio de Janeiro, Hospital Universitário Pedro Ernesto, Rio de Janeiro, RJ, Brazil
Leonardo de Lima Silveira
ITORK - Instituto de Ortopedia e Traumatologia Romeu Krause Recife, PE, Brazil
Liszt Palmeira de Oliveira
(https://orcid.org/0000-0002-9051-937X)
Hospital Universitário Pedro Ernesto – UERJ Rio de Janeiro, RJ, Brazil
Lourenço Galizia Heitzmann
(https://orcid.org/0000-0003-4345-7222)
Hospital do Servidor Público Estadual – IAMSPE, São Paulo, SP, Brazil
Lourenço Pinto Peixoto
(https://orcid.org/0000-0002-3210-7609)
Instituto Nacional de Traumatologia e Ortopedia - INTO
Rio de Janeiro, RJ, Brazil
Luciana Andrade Silva
(https://orcid.org/0000-0002-9385-1941)
Santa Casa de Misericórdia de São Paulo, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil
Luciana Gomes Pedro Brandão
(https://orcid.org/0000-0002-5271-422X)
Instituto Nacional de Infectologia Evandro Chagas – Fiocruz, Rio de Janeiro, RJ, Brazil
Luciano Ruiz Torres
(https://orcid.org/0000-0002-6608-4062)
Instituto de Ortopedia e Traumatologia da FMUSP, Departamento de Ortopedia e Traumatologia HCFMUSP, São Paulo, SP, Brazil
Lúcio Honório de Carvalho Júnior
(https://orcid.org/0000-0003-2683-6386)
Hospital Madre Teresa, Belo Horizonte, MG, Brazil
Luis Alfredo Gomez Vieira
(https://orcid.org/0000-0002-3988-4451)
Hospital Português da Bahia, Salvador, BA, Brazil
Luis Eduardo Carelli Teixeira da Silva
(https://orcid.org/0000-0003-2631-5492)
Instituto Nacional de Traumatologia e Ortopedia – INTO, Rio de Janeiro, RJ, Brazil
Luis Eduardo Munhoz da Rocha
Hospital Pequeno Príncipe
Curitiba, PR, Brazil
Luis Gustavo Prata Nascimento
(https://orcid.org/0000-0003-0889-3360)
Faculdade de Medicina do ABC – FMABC, Santo André, SP, Brazil
Luiz Angelo Vieira
(https://orcid.org/0000 0003 4406 2492)
Pontifícia Universidade Católoca – PUC, Sorocaba, SP, Brazil
Luiz Carlos Sobânia
(https://orcid.org/0000-0002-3775-619X)
Universidade Federal do Paraná – UFPR, Curitiba, PR, Brazil
Luiz Eduardo Moreira Teixeira
(https://orcid.org/0000-0003-1276-5679)
Universidade Federal Minas Gerais – UFMG, Faculdade de Medicina, Departamento Aparelho Locomotor, Belo Horizonte, MG, Brazil
Luiz Gabriel Betoni Guglielmetti
(https://orcid.org/0000-0003-2711-529X)
Santa Casa de Misericórdia de São Paulo, Faculdade Ciências Médicas Santa Casa de São Paulo, São Paulo, SP, Brazil
Luiz Sérgio Marcelino Gomes
(https://orcid.org/0000-0003-1813-7171)
Serviço de Cirurgia e Reabilitação Ortopédico-Traumatológica de Batatais – SECROT, Campinas, SP, Brazil
Marcelo Back Sternick
(https://orcid.org/0000-0002-3631-7734)
Hospital Vera Cruz, Belo Horizonte, MG, Brazil
Marcelo Bragança dos Reis Oliveira
(https://orcid.org/0000-0003-1986-7002)
Universidade Federal do Rio de Janeiro
Rio de Janeiro, RJ, Brazil
Marcelo Cavalheiro de Queiroz
(https://orcid.org/0000-0003-2347-0921)
Santa Casa de Misericórdia de São Paulo, Faculdade Ciências Médicas Santa Casa de São Paulo, São Paulo, SP, Brazil
Marcelo Hide Matsumoto
(https://orcid.org/0000-0003-2556-7161)
Universidade Federal de São Paulo – UNIFESP, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil
Marcelo Italo Risso Neto
(https://orcid.org/0000-0003-0990-6901)
Universidade Estadual de Campinas – UNICAMP, Faculdade de Ciências Médicas – FCM, Campinas, SP, Brazil
Marcelo Schmidt Navarro
(https://orcid.org/0000-0002-0466-4993)
Faculdade de Medicina do ABC – FMABC, São Caetano do Sul, SP, Brazil
Marcelo Teodoro Ezequiel Guerra
(https://orcid.org/0000-0002-1007-4818)
Universidade Luterana do Brazil – ULBRA, Porto Alegre, RS, Brazil
Marcelo Wajchenberg
(https://orcid.org/0000-0003-1961-6537)
Universidade Federal de São Paulo – UNIFESP, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil
Marcio Cohen
(https://orcid.org/0000-0003-1483-0585)
Instituto Nacional de Traumatologia e Ortopedia – INTO, Rio de Janeiro, RJ, Brazil
Marcio Fernando Aparecido de Moura
(https://orcid.org/0000-0002-9873-930x)
Hospital de Clínicas da Universidade Federal do Paraná – UFPR, Curitiba, PR, Brazil
Márcio Schiefer de Sá Carvalho
(https://orcid.org/0000-0003-2785-8261)
Universidade Federal do Rio de Janeiro
Rio de Janeiro, RJ, Brazil
Marco Antonio de Castro Veado
(https://orcid.org/0009-0005-7741-3748)
Depto. Ortop. Fac. de Ciências Médicas de Minas Gerais
Belo Horizonte, MG, Brazil
Marco Antonio Percope de Andrade
(https://orcid.org/0000-0001-6284-213X)
Fac. Med. Univ. Federal de Minas Gerais – UFMG
Belo Horizonte, MJ, Brazil
Marco Bernardo Cury Fernandes
(https://orcid.org/0000-0003-1157-6243)
Instituto Nacional de Ortopedia e Traumatologia – INTO, Rio de Janeiro, RJ, Brazil
Marco Túlio Costa
(https://orcid.org/0000-0001-9411-9376)
Santa Casa de Misericórdia de São Paulo, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil
Marco Tulio Lopes Caldas
(https://orcid.org/0000-0001-8231-3948)
Fundação Hospitalar do Estado de Minas Gerais – FHEMIG, Belo Horizonte, MG, Brazil
Marcos Antonio Almeida Matos
(https://orcid.org/0000-0002-3592-986X)
Escola Baiana de Medicina e Saúde Pública, Salvador, BA, Brazil
Marcos Barbieri Mestriner
(https://orcid.org/0000-0002-1554-7514)
Santa Casa de Misericórdia de São Paulo, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil
Marcos Noberto Giordano
(https://orcid.org/0000-0001-5397-4958)
Hospital de Força Aérea do Galeão – HFAG, Rio de Janeiro, RJ, Brazil
Marcos Vaz de Lima
(https://orcid.org/0000-0002-6946-1628)
Santa Casa de Misericórdia de São Paulo, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil
Marcus Aurélio Preti
Universidade Estadual do Pará - UEPA
Pará, PA, Brasil
Marcus Vinícius Galvão Amaral
(https://orcid.org/0000-0001-7301-3644)
Instituto Nacional de Ortopedia e Traumatologia – INTO Rio de Janeiro, RJ, Brasil
Maria Fernanda Silber Caffaro
(https://orcid.org/0000-0002-2823-8534)
Santa Casa de Misericórdia de São Paulo, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil

Maria Isabel Pozzi Guerra
(https://orcid.org/0000-0002-5935-2460)
Hospital Universitário Canoa – ULBRA, Rio Grande do Sul, RS, Brazil

Mario Carneiro Filho
(https://orcid.org/0000-0002-9409-5607)
Depto. Ortop. Traumatol. Univ. Federal de São Paulo – UNIFESP
São Paulo, SP, Brazil

Mario Ferretti Filho
(https://orcid.org/0000-0002-5298-2486)
Hospital Israelita Albert Einstein, São Paulo, SP, Brazil

Maurício Etchebehere
(https://orcid.org/0000-0002-5176-2369)
Universidade Estadual de Campinas – UNICAMP, Faculdade de Ciências Médicas, Departamento Ortopedia Traumatologia, Campinas, SP, Brazil

Mauro Cesar de Morais Filho
(https://orcid.org/0000-0003-2670-3030)
Associação de Assistência à Criança Defi ciente – AACD,
São Paulo, SP, Brazil

Mauro dos Santos Volpi
(https://orcid.org/0000-0002-4847-602X)
Faculdade de Medicina de Botucatu da UNESP, Botucatu, SP, Brasil

Mauro José Costa Salles
(http://orcid.org/0000-0002-5443-6024)
Santa Casa de Misericórdia de São Paulo, Faculdade Ciências Médicas Santa Casa de São Paulo, São Paulo, SP, Brazil

Mateus Saito
(https://orcid.org/0000-0002-0909-706X)
Instituto de Ortopedia e Traumatologia da FMUSP, Faculdade de Medicina Universidade de São Paulo, São Paulo, SP, Brazil

Miguel Akkari
(https://orcid.org/0000-0002-1533-8915)
Universidade Federal de São Paulo – UNIFESP, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil
São Paulo, SP, Brazil

Milton Bernardes Pignataro
(https://orcid.org/0000-0001-8280-1482)
Santa Casa de Porto Alegre, Departamento Ortopedia, Porto Alegre, RS, Brazil

Murilo Antonio Rocha
(https://orcid.org/000-0001-6687-6265)
Universidade Federal do Triângulo Mineiro – UFTM, Uberlândia,
MG, Brazil

Nacime Salomão Barbachan Mansur
(https://orcid.org/0000-0003-1067-727X)
Universidade Federal de São Paulo – UNIFESP, Departamento Ortopedia Traumatologia, São Paulo,
SP, Brazil

Nelson Hiroyuki Miyabe Ooka
(https://orcid.org/0000-0003-0853-7630)
Universidade do Estado do Rio de Janeiro – UERJ, Hospital Universitário Pedro Ernesto, Rio de Janeiro, RJ, Brazil

Nilson Roberto Severino
(https://orcid.org/0000-0002-1730-0216)
Santa Casa de Misericórdia de São Paulo, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil

Noé De Marchi
(https://orcid.org 0000-0001-7696-2220)
Santa Casa de Misericórdia de São Paulo, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil

Paulo Henrique Ruschel
(https://orcid.org/0000-0001-9398-5475)
Santa Casa de Porto Alegre, Departamento Ortopedia, Porto Alegre, RS, Brazil

Paulo Lobo Júnior
(https://orcid.org/0000-0001-7625-710X)
Hospital Ortopédico e Medicina Especializada – HOME, Brasília,
DF, Brazil

Priscila Rosalba Domingos de Oliveira
Fac. Ciências Méd. Sta. Casa de Misericórdia de São Paulo São Paulo, SP, Brazil

Rafael Augusto Dantas Prinz
(https://orcid.org/0000-0003-1814-8815)
Instituto Nacional de Traumatologia e Ortopedia – INTO, Rio de Janeiro, RJ, Brazil

Rafael Trevisan Ortiz
(https://orcid.org/0000-0001-7742-829X)
Instituto de Ortopedia e Traumatologia da FMUSP, Faculdade de Medicina Universidade São Paulo, São Paulo,
SP, Brazil

Ralph Walter Christian (https://orcid.org/0000-0003-2851-94747)
Universidade Federal de São Paulo – UNIFESP, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil

Rames Mattar Junior
(https://orcid.org/0000-0003-4202-4652)
Depto. Ortop. Traumatol. FMUSP
São Paulo, SP, Brasil

Raquel Bernardelli Iamaguchi
(https://orcid.org/0000-0002-8965-5147)
Clínica Iamaguchi, São Paulo, SP, Brazil

Renato Hiroshi Salvioni Ueta
(https://orcid.org/0000-0002-3458-0184)
Universidade Federal de São Paulo – UNIFESP, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil

Reynaldo Jesus-Garcia Filho
(https://orcid.org/0000-0001-7895-5729)
Universidade Federal de São Paulo – UNIFESP, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil

Ricardo Cardenuto Ferreira
(https://orcid.org/0000-0002-9886-5082)
Santa Casa de Misericórdia de São Paulo, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil

Ricardo de Paula Leite Cury
(https://orcid.org/0000-0003-0507-4976)
Santa Casa de Misericórdia de São Paulo, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil

Ricardo Sprenger Falavinha
Hospital Universitário Cajurú, PUC Curitiba Curitiba, PR, Brazil

Riccardo Gomes Gobbi
(https://orcid.org/0000-0002-1715-4343)
Instituto de Ortopedia e Traumatologia da FMUSP, Faculdade de Medicina UniversidadeSão Paulo, São Paulo,
SP, Brazil

Robert Meves
(https://orcid.org/0000-0002-8695-3982)
Santa Casa de Misericórdia de São Paulo, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil

Roberto Dantas Queiroz
(https://orcid.org/0000-0001-5662-4830)
Hospital do Servidor Público Estadual de São Paulo – IAMSPE, São Paulo, SP,
Brazil

Roberto Freire da Mota e Albuquerque
(https://orcid.org/0000-0002-0848-9475)
Instituto de Ortopedia e Traumatologia da FMUSP, Faculdade de Medicina Universidade São Paulo, São Paulo,
SP, Brazil

Roberto Luiz Sobânia
(https://orcid.org/0000-0002-3775-619X)
Santa Casa de Misericórdia de Curitiba, Curitiba, PR, Brazil

Roberto Sérgio de Tavares Canto
Universidade Federal de Uberlândia Uberlândia, MG, Brazil

Roberto Yukio Ikemoto
(https://orcid.org/0000-0001-7718-1186)
Faculdade Medicina do ABC – FMABC, Departamento de Ortopedia Traumatologia, Santo André, SP,
Brazil

Roberto Zambelli de Almeida Pinto
(https://orcid.org/0000-0001-9692-5283)
Hospital Mater Dei de Belo Horizonte, Belo Horizonte, MG, Brazil

Robinson Esteves Santos Pires
(https://orcid.org/0000-0002-3572-5576)
Universidade Federal de Minas Gerais – UFMG, Departamento Aparelho Locomotor, Belo Horizonte, MG, Brazil

Rodrigo Gonçalves Pagnano
(https://orcid.org/0000-0002-6064-2027)
Universidade Estadual de Campinas – UNICAMP, Faculdade de Ciências Médicas, Campinas, SP, Brazil

Rodrigo Mota Pacheco Fernandes
(https://orcid.org/0000-0003-0481-6528)
Universidade Federal Fluminense – UFF, Niterói, RJ, Brazil

Rodrigo Pereira Guimarães
(https://orcid.org/0000-0002-0764-6555)
Santa Casa de Misericórdia de São Paulo, Departamento Ortopedia T raumatologia, São Paulo,
SP, Brazil

Rodrigo Ribeiro Pinho Rodarte
(https://orcid.org/0000-0003-1410-601X)
Hospital Central da Polícia Militar, Rio de Janeiro, RJ, Brazil

ISSN 0102-3616

Rogério Meira Barros
(https://orcid.org/0000-0002-0654-2316)
Santa Casa de Misericórdia de Salvador, Salvador, BA, Brazil

Rogério Teixeira de Carvalho
(https://orcid.org/0000-0001-8387-7104)
Universidade Federal de São Paulo – UNIFESP, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil

Romeu Krause Gonçalves
(https://orcid.org/0000-0002-7103-481X)
Instituto de Traumatologia e Ortopedia Romeu Krause – ITORK, Recife, PE, Brazil

Ronaldo Percopi de Andrade
(https://orcid.org/0009-0002-6892-0367)
Depto. Ortop. Traumatol. Hospital Madre Teresa de Belo Horizonte
Belo Horizonte, MG, Brazil

Samuel Faccioni
(https://orcid.org/0000-0002-3991-1499)
Instituto de Ortopedia e Traumatologia de Passo Fundo, Passo Fundo, RS, Brazil

Samuel Ribak
(https://orcid.org/0000-0003-0345-3921)
Pontifícia Universidade Católica de Campinas – PUCAMP, Campinas, SP, Brazil

Sandro Castro Adeodato de Souza
(https://orcid.org/0009-0007-7886-9995)
Universidade Federal do Rio de Janeiro
Rio de Janeiro, RJ, Brazil

Sérgio Rocha Piedade
(https://orcid.org/0000-0003-3774-5914)
Universidade Estadual de Campinas UNICAMP, Campinas, SP, Brasil

Suely Akiko Nakagawa
(https://orcid.org/0000-0002-9195-2087)
Hospital AC Camargo Câncer Center, Departamento de Ortopedia,
São Paulo, SP, Brazil

Susana dos Reis Braga
(https://orcid.org/0000-0003-0807-5990)
Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brazil

Sergio Zylbersztejn
(https://orcid.org/0000-0002-6560-6500)
Universidade Federal de Ciências da Saúde de Porto Alegre
Porto Alegre, RS, Brazil

Tania Szejnfeld Mann
(https://orcid.org/0000-0003-4168-0981"0000-0003-4168-0981)
Santa Casa de São Paulo São Paulo, SP, Brasil

Takeshi Chikude
(https://orcid.org/0000-0003-0568-175X)
Faculdade Medicina do ABC – FMABC, Departamento de Ortopedia Traumatologia, Santo André, SP, Brazil

Tatiana Zotti Pitagóras
(https://orcid.org/0000-0002-2714-3664)
Hospital São Vicente de Paulo, Passo Fundo, RS, Brazil

Teng Hsiang Wei
(https://orcid.org/0000-0001-6219-0047)
Instituto de Ortopedia e Traumatologia da FMUSP, Faculdade de Medicina Universidade São Paulo, São Paulo, SP, Brazil

Thiago Sampaio Busato
(https://orcid.org/0000-0002-7165-5173)
Centro de Reconstrução e Instituto de Pesquisa Articular – CRIAR, Campina Grande do Sul, PR, Brazil

Túlio Diniz Fernandes
(https://orcid.org/0000-0002-9687-7143)
Instituto de Ortopedia e Traumatologia da FMUSP, Faculdade de Medicina Universidade São Paulo, São Paulo, SP, Brazil

Verônica Fernandes Vianna
(https://orcid.org/0000-0002-4285-355X)
Instituto D'Or de Pesquisa e Ensino Rio de Janeiro, RJ, Brasil

Victor Marques Oliveira
(https://orcid.org/0000-0001-7236-4936)
Santa Casa de Misericórdia de São Paulo, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil

Vincenzo Giordano Neto
(https://orcid.org/0000-0002-4429-312X)
Hospital Municipal Miguel Couto, Departamento Ortopedia, Rio de Janeiro, RJ, Brazil

Vinicius Ynoe de Moraes
(https://orcid.org/0000-0002-4933-4007)
Universidade Federal de São Paulo – UNIFESP, São Paulo, SP, Brazil

Vladimir Cordeiro de Carvalho
(https://orcid.org/0000-0001-7919-0553)
Inst. de Ortop. Traumatologia do Hospital das Clínicas
São Paulo, SP, Brazil

Walter Ricioli Júnior
(https://orcid.org/0000-0002-7676-5806)
Santa Casa de Misericórdia de São Paulo, Departamento Ortopedia Traumatologia, São Paulo, SP, Brazil

Wiliam Soltau Dani
(https://orcid.org/0000-0001-5202-4184)
Clinitrauma Lages, SC, Brasil

Yussef Ali Abdouni
(https://orcid.org/0000-0003-0752-5128)
Irmandade da Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brazil

ISSN 0102-3616

Brazilian Orthopaedic Journal

2024 BOARD OF DIRECTORS

2024 SBOT President

Fernando Baldy dos Reis (SP)

1st Vice-President

Paulo Lobo Junior (DF)

2nd Vice-President

Miguel Akkari (SP)

President SBOT 2023

João Antônio Matheus Guimarães

General Secretary

Alexandre Fogaça Cristante (SP)

1st Secretary

Roberto Luiz Sobânia (PR)

2nd Secretary

Marcelo Carvalho Krause Gonçalves (PE)

1st Treasurer

Alberto Naoki Miyazaki (SP)

2nd Treasurer

Tito Henrique de Noronha Rocha (RJ)

Communications and Marketing Director

Maria Fernanda Silber Caffaro (SP)

Regional Director

Francisco Carlos Salles Nogueira (BH)

Committee Director

Sandro da Silva Reginaldo (GO)

CEO

Adimilson Cerqueira

Volume 59, Number 5/2024

RBO
Brazilian Orthopaedic Journal

Editorial

641 Systematic Reviews and Meta-analyses
João Carlos Belloti

Update Articles

Knee

642 New Graft Choices for ACL Reconstruction: Update Article
Paulo Henrique Schmidt Lara, João Victor Novaretti, Gilvan Rodrigues da Silva Nunes, Moises Cohen, and Leonardo Addêo Ramos

Sports Medicine

650 Chronic Compartment Syndrome in Athletes
Pedro Baches Jorge, Mariana Belaunde Toledo, Flora Chaves Mari, Rodrigo Ruas Floriano de Toledo, Marcos Vaz de Lima, and Jan Willem Cerf Sprey

Systematic Review

Knee

657 Thermography as a Supporting Tool for the Diagnosis of Patellar Tendon Dysfunctions: A Systematic Review
Sálvio Tadeu Correia de Barros, Eduardo Borba Neves, and Marcos Leal Brioschi

Original Articles

Asami

663 Comparison of External Circular Fixation and Plate and Screw Fixation Methods in Tibial Pilon Fractures
Marco Antonio Schueda, Leonardo Maranhão Gubert, Yan Celuppi Dal Vesco, Fernanda Fossa Dal Piva, Felipe Guglielmi Niada, and Ryad Fayez Mehanna

672 Doctor, Will My Surgical Hardware Set Off Metal Detector in the Airport?
Igor Guedes Nogueira Reis, Beatriz Marinho Guimarães, Samuel Henrique Ferreira de Souza, Marco Antônio Percope de Andrade, and Robinson Esteves Pires

Sports Medicine

682 Ankle Sprains in Brazilian Professional Soccer: Epidemiological Analysis of 126,357 Match Hours
Ewerton Borges de Souza Lima, Gabriel de Melo Salgado, Eduardo Patrício Mello, Paulo Henrique Schmidt Lara, Gustavo Gonçalves Arliani, and Moisés Cohen

Spine

689 Convolutional Neural Networks in the Diagnosis of Cervical Myelopathy
Murat Korkmaz, Hakan Yılmaz, Merve Damla Korkmaz, and Turgut Akgül

Thieme Revinter Publicações Ltda

online www.thieme-connect.com/products

Knee

696 Causes of Revision of Total Knee Arthroplasties in a Tertiary Hospital in Brazil
Alan de Paula Mozella, Hugo Alexandre de Araújo Barros Cobra, Sandra Tie Nishibe Minamoto, Rodrigo Salim, and Ana Carolina Leal

702 Meniscal Ramp Injury Diagnosis
Pedro Baches Jorge, Diego Escudeiro de Oliveira, Guilherme do Amaral Mussatto, Melanie Mayumi Horita, Victor Eduardo Roman Salas, and Rafael Baches Jorge

707 Precision of Magnetic Resonance Imaging in Detection of Anterior Cruciate Ligament and Posterior Cruciate Ligament Ruptures and Subsequent Arthroscopic Correlations: An Investigation
Vijendra Yadav, Chidanand Kaudki Janekunte Chandrashekhar, Rishi Pothuri Ram, and Rafeeq Mohammed

Hand

712 Comparison between Atasoy-Kleinert V-Y Advancement Flap and Figueiredo Techniques for the Treatment of Transverse and Dorsal Oblique Fingertip Injuries
Leandro Azevedo de Figueiredo, Rafael de Souza Ribeiro, Pedro Hemerly Figueiredo, André Luiz Machado Lima, Felipe Mantovani de Oliveira, and Dalton Silva de Oliveira Júnior

719 Arthroscopy Treatment of Scaphoid Pseudarthrosis: Description of the Technique and Case Series
Ricardo Kaempf, João Brunelli, Leohnard Bayer, Márcio Aita, Santhiago Pereira Schneider, and Pedro J. Delgado

Foot and Ankle

730 Percutaneous Surgery for Tailor's Bunion: A Comparative Study
Luiz Carlos Ribeiro Lara, Lara Furtado Lancia, Diego Vitor Braga Santos, Matheus Maciel Dornelles de Carvalho, Frederico Pinheiro de Lima, and João Lucas Gonçalves Arruda

Pediatric Orthopedics

737 Three-dimensional Evaluation of Gait: Kinetics, Kinematics, and Electromyographic in Patients with Mucopolysacharidosis Types IV and VI
Francisco Robson Queiroz Rego, Herison Franklin Viana de Oliveira, and Epitácio Leite Rolim Filho

Hip

745 Periprosthetic Fractures of the Femur during the Operation of Primary Total Hip Arthroplasties
Conrado Auer Trentini, Marcela de Andrade Balsano, Mark Deeke, and Francisco José Zaniolo

752 A Retrospective Cohort Study of the Effects of Canal Filling Ratio and Femoral Bone Density Change on the Outcomes of Anatomical and Double-tapered Wedge Stems
Thakrit Chompoosang, and Patcharavit Ploynumpon

Shoulder and Elbow

758 Proximal Biceps Tenodesis – Biomechanical Analysis in Sheep: Comparison between Metallic Anchor, Onlay Bioabsorbable Knotless Anchor, and Interference Screw
Amauri João Orso Júnior, Mateus Franceschi Dallanora, Paulo Cesar Faiad Piluski, Carlos Humberto Castillo Rodriguez, João Artur Bonadiman, and Osvandré Lech

765 Validation of the Brazilian Portuguese Version of the Western Ontario Shoulder Instability Index (WOSI) Questionnaire
Jose Carlos Souza Vilela, Tadeu Fonseca Barbosa, Daniel Oliveira Araujo, Yuri Vinicius Teles Gomes, and Thalles Leandro Abreu Machado

771 Comparative Clinical Evaluation of Two Techniques in the Arthroscopic Treatment of Partial Articular Rotator Cuff Tears after Six Years of Follow-up
Guilherme do Val Sella, Luciana Andrade da Silva, Ricardo Makoto Okamoto, Hector Carmona Marmille, Pedro Gabriel Pelegrino do Val, and Alberto Naoki Miyazaki

Trauma

779 Polypropylene Prosthesis in the Treatment of Extended Injuries and Coverage of Graft-free Donor Areas: Case Series
Raphael De Sá Vasconcelos Uchôa, Luís Filipe e Silva Lessa Ferreira, and Ana Luiza Simões de Brito Uchôa

Technical Notes

Pediatric Orthopedics

786 Shanz-assisted Closed Reduction (SACR): A Novel Reduction Technique for Elastic Stable Intramedullary Nailing of Pediatric Forearm Fractures
Julio Javier Masquijo

Shoulder and Elbow

789 Kapandji-assisted Closed Reduction and Percutaneous K-wire Fixation for Proximal Humerus Fractures in Adolescents: A Technical Note
Florencia Turazza, Heloisa Zimmermann Faggion, and Julio Javier Masquijo

Case Reports

Hip

793 Long-term Survival of Hip Cement Spacer: A Case Report
Roshan Jacob, Mackenzie Sowers, Kelly Chandler, Mihir Patel, Ashish B. Shah, and Sameer Mahadeorao Naranje

Pediatric Orthopedics

797 Van Neck-Odelberg Disease — A Rare or Underdiagnosed Condition?
Mafalda Moreira, Diana Alba, Hélder Nogueira, and Sandra Teixeira

Knee

801 Total Duplication of the Femur: Case Report with 23 Years Follow-up
Rafael Garcia de Oliveira, Giampaulo Marcelo Catelan, and Cicero Ricardo Gomes

Letters to the Editor

Hand

805 *Smartphones*: A New Source of Pain in the Wrist and Hand in the 21st Century – Letter Regarding the Study by Gonçalves et al.
Sitanshu Barik, Vishal Kumar, and Vikash Raj

Spine

806 Letter to the Editor Regarding: "Padilha VH, et al. Lumbopelvic Muscle Mobility and Resistance and Their Association with Musculoskeletal Pain in Ballet Dancers. Rev Bras Ortop (São Paulo). 2023;58(3):410–416"
André Pontes-Silva

Cover design: © Thieme

© 2024. Sociedade Brasileira de Ortopedia e Traumatologia. All rights reserved.
Revista Brasileira de Ortopedia is published bimonthly by Thieme-Revinter Publicações Ltda., Rua do Matoso, 170, Rio de Janeiro 20270-135, Brazil.

Editorial comments should be sent to **journals@thieme.com**. Articles may be submitted to this journal on an open-access basis. For further information, please send an e-mail to openaccess@thieme.com. The content of this journal is available online at **www.thieme-connect.com/products**. Visit our Web site at **www.thieme.com** and the direct link to this journal at **www.thieme.com/rbo.**

Revista Brasileira de Ortopedia is an official publication of the Brazilian Society of Orthopedics and Traumatology (Sociedade Brasileira de Ortopedia e Traumatologia, SBOT), It is listed in PubMed, PubMed Central, Scopus, SciELO, and LILACS (Literatura Latino-Americana e do Caribe em Ciências da Saúde). Thieme Medical Publishers is a member of the CrossRef initiative.

ISSN 0102-3616

Some of the product names, patents, and registered designs referred to in this publication are in fact registered trade marks or proprietary names even though specifi c reference to this fact is not always made in the text. Therefore, the appearance of a name without designation as proprietary is not to be construed as a representation by the Publisher that it is in the public domain.

All rights, including the rights of publication, distribution, and sales, as well as the right to translation, are reserved. No part of this work covered by the copyrights hereon may be reproduced or copied in any form or by any means—graphic, electronic, or mechanical, including photocopying, recording, taping, or information and retrieval systems—without written permission of the Publisher.

Important Note: Medical knowledge is ever-changing. As new research and clinical experience broaden our knowledge, changes in treatment and drug therapy may be required. The authors and editors of the material herein have consulted sources believed to be reliable in their efforts to provide information that is complete and in accord with the standards accepted at the time of publication. However, in view of the possibility of human error by the authors, editors, or publisher of the work herein, or changes in medical knowledge, neither the authors, editors, or publisher, nor any other party who has been involved in the preparation of this work, warrants that the information contained here in is in every respect accurate or complete, and they are not responsible for any errors or omissions or for the results obtained from use of such information. Because of rapid advances in the medical sciences, independent verification of diagnoses and drug dosages should be made. Readers are encouraged to confirm the information contained herein with other sources. For example, readers are advised to check the product information sheet included in the package of each drug they plan to administer to be certain that the information contained in this publication is accurate and that changes have not been made in the recommended dose or in the contraindications for administration. This recommendation is of particular importance in connection with new or infrequently used drugs.

Although all advertising material is expected to conform to ethical (medical) standards, inclusion in this journal does not constitute a guarantee or endorsement of the quality or value of such product or of claims made by its manufacturer.

Editorial

Revisões sistemáticas e metanálises

Systematic Reviews and Meta-analyses

João Carlos Belloti[1]

[1] Department of Orthopedics and Traumatology, Universidade Federal de São Paulo (UNIFESP), São Paulo, SP, Brazil

Rev Bras Ortop 2024;59(5):e641.

Systematic reviews and meta-analyses are secondary studies that have increasingly been published in major medical and orthopedic journals. This is due to their intrinsic property of synthesizing the best evidence from the literature on a specific clinical question, thus being the study with the highest level of evidence.

A systematic review should address a clearly formulated clinical question and use reproducible systematic methods with the following distinct steps: development of specific search strategies for each database to be explored; study selection by at least two authors according to clearly previously established inclusion and exclusion criteria; data extraction, considering all measured outcomes and patient follow-up time; assessment of methodological quality and analysis of potential biases of each included study; statistical analysis and synthesis of results; analysis of heterogeneity and publication bias; evaluation of the quality of the evidence generated by the study; and proper writing following minimum criteria of the guidelines already established in the literature. These steps show that these studies require a long time to perform with a systematized and reproducible methodology. The outcome synthesis of the systematic review (meta-analysis) can use statistical methods, summarizing the results of the included studies.

Given the critical role of this type of study, it is recommended to summarize results from primary studies with a high level of evidence. Systematic reviews on treatment should include randomized clinical trials alone.

In recent years, there has been a considerable increase in the publication of systematic reviews. However, the quality of these studies ranged substantially, raising great concern about publications with redundant results or low methodological quality. Many published systematic reviews do not meet the appropriate methodological criteria, leading to information that may confuse readers.

To provide our readers with clarity and reliability in the scientific information of published systematic reviews and meta-analyses, *Revista Brasileira de Ortopedia* (RBO) establishes the following criteria for considering the publication of this type of study:

- Other review types will not be considered for publication, such as narrative, integrative, rapid reviews, mapping, or scoping reviews, except for those deemed relevant by RBO's editor-in-chief.
- For submission, authors must describe the manuscript's relevance and list the systematic reviews and meta-analyses published in the last five years on the topic. Submitted reviews with similar studies on the same subject published in the last five years will not be accepted for publication (redundant studies), unless there is a substantial change in the results, justified by the authors.
- Only systematic reviews and meta-analyses on treatment including high-quality studies (randomized clinical trials) will be considered for publication.
- We recommend and encourage authors to submit systematic review protocols, following the guidelines recommended by the Preferred Reporting Items for Systematic Review and Meta-analysis Protocols (PRISMA-P) and the *Cochrane handbook for systematic reviews*.

Conflict of Interest

The author declares that there is no conflict of interest.

Address for correspondence João Carlos Belloti, Departamento de Ortopedia e Traumatologia da Universidade Federal de São Paulo (UNIFESP), São Paulo, SP 09972-270, Brazil (e-mail: jcbelloti@gmail.com).

DOI https://doi.org/10.1055/s-0044-1791716.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

New Graft Choices for ACL Reconstruction: Update Article

Novas técnicas de enxertia para reconstrucão do LCA: Artigo de atualização

Paulo Henrique Schmidt Lara[1] João Victor Novaretti[1] Gilvan Rodrigues da Silva Nunes[1] Moises Cohen[2] Leonardo Addêo Ramos[1]

[1] Sports Traumatology Center, Paulista School of Medicine, Federal University of São Paulo, São Paulo, SP, Brazil
[2] Department of Orthopedics and Traumatology, Paulista School of Medicine, Federal University of São Paulo, São Paulo, SP, Brazil

Address for correspondence Paulo Henrique Schmidt Lara, MD, Rua Estado de Israel, 713 - Vila Clementino, 04022-002, São Paulo, SP, Brazil (e-mail: phslara@gmail.com).

Rev Bras Ortop 2024;59(5):e642–e649.

Abstract

Reconstruction of the anterior cruciate ligament (ACL) is a common procedure for injuries to this ligament, especially in athletes. There are different types of grafts used, and the choice depends on several factors. Autologous grafts, from the patients themselves, are the most common option, with rapid incorporation and a lower failure rate. Allografts from donors have their role in specific cases. Synthetic grafts, used in the 1980s, have advantages such as the absence of morbidity at the donor site, but studies have shown long-term complications. Hybrid grafts, combining autologous grafts and allografts, have gained interest, allowing a larger diameter and reducing morbidity. Peroneus longus tendon autograft has received attention, with positive results, good knee function and less hypotrophy of the thigh at the donor site. Autologous quadriceps tendon graft has gained popularity, with results comparable to patellar and flexor tendon grafts, lower morbidity at the donor site and a lower rate of re-rupture. The choice of graft has evolved, with autologous flexor grafts being preferred for less active patients and patellar grafts with bone fragments for high-performance athletes. Allografts, synthetic and hybrid grafts have their role in specific circumstances. The choice must be based on scientific evidence, considering advantages and disadvantages. ACL reconstruction is a complex procedure that requires individual considerations to select the most appropriate graft.

Keywords
- anterior cruciate ligament
- grafting
- knee

Work carried out at the Sports Traumatology Center, Paulista School of Medicine, Universidade Federal de São Paulo, São Paulo, Brazil.

received
July 12, 2023
accepted
August 10, 2023

DOI https://doi.org/10.1055/s-0044-1779335.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Resumo

A reconstrução do ligamento cruzado anterior (LCA) é um procedimento comum para lesões desse ligamento, especialmente em atletas. Existem diferentes tipos de enxertos utilizados, e a escolha depende de vários fatores. Os enxertos autólogos, do próprio paciente, são a opção mais comum, com rápida incorporação e menor taxa de falha. Enxertos aloenxertos, de doadores, têm seu papel em casos específicos. Os enxertos sintéticos, usados na década de 80, têm vantagens como ausência de morbidade no local doador, mas estudos mostraram complicações a longo prazo. Os enxertos híbridos, combinando enxertos autólogos e aloenxertos, têm ganhado interesse, permitindo um diâmetro maior e reduzindo a morbidade. O enxerto autólogo do tendão do músculo fibular longo tem recebido atenção, com resultados positivos, boa função do joelho e menor hipotrofia da coxa no local doador. O enxerto autólogo do tendão quadricipital tem ganhado popularidade, com resultados comparáveis aos enxertos de tendão patelar e de flexores, menor morbidade no local doador e menor taxa de re-ruptura. A escolha do enxerto evoluiu, com os enxertos autólogos de flexores sendo preferidos para pacientes menos ativos e o enxerto patelar com fragmento ósseo para atletas de alta performance. Enxertos aloenxertos, sintéticos e híbridos têm seu papel em circunstâncias específicas. A escolha deve ser baseada em evidências científicas, considerando vantagens e desvantagens. A reconstrução do LCA é um procedimento complexo que requer considerações individuais para selecionar o enxerto mais adequado.

Palavras-chave

- enxerto
- joelho
- ligamento cruzado anterior

Introduction

Anterior cruciate ligament (ACL) rupture is a common injury in the general population, with an incidence of up to 75 per 100,000 people per year,[1] particularly in active individuals involved in contact sports. Although a reconstructed ACL does not completely restore the original structure or biomechanical properties of the native ACL,[2] the graft used for reconstruction must not only have structural and mechanical properties that resemble those of the native ligament, it must also exhibit minimal antigenicity and sufficient innate biological potential to incorporate into the host's bone. When selecting graft types, there are several considerations: autograft versus allograft and soft tissue-only grafts versus grafts with bone fragments. Examples of allografts are shown in ►**Fig. 1**.

The commonly used autografts are: patellar with bone fragment, knee flexors, quadriceps (with or without patellar bone fragment); Among allografts, additional options include anterior and posterior tibial, peroneal, and calcaneal.[3–7] In ►**Fig. 2** different types of grafts are demonstrated.

Optimal graft selection depends not only on the properties of the graft, but mainly on the patient's characteristics and expectations.

Autograft versus Allograft

All allografts demonstrated slower rates of incorporation compared to autografts, as well as a higher failure rate of approximately 25% in the active population (43 versus 75%).[8] Current evidence suggests the use of allografts in specific circumstances such as multiligament knee reconstructions, inadequate autograft tissue, or in older, less active populations.[9] The theoretical advantages of allografts are: elimination of donor site morbidity, less pain, shorter surgical and rehabilitation times and better cosmetic results.[10] Krych et al.[11] reported a fivefold higher risk of rerupture in cases that used an allograft. When excluding irradiated and chemically processed grafts, there was no difference in rerupture rate; however, their systematic review included only 6 studies. Kraeutler et al.[12] demonstrated similar results with a risk of rerupture approximately 3 times higher in the allograft group (12.7% vs. 4.3%). They also demonstrated increased knee laxity, and worse results in the single-leg hop test and subjective satisfaction.[12]



Fig. 1 Photo of allografts ready to be prepared. Grafts with a bone part (Patellar) and without bone parts (Tibial Posterior) are observed.

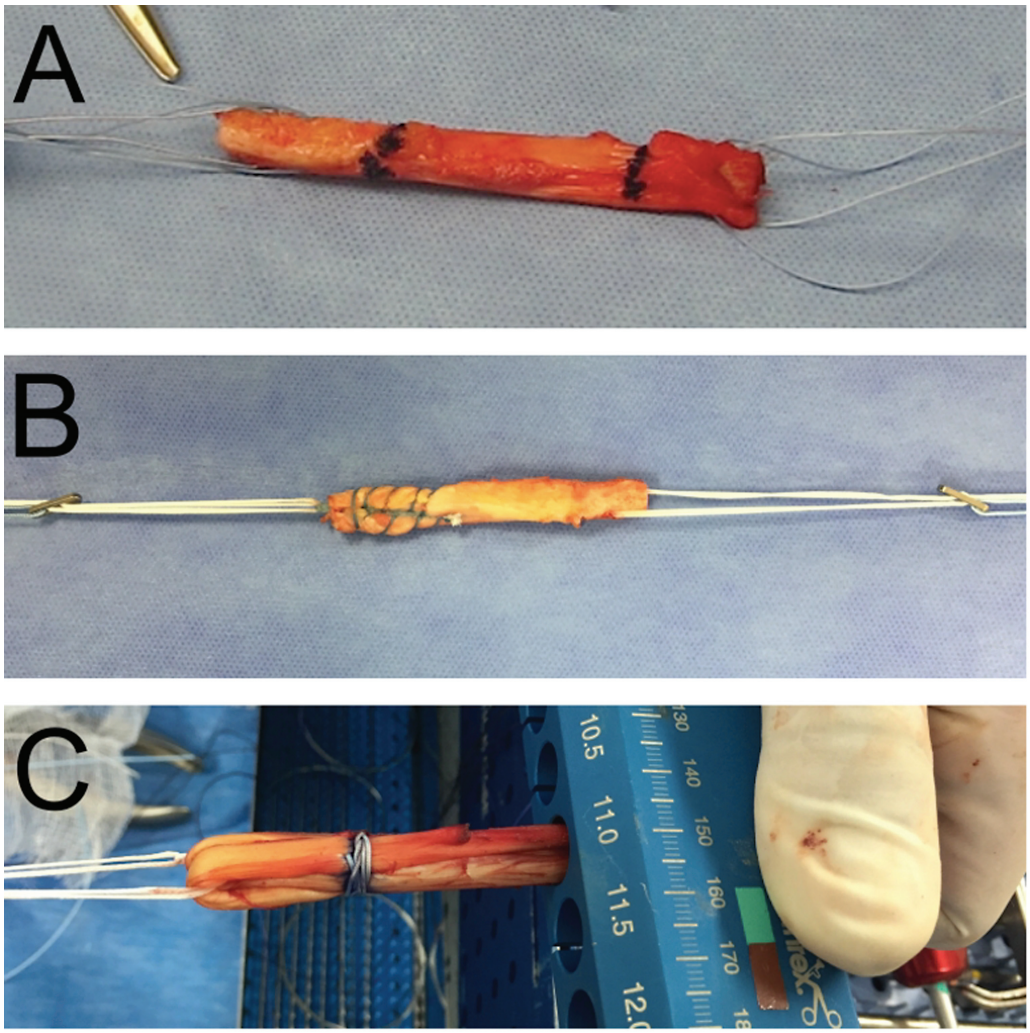


Fig. 2 Different types of grafts: (A) patellar tendon graft, (B) quadriceps tendon graft with bone plug, (C) sextuple flexor graft.

The prospective cohort study carried out by Kaeding et al.[13] evaluated the number of variables to determine predictors of graft rupture in the 2 years after reconstruction. Allograft use and young age significantly increased the risk of graft rupture.[13] Other recent studies have found increased rates of graft rupture in patients who received allografts and had a high level of postoperative activity.[14–16]

In laboratory and clinical studies, autografts show better results than irradiated and processed allografts.[17] Allografts may be considered for less active patients who are willing to accept the increased risk of graft failure.[17]

In an outpatient surgery setting, the autograft group had a significantly lower bill than the allograft group.[18] The decrease in surgical time did not compensate for the cost of the allograft (around $1,000).[18]

Regarding graft processing, it is believed that sterilization techniques alter biomechanical properties and the more a graft is processed, the worse its performance.[17] Park et al.[19] performed a systematic review of irradiated versus non-irradiated allografts with at least two years of follow-up, demonstrating worse functional scores in the irradiated group, decreased stability for Lachman, pivot-shift and KT-1000 testing, and increased risk of revision. The study by Tian et al.[20] demonstrated similar results. Allograft sterilization techniques alter the mechanical properties of allografts and are categorized into radiation or ethylene oxide. The extent of change in mechanical properties is dependent on the irradiation exposure dose.[7]

Farago et al.[21] reviewed 29 years of articles that evaluated the impact of sterilization techniques on tendons. Review results support that the technique with the greatest biomechanical preservation was freezing followed by radiation at 14.8-28.5 kGy.[21] However, allograft failure is not solely attributed to sterilization techniques, whereas allograft failure rates still remain high when comparing fresh allografts to autografts.[21]

Synthetic Grafts

Synthetic grafts were initially used in the 1980s as an option, offering advantages such as the absence of donor site morbidity, shorter surgical time, and reduced risk of disease transmission.[22–24] And potentially the possibility of an earlier return to sports.[22–24] However, early studies reported satisfactory short-term results, but in the medium and long term, there were complications such as an immune response, foreign body

synovitis, tunnel osteolysis, fractures of the femur and tibia near the tunnels, and late graft failure.[22–26] This resulted in a decline in the use of synthetic grafts, but there is currently renewed interest in a new generation of artificial grafts that have shown favorable results when used in special circumstances, such as in the older population.[24,25] It has gained some popularity among athletes recently due to the potential for immediate graft stability, faster rehabilitation, and a quicker return to sports.[27] A systematic review conducted by Machotka et al.[28] on the Ligament Advanced Reinforcement System (LARS) recommended caution when considering the use of synthetic grafts, as more studies are needed. In the study by Bianchi et al.[29] comparing LARS and knee flexor grafts, the LARS group demonstrated greater stability, and no patient required revision surgery. LARS can be considered in patients who require a rapid recovery, while being aware of the risk of graft failure and iatrogenic osteoarthritis.[30,31]

Hybrid Graft

It consists of a combination of auto and allografts and was initially described in 2015.[32] These grafts, typically formed from a combination of autologous flexor graft and soft tissue allograft, have gained interest from orthopedists for use in ACL reconstructions.[33] They are generally used in cases of small size of flexor grafts.[32] When planning to use hybrid grafts, only the semitendinosus graft can be removed instead of the semitendinosus and gracilis. Therefore, the use of hybrid grafts can reduce postoperative morbidity at the donor site.[33] A non-irradiated posterior tibial or peroneus longus allograft is generally used. In addition to the benefit of lower donor site morbidity, hybrid grafts also allow the graft to have a larger diameter than the semitendinosus/gracilis autograft, which may reduce the risk of postoperative failure. Therefore, hybrid grafts may be an option for older patients.[33]

Peroneus Longus Tendon Autologous Graft

As an autologous graft, the peroneus longus muscle tendon is an old option, however it has received greater attention in recent years due to its biomechanical properties similar to the native ACL ligament and the hamstring graft..[34–36] ►**Fig. 3** shows the graft and its removal.

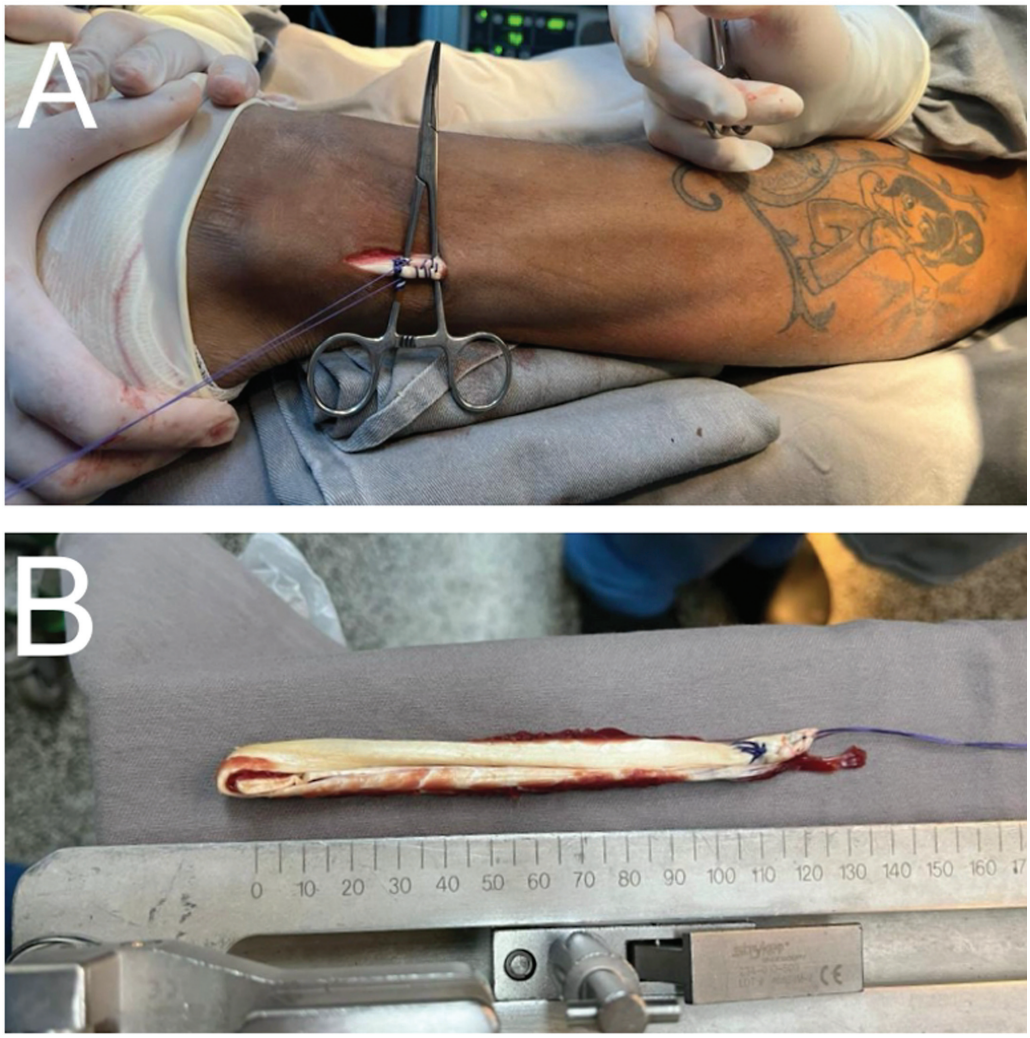


Fig. 3 Peroneus brevis graft: (A) small access route for graft removal with minimal morbidity and (B) peroneus brevis tendon graft ready to be prepared on the table with good length and good thickness.

More recent studies have evaluated its use in ACL reconstruction as well as postoperative function and donor site morbidity. These studies consistently demonstrate positive results, supporting the viability of autologous peroneus longus tendon graft as a good graft option in reconstructions.[37–40]

In terms of functional results, patients undergoing ACL reconstruction using the peroneus longus tendon autograft achieved excellent scores on several assessment tools, the main ones being the IKDC, Modified Cincinnati, Tegner-Lysholm, AOFAS and FADI scores.[35,41,42]

These scores indicate good knee function, ankle stability, and overall patient satisfaction. Functional results comparable to traditional graft options such as autologous hamstring tendon graft were also achieved.[35,43,44] Furthermore, autologous peroneus longus tendon graft has demonstrated advantages over other graft options. It featured a larger graft diameter, which may contribute to improved mechanical properties and stability.[35,36,39,45] It was associated with less thigh hypotrophy, indicating a reduction in muscle loss at the donor site. Donor ankle activity was not compromised as evidenced by positive scores on ankle function assessment tools and jumping tests.[35,36,40]

Another factor that makes the peroneus longus muscle tendon an ideal candidate for ACL reconstruction is that it is technically safe and easy to remove.[46] The tendon is superficially located and its position is not difficult to access by adjacent structures, such as the tendons of the hamstring muscle.[46,47]

Morbidity at the donor site was minimal, with no significant differences observed in ankle eversion and plantarflexion strength of the first ray between the donor site and the contralateral healthy site.[35,36] These findings suggest that autologous peroneus longus tendon graft does not cause significant morbidity at the donor site.[48]

In conclusion, ACL reconstruction using autologous peroneus longus tendon graft is a scientifically supported procedure with favorable results. It offers functional results comparable to traditional graft options such as hamstring tendon and can be used as an alternative to the autologous grafts most commonly used for ACL reconstruction: the patellar tendon and the tendon of the hamstring muscle.

Autologous Quadricipital Tendon Graft

The autologous quadriceps tendon (QT) graft for ACL reconstruction, despite currently being one of the least used grafts, has seen an increase in popularity in recent years, both for primary reconstructions and revisions.[49,50] QT graft can be used with or without a bone fragment removed from the patella. The advantages of removing the QT graft with a bone fragment are a longer graft and a possible better integration of the bone part of the graft into the tunnel created for the graft. The disadvantages are possible residual pain at the site of removal of the patellar bone block and the risk of fracture of the patella. Despite these differences, a recent systematic review compared the use of the QT graft with or without a bone fragment and showed that both grafts are safe and viable, with comparable clinical results, complications and revision rates.[51] Furthermore, QT graft can be used with partial or full thickness, with no difference between them in a recent systematic review.[52]

When compared to other graft options, the QT graft has benefits such as lower morbidity at the donor site (defined as anterior knee pain, difficulty or inability to kneel or both) when compared to the patellar tendon autograft.[53] In a cohort study, ACL reconstruction using a QT graft showed a lower rate of re-rupture when compared to autologous flexor graft.[54] In a recent study with 6,652 ACL reconstructions, cases using QT graft had a lower rate of septic arthritis when compared to cases using flexor grafts, patellar tendon grafts or allografts.[55] Regarding biomechanics, QT graft has an elastic modulus similar to that of the native ACL, which, at least from a theoretical point of view, is positive as it would allow biomechanics closer to the biomechanics of the knee before the injury.[56,57] Meanwhile, both the patellar tendon graft and the flexor graft have a significantly higher modulus of elasticity than that of the native ACL.[57,58] As for the load to failure, QT graft presents a load similar to the load of the flexor graft and a load significantly greater than the loads of the patellar tendon graft and the native ACL.[56–60] Finally, regarding the clinical results of graft rupture rate and patient-reported outcomes, the current literature does not present significant differences when QT graft is compared to patellar tendon and flexor grafts.[61]

Table 1 Advantages and disadvantages of the aforementioned grafts

Types of graft	Advantages	Disadvantages
Allograft	- Absence of donor site morbidity - Choice of graft size - Shorter surgical time - Better cosmetic result	- High cost - Low availability - Risk of disease transmission - Higher re-rupture rate (mainly in young people with high demand)
Peroneus longus	- Easy withdrawal technique - Less hypotrophy of the thigh - Larger graft diameter - Good functional results	- Donor site morbidity
Quadriceptal	- Possibility of use with or without bone plug - Modulus of elasticity similar to native LCA - Good functional results	- Donor site morbidity (residual pain and risk of patella fracture in cases of bone plug)

Discussion

The study by Arnold et al.[61] demonstrated the result of research conducted over the last 14 meetings of the ACL group regarding the preferred graft type in ACL reconstructions. Over time, the choice of graft type can be divided into 4 phases: dominance of the autologous patellar graft with a bone fragment; dominance of the autologous patellar graft with a bone fragment with an increase in the use of autologous flexor grafts; dominance of autologous flexor grafts with a decrease in the use of autologous patellar grafts with a bone fragment and an increase in allograft use; and finally, dominance of autologous flexor grafts with the maintenance of the levels of flexor graft selection and an increase in autologous quadriceps grafts. Currently, more than 50% of the respondents state that their first choice is autologous flexor grafts, while fewer than 40% use autologous patellar grafts with a bone fragment. Allografts increased in popularity from 2006 to 2012, reaching 12% of choices in 2012. Currently, only 1% of the respondents use allografts as their first choice, and none use allografts with a bone fragment. Autologous quadriceps grafts have increased in frequency of selection since 2014, with a peak of over 10% in 2018.[61]

When selecting a graft for a primary ACL reconstruction, we must take into account a series of factors, including age, activity level, previous injuries, among others. Each graft option has its advantages and disadvantages. Patellar and knee flexor autografts are still the most used, but there are other options as shown in the initial part of this article. Allografts, quadriceps autograft and peroneus longus autograft are options and their main advantages and disadvantages are shown in ►**Table 1**.

Final Considerations

Patellar autograft with bone fragment remains the first choice for high-performance athletes who wish to return to their pre-injury sporting level, and flexor autograft is the first choice for patients with lower sporting demands. Allografts may be an alternative in patients with a lower level of physical activity, especially in those over 40 years of age. Quadriceptal and peroneus longus autografts have shown favorable functional results and are options of choice.

Financial Support
The authors declare that there was no financial support from public, commercial or non-profit sources.

Conflict of Interests
The authors declare no conflict of interest.

References

1 Herzog MM, Marshall SW, Lund JL, Pate V, Mack CD, Spang JT. Trends in Incidence of ACL Reconstruction and Concomitant Procedures Among Commercially Insured Individuals in the United States, 2002-2014. Sports Health 2018;10(06):523–531
2 Galatz LM, Gerstenfeld L, Heber-Katz E, Rodeo SA. Tendon regeneration and scar formation: The concept of scarless healing. J Orthop Res 2015;33(06):823–831
3 Bottoni CR, Smith EL, Shaha J, et al. Autograft versus allograft anterior cruciate ligament reconstruction: A prospective, randomized clinical study with a minimum 10-year follow-up. Am J Sports Med 2015;43(10):2501–2509
4 Shumborski S, Salmon LJ, Monk C, Heath E, Roe JP, Pinczewski LA. Allograft donor characteristics significantly influence graft rupture after anterior cruciate ligament reconstruction in a young active population. Am J Sports Med 2020;48(10):2401–2407
5 Su M, Jia X, Zhang Z, et al. Medium-term (Least 5 Years) comparative outcomes in anterior cruciate ligament reconstruction using 4SHG, allograft, and LARS ligament. Clin J Sport Med 2021;31(02): e101–e110
6 Goetz G, de Villiers C, Sadoghi P, Geiger-Gritsch S. Allograft for Anterior Cruciate Ligament Reconstruction (ACLR): a systematic review and meta-analysis of long-term comparative effectiveness and safety. results of a health technology assessment. Arthrosc Sports Med Rehabil 2020;2(06):e873–e891
7 Guo L, Yang L, Duan XJ, et al. Anterior cruciate ligament reconstruction with bone-patellar tendon-bone graft: comparison of autograft, fresh-frozen allograft, and γ-irradiated allograft. Arthroscopy 2012;28(02):211–217
8 Kaeding CC, Pedroza AD, Reinke EK, et al; MOON Knee Group. Change in anterior cruciate ligament graft choice and outcomes over time. Arthroscopy 2017;33(11):2007–2014
9 Sim K, Rahardja R, Zhu M, Young SW. Optimal graft choice in athletic patients with anterior cruciate ligament injuries: Review and clinical insights. Open Access J Sports Med 2022;13:55–67
10 Clark JC, Rueff DE, Indelicato PA, Moser M. Primary ACL reconstruction using allograft tissue. Clin Sports Med 2009;28(02): 223–244, viii
11 Krych AJ, Jackson JD, Hoskin TL, Dahm DL. A meta-analysis of patellar tendon autograft versus patellar tendon allograft in anterior cruciate ligament reconstruction. Arthroscopy 2008;24(03):292–298
12 Kraeutler MJ, Bravman JT, McCarty EC. Bone-patellar tendon-bone autograft versus allograft in outcomes of anterior cruciate ligament reconstruction: a meta-analysis of 5182 patients. Am J Sports Med 2013;41(10):2439–2448
13 Kaeding CC, Aros B, Pedroza A, et al. Allograft versus autograft anterior cruciate ligament reconstruction: Predictors of failure from a MOON prospective longitudinal cohort. Sports Health 2011;3(01):73–81
14 Barrett GR, Luber K, Replogle WH, Manley JL. Allograft anterior cruciate ligament reconstruction in the young, active patient: Tegner activity level and failure rate. Arthroscopy 2010;26(12): 1593–1601
15 Borchers JR, Pedroza A, Kaeding C. Activity level and graft type as risk factors for anterior cruciate ligament graft failure: a case-control study. Am J Sports Med 2009;37(12):2362–2367
16 Singhal MC, Gardiner JR, Johnson DL. Failure of primary anterior cruciate ligament surgery using anterior tibialis allograft. Arthroscopy 2007;23(05):469–475
17 Lin KM, Boyle C, Marom N, Marx RG. Graft selection in anterior cruciate ligament reconstruction. Sports Med Arthrosc Rev 2020; 28(02):41–48
18 Nagda SH, Altobelli GG, Bowdry KA, Brewster CE, Lombardo SJ. Cost analysis of outpatient anterior cruciate ligament reconstruction: autograft versus allograft. Clin Orthop Relat Res 2010;468 (05):1418–1422
19 Park SS, Dwyer T, Congiusta F, Whelan DB, Theodoropoulos J. Analysis of irradiation on the clinical effectiveness of allogenic tissue when used for primary anterior cruciate ligament reconstruction. Am J Sports Med 2015;43(01):226–235
20 Tian S, Wang B, Liu L, et al. Irradiated hamstring tendon allograft versus autograft for anatomic double-bundle anterior cruciate

ligament reconstruction: Midterm clinical outcomes. Am J Sports Med 2016;44(10):2579–2588
21 Farago D, Kozma B, Kiss RM. Different sterilization and disinfection methods used for human tendons - a systematic review using mechanical properties to evaluate tendon allografts. BMC Musculoskelet Disord 2021;22(01):404
22 Legnani C, Ventura A, Terzaghi C, Borgo E, Albisetti W. Anterior cruciate ligament reconstruction with synthetic grafts. A review of literature. Int Orthop 2010;34(04):465–471
23 Satora W, Królikowska A, Czamara A, Reichert P. Synthetic grafts in the treatment of ruptured anterior cruciate ligament of the knee joint. Polim Med 2017;47(01):55–59
24 Fan D, Ma J, Zhang L. Patellar tendon versus artificial grafts in anterior cruciate ligament reconstruction: a systematic review and meta-analysis. J Orthop Surg Res 2021;16(01):478
25 Pan X, Wen H, Wang L, Ge T. Bone-patellar tendon-bone autograft versus LARS artificial ligament for anterior cruciate ligament reconstruction. Eur J Orthop Surg Traumatol 2013;23(07):819–823
26 Ventura A, Terzaghi C, Legnani C, Borgo E, Albisetti W. Synthetic grafts for anterior cruciate ligament rupture: 19-year outcome study. Knee 2010;17(02):108–113
27 Macaulay AA, Perfetti DC, Levine WN. Anterior cruciate ligament graft choices. Sports Health 2012;4(01):63–68
28 Machotka Z, Scarborough I, Duncan W, Kumar S, Perraton L. Anterior cruciate ligament repair with LARS (ligament advanced reinforcement system): a systematic review. Sports Med Arthrosc Rehabil Ther Technol 2010;2:29
29 Bianchi N, Sacchetti F, Bottai V, et al. LARS versus hamstring tendon autograft in anterior cruciate ligament reconstruction: a single-centre, single surgeon retrospective study with 8 years of follow-up. Eur J Orthop Surg Traumatol 2019;29(02):447–453
30 Gao K, Chen S, Wang L, et al. Anterior cruciate ligament reconstruction with LARS artificial ligament: a multicenter study with 3- to 5-year follow-up. Arthroscopy 2010;26(04):515–523
31 Parchi PD, Ciapini G, Paglialunga C, et al. Anterior cruciate ligament reconstruction with LARS artificial ligament—clinical results after a long-term follow-up. Joints 2018;6(02):75–79
32 Alvarez-Pinzon AM, Barksdale L, Krill MK, Leo BM. Hybrid graft anterior cruciate ligament reconstruction: a predictable graft for knee stabilization. Orthopedics 2015;38(06):e473–e476
33 Kraeutler MJ, Kim SH, Brown CC, et al. Clinical outcomes following primary anterior cruciate ligament reconstruction with hamstring autograft versus planned hybrid graft. J Knee Surg 2018;31(09):827–833
34 Vincelot-Chainard C, Buisson X, Taburet JF, Djian P, Robert H. ACL autograft reconstruction revisions with tendon allografts: Possibilities and outcomes. A one-year follow-up of 39 patients. Orthop Traumatol Surg Res 2022;108(03):102832
35 Hossain GMJ, Islam MS, Rahman Khan MM, et al. A prospective study of arthroscopic primary ACL reconstruction with ipsilateral peroneus longus tendon graft: Experience of 439 cases. Medicine (Baltimore) 2023;102(09):e32943
36 Rhatomy S, Wicaksono FH, Soekarno NR, Setyawan R, Primasara S, Budhiparama NC. Eversion and first ray plantarflexion muscle strength in anterior cruciate ligament reconstruction using a peroneus longus tendon graft. Orthop J Sports Med 2019;7(09):2325967119872462
37 Rhatomy S, Hartoko L, Setyawan R, et al. Single bundle ACL reconstruction with peroneus longus tendon graft: 2-years follow-up. J Clin Orthop Trauma 2020;11(Suppl 3):S332–S336
38 Agarwal A, Singh S, Singh A, Tewari P. Comparison of functional outcomes of an anterior cruciate ligament (ACL) reconstruction using a peroneus longus graft as an alternative to the hamstring tendon graft. Cureus 2023;15(04):e37273
39 Rhatomy S, Asikin AIZ, Wardani AE, Rukmoyo T, Lumban-Gaol I, Budhiparama NC. Peroneus longus autograft can be recommended as a superior graft to hamstring tendon in single-bundle ACL reconstruction. Knee Surg Sports Traumatol Arthrosc 2019;27(11):3552–3559
40 Wiradiputra AE, Febyan , Aryana GNW. Peroneus longus tendon graft for anterior cruciate ligament reconstruction: A case report and review of literature. Int J Surg Case Rep 2021;83:106028
41 Kerimoğlu S, Aynaci O, Saraçoğlu M, Aydin H, Turhan AU. [Anterior cruciate ligament reconstruction with the peroneus longus tendon]. Acta Orthop Traumatol Turc 2008;42(01):38–43
42 He J, Tang Q, Ernst S, et al. Peroneus longus tendon autograft has functional outcomes comparable to hamstring tendon autograft for anterior cruciate ligament reconstruction: a systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc 2021;29(09):2869–2879
43 Kumar VK, Narayanan SK, Vishal RB. A study on peroneus longus autograft for anterior cruciate ligament reconstruction. Int J Res Med Sci 2020;8(01):183–188
44 D'Ambrosi R, Meena A, Raj A, et al. Good results after treatment of RAMP lesions in association with ACL reconstruction: a systematic review. Knee Surg Sports Traumatol Arthrosc 2023;31(01):358–371
45 Kusumastutia AH, Rukmoyo T, Rhatomy S, Sakti YM. Anterior cruciate ligament reconstruction with peroneus longus tendon autograft: functional outcome and donor site morbidity. Orthop J Sports Med 2020;8(5 Suppl 5):232596712OS00084
46 Arora M, Shukla T. peroneus longus graft harvest: A technique note. Indian J Orthop 2023;57(04):611–616
47 Kumar PM, Shevte I, Phalak M, Nair A. Arthroscopic anterior cruciate ligament reconstruction with semitendinosus graft versus peroneus longus tendon graft. Int J Res Orthop 2020;6(02):386–392
48 Angthong C, Chernchujit B, Apivatgaroon A, Chaijenkit K, Nualon P, Suchao-in K. The anterior cruciate ligament reconstruction with the peroneus longus tendon: A biomechanical and clinical evaluation of the donor ankle morbidity. J Med Assoc Thai 2015;98(06):555–560
49 Winkler PW, Vivacqua T, Thomassen S, et al. Quadriceps tendon autograft is becoming increasingly popular in revision ACL reconstruction. Knee Surg Sports Traumatol Arthrosc 2022;30(01):149–160
50 Lubowitz JH. Editorial Commentary: Quadriceps tendon autograft use for anterior cruciate ligament reconstruction predicted to increase. Arthroscopy 2016;32(01):76–77
51 Meena A, D'Ambrosi R, Runer A, et al. Quadriceps tendon autograft with or without bone block have comparable clinical outcomes, complications and revision rate for ACL reconstruction: a systematic review. Knee Surg Sports Traumatol Arthrosc 2023;31(06):2274–2288
52 Kanakamedala AC, de Sa D, Obioha OA, et al. No difference between full thickness and partial thickness quadriceps tendon autografts in anterior cruciate ligament reconstruction: a systematic review. Knee Surg Sports Traumatol Arthrosc 2019;27(01):105–116
53 Kunze KN, Moran J, Polce EM, Pareek A, Strickland SM, Williams RJ III. Lower donor site morbidity with hamstring and quadriceps tendon autograft compared with bone-patellar tendon-bone autograft after anterior cruciate ligament reconstruction: a systematic review and network meta-analysis of randomized controlled trials. [published online ahead of print, 2023 Mar 31]Knee Surg Sports Traumatol Arthrosc 2023;31(08):3339–3352. Doi: 10.1007/s00167-023-07402-2
54 Runer A, Csapo R, Hepperger C, Herbort M, Hoser C, Fink C. Anterior cruciate ligament reconstructions with quadriceps tendon autograft result in lower graft rupture rates but similar patient-reported outcomes as compared with hamstring tendon autograft: A comparison of 875 patients. Am J Sports Med 2020;48(09):2195–2204

55 Özbek EA, Dadoo S, Chang A, et al. Rates of septic arthritis after ACL reconstruction: A single-center analysis highlighting quadriceps tendon grafts. Am J Sports Med 2023;51(07):1708–1714
56 Shani RH, Umpierez E, Nasert M, Hiza EA, Xerogeanes J. Biomechanical comparison of quadriceps and patellar tendon grafts in anterior cruciate ligament reconstruction. Arthroscopy 2016;32(01):71–75
57 Woo SL, Hollis JM, Adams DJ, Lyon RM, Takai S. Tensile properties of the human femur-anterior cruciate ligament-tibia complex. The effects of specimen age and orientation. Am J Sports Med 1991;19(03):217–225
58 Urchek R, Karas S. Biomechanical Comparison of Quadriceps and 6-Strand Hamstring Tendon Grafts in Anterior Cruciate Ligament Reconstruction. Orthop J Sports Med 2019;7(10):2325967119879113
59 Strauss MJ, Miles JW, Kennedy ML, et al. Full thickness quadriceps tendon grafts with bone had similar material properties to bone-patellar tendon-bone and a four-strand semitendinosus grafts: a biomechanical study. Knee Surg Sports Traumatol Arthrosc 2022; 30(05):1786–1794
60 Castile RM, Jenkins MJ, Lake SP, Brophy RH. Microstructural and Mechanical Properties of Grafts Commonly Used for Cruciate Ligament Reconstruction. J Bone Joint Surg Am 2020;102(22): 1948–1955
61 Arnold MP, Calcei JG, Vogel N, et al; ACL Study Group. ACL Study Group survey reveals the evolution of anterior cruciate ligament reconstruction graft choice over the past three decades. Knee Surg Sports Traumatol Arthrosc 2021;29(11):3871–3876

Chronic Compartment Syndrome in Athletes

A síndrome compartimental crônica em atletas

Pedro Baches Jorge[1,2] Mariana Belaunde Toledo[1] Flora Chaves Mari[2]
Rodrigo Ruas Floriano de Toledo[2] Marcos Vaz de Lima[1,2] Jan Willem Cerf Sprey[1,2]

[1] Sports Trauma Group, Orthopedics and Traumatology Department, Irmandade de Misericórdia da Santa Casa de São Paulo, São Paulo, SP, Brazil
[2] Sports Medicine Group, Orthopedics and Traumatology Department, Irmandade de Misericórdia da Santa Casa de São Paulo, São Paulo, SP, Brazil

Address for correspondence Jan Willem Cerf Sprey, MD, Sports Trauma Group, Orthopedics and Traumatology Department, Irmandade de Misericórdia da Santa Casa de São Paulo, Rua Cesário Mota Junior 112–Vila Buarque, São Paulo, SP, Brazil (e-mail: drjansprey@hotmail.com).

Rev Bras Ortop 2024;59(5):e650–e656.

Abstract

Chronic compartment syndrome (CCS) is a pressure increase within a non-expandable fibro-osseous space resulting from continuous and intense physical activity. Its symptoms usually improve with rest or reduced activity. It is a critical cause of lower limb pain in athletes and the second most common cause of effort-related leg pain. Less frequent reports include CCS in the lumbar paravertebral compartments, in the hand, the forearm, the thigh, and the foot. Although CCS mainly affects long-distance runners, it may also occur in sports such as lacrosse, football, basketball, skiing, and field hockey. Muscle tension, cramps, symptoms worsening with physical exercise, pain, and reduced sensitivity in the upper part of the foot are the main CCS findings, and diagnosis is essentially clinical. Even though controversial and with some limitations, CCS diagnosis has relied on measuring the intracompartmental pressure after exercise. However, new alternative tools are under study, particularly those less invasive, such as magnetic resonance imaging (MRI) after the exercise protocol. For years, open fasciotomy was the most relevant treatment for CCS in athletes, but new surgical techniques are gaining importance, such as minimally-invasive fasciotomy and endoscopic procedures. Some conservative therapies hold promise as potential alternatives for patients who do not want surgery, but robust evidence to support them remains lacking, especially for athletes.

Keywords
- athletes
- compartment syndromes
- sports injuries
- sports medicine

Resumo

A síndrome compartimental crônica (SCC) pode ser definida como uma elevação da pressão dentro de um espaço fibro-ósseo não expansível, que surge por meio de atividades físicas contínuas e intensas, com sintomas que geralmente melhoram com repouso ou redução da atividade. É uma causa importante de dor nos membros inferiores em atletas, sendo a segunda causa mais comum de dores nas pernas relacionada ao esforço, embora existam relatos menos comuns em compartimentos paravertebrais lombares, na mão, no antebraço, na coxa e no pé. É mais frequentemente observada em corredores de longa distância; porém, outros esportes também têm sido associados a essa entidade, como lacrosse, futebol, basquete, esqui e hóquei de campo. A tensão muscular, cãibras, piora dos sintomas com o exercício físico, dor e

Palavras-chave
- atletas
- medicina do esporte
- sindromes compartimentais
- traumatismos em atletas

received
August 14, 2023
accepted
February 20, 2024

DOI https://doi.org/10.1055/s-0044-1787766.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

redução da sensibilidade na parte superior do pé são os principais sintomas relacionados a essa síndrome, sendo o diagnóstico essencialmente clínico. Embora controversa e com algumas limitações, a medição da pressão intracompartimental após o exercício tem sido utilizada para o diagnóstico da SCC. No entanto, novas ferramentas estão sendo estudadas como alternativa, especialmente aquelas que são menos invasivas, como a imagem de ressonância magnética (RM) após protocolo de exercício. A fasciotomia aberta foi por vários anos o tratamento mais relevante para SCC em atletas, porém novas técnicas cirúrgicas estão ganhando importância, como a fasciotomia minimamente invasiva e o procedimento endoscópico. Alguns tratamentos conservadores são promissores como alternativas possíveis para aqueles que não desejam a cirurgia, mas ainda há falta de evidências robustas para sustentá-los, especialmente para atletas.

Introduction

Von Volkmann first described compartment syndrome (CS) in 1881. Subsequently, there were CS reports in several anatomical regions, especially the lower extremities.[1] In addition, although there are rarer and limited CS cases reported in the hand, forearm, and paravertebral compartments.[1–3]

Compartment syndrome is an increased pressure within a non-expandable fibro-osseous space, leading to compromised tissue perfusion in that specific area. Reduced perfusion initially causes ischemic pain, followed by reversible and eventually irreversible tissue damage within the compartment. The resulting edema creates a vicious cycle, further aggravating the ischemic injury.[1]

Compartment syndrome manifestation can be acute, characterized by severe symptoms over a short period, or chronic, lasting for a long time. Acute compartment syndrome (ACS) is a medical emergency, typically resulting from a severe injury or trauma that leads to intense pain. On the other hand, chronic CS (CCS) is often not an immediate medical emergency, and it appears after intense and repetitive athletic activity in the absence of acute trauma. Its treatment involves rest and recovery.[4,5]

Along with other exertion-related conditions, CCS can significantly contribute to developing exertion-dependent symptoms. Therefore, this condition has particular importance in sports and physical exercise. One of the first descriptions of CCS occurred during the British expedition to the South Pole in 1912, in which Edward Wilson described swelling and pain in the anterior compartment of the leg during long walks in the Antarctic region. Subsequent historical records have also emphasized the prevalence of CCS in military cohorts, leading to the nickname "marching gangrene".[4]

Pathophysiology

Numerous hypotheses have attempted to elucidate CCS pathophysiology. However, the true etiology and development process of the condition remain undetermined.[6]

We know that intense exercise can lead to substantial increases in muscle volume resulting from increased metabolic demands, tissue perfusion, and muscle fiber growth. Compartment syndrome occurs when the pressure within the fascial compartment exceeds the diastolic pressure. This compromised blood flow causes tissue ischemia, metabolite accumulation, and pain in the affected area.[4]

Some researchers have suggested that untreated CCS can result in neural compression and irreversible damage due to fluid leakage and increased intracompartmental pressures. Decreased capillary density and impaired venous flow have also been implicated in CCS development.[4]

Chronic CS results from increased intracompartmental pressures potentially triggered by several precipitating events. Local blood flow, determined by local arterial pressure, venous pressure, and vascular resistance, impacts pressure within a muscular compartment. Ischemia occurs when interstitial pressure exceeds capillary perfusion pressure (CPP). Skeletal muscle ischemia releases a histamine-like substance that increases vascular permeability, causing the formation of blood thrombi and worsening ischemic conditions. Myocyte rupture releases proteins, which results in water escaping from the arterial blood into the compartment.[7]

Other contributing factors associated with CCS involve inadequate training methods, limb misalignment, leg length discrepancies, running style, and poor neuromuscular control.[8]

Although the precise underlying mechanism is still debatable, consensus points to CCS development resulting from muscular effort repetition within a compartment, which reduces blood perfusion.[8]

Epidemiology and Risk Factors

The precise prevalence of CCS remains uncertain due to factors that include self-treatment or activity modification, errors in clinical diagnosis, and failure to seek medical care. It is estimated that 14 to 34% of leg pain referred for orthopedic treatment because of activity or exertion is consistent with

CCS.[4] The current prevalence of CCS in the general population is unknown. However, it has been documented in specific athletic subgroups at a rate of 0.49 cases per one thousand people per year.[9]

Chronic compartment syndrome primarily affects the leg, with more than 95% of cases reported in this region. However, there are variable reports of involvement in the lumbar paravertebral compartment,[1] hand, forearm, thigh, and foot from specific high-risk groups.[4] Among leg compartments, the most affected is the anterior compartment (42–60%), followed by the lateral (35–36%), deep posterior (19–32%), and superficial posterior compartments (3–21%). Single-compartment involvement is less common (37%); approximately 40% of symptomatic cases involve 2 compartments, 18% involve 3 compartments, and only 5% affect all 4 compartments. Bilateral involvement is more prevalent, representing up to 95% of cases, with no differences in laterality.[4]

Anatomical disparities between adolescents and adults increase the risk of CS development in younger patients.[7] Shadgan et al.[10] noted clinicians often believe that younger subjects have a stiffer/narrower and stronger fascia, combined with greater muscle density, increasing their vulnerability to CS. Therefore, CCS diagnosis is frequent, although not limited to, in young athletes involved in repetitive activities, such as long-distance or cross-country running.[7]

Older studies showed conflicting outcomes regarding the prevalence of CCS in men and women. Some studies reported a higher CCS occurrence in men, while others have suggested a potential increased occurrence in women. However, the latest literature investigations reported a similar incidence of CSS among men and women.[4]

Rothman et al.[11] found that women were less likely than men to return to sports after a surgical intervention, and factors such as intracompartmental pressures, sports participation, and postoperative outcomes were not statistically different between genders.

More than 90% of people diagnosed with CSS participate in athletic activities, with no difference reported between those participating in elite or recreational levels of competition. Although several sports have been linked to CCS, including lacrosse, football, basketball, skiing, and field hockey, the condition is more frequent in endurance runners, who account for up to 68% of cases.[4] Some rare cases have occurred in weightlifting, American football, and baseball athletes.[2,3,12] However, CCS can also affect less active populations.

Intense exercise, including running, although not exclusively, has been associated with an increased CCS incidence. Physiological and metabolic changes due to significant physical activity affect muscle volume and compartmental pressures. Eccentric muscle strengthening in adults is a potential cause for decreased fascial conformity and CCS development. Patients with CCS often have a thickened fascia and a higher prevalence of fascial defects compared with asymptomatic individuals. Anabolic androgenic steroids and other performance-enhancing drugs for muscle growth may also contribute to abnormal elevations in intracompartmental pressures, and some suggested them as potential risk factors for CCS.[4] Some evidence indicated that training errors, specifically an abrupt increase in training volume, intensity, or both, can be the chief risk factor for CCS development.[13]

Anatomy and Clinical Presentation

Chronic CS is the second most common cause of exertion-related leg pain, followed by medial tibial stress syndrome (MTSS), affecting approximately one third of athletes. It is critical to consider other potential diagnoses of exercise-induced leg pain, such as nerve entrapment, bone stress injuries, deep vein thrombosis, MTSS, and miscellaneous clinical conditions during symptom evalution.[4,13]

A comprehensive knowledge of lower limb anatomy is crucial for CCS diagnosis and identification of the compartments involved. The lower leg anatomically has four compartments, namely, anterior, lateral, superficial posterior, and deep posterior, with an additional fifth compartment for the tibialis posterior muscle, which has a fascia (►**Fig. 1**).[14]

The anterior compartment contains the deep peroneal nerve, anterior tibial artery, anterior tibialis muscle, extensor digitorum longus muscle, extensor hallucis longus muscle, and fibularis tertius muscle. Increased pressure in this compartment can lead to sensory loss in the first interdigital space and weakness during toe and ankle dorsiflexion.[14]

The lateral compartment has the peroneus longus and brevis muscles, the peroneal artery, and the superficial peroneal nerve. Compression in this compartment can result in weakness during foot eversion and reduced sensation in the dorsum of the foot.[14]

The posterior superficial compartment contains the posterior tibial artery, gastrocnemius, soleus, and plantaris muscles, in addition to the distal segment of the sural nerve. Its compression can cause numbness on the side of the foot and distal calf.[14]

The deep posterior compartment has the tibialis posterior muscle, flexor digitorum longus muscles, peroneal artery, and tibial nerve. Increased pressure in this compartment can lead to weakness in plantar flexion and numbness in the sole.[14] Since most cases occur in the lower limbs, we will not discuss anatomical details from other regions.

The natural progression of CCS is often atraumatic, although some subjects may report a history of low-energy trauma. Patients usually experience stiffness, pain, or discomfort in the anterior and lateral part of the leg after prolonged exercise, and symptoms frequently improve with rest or activity reduction; this particular detail is a specific criterion for the disease.[13] The symptoms of CCS are bilateral in up to 95% of patients. At the superficial peroneal nerve distribution, affected subjects may experience reduced vibratory sensitivity and decreased motor range, leading to lower foot and ankle control loss described before.[4] Cramps, hyposensitivity, or muscle weakness are evident in approximately one third of patients.[13]

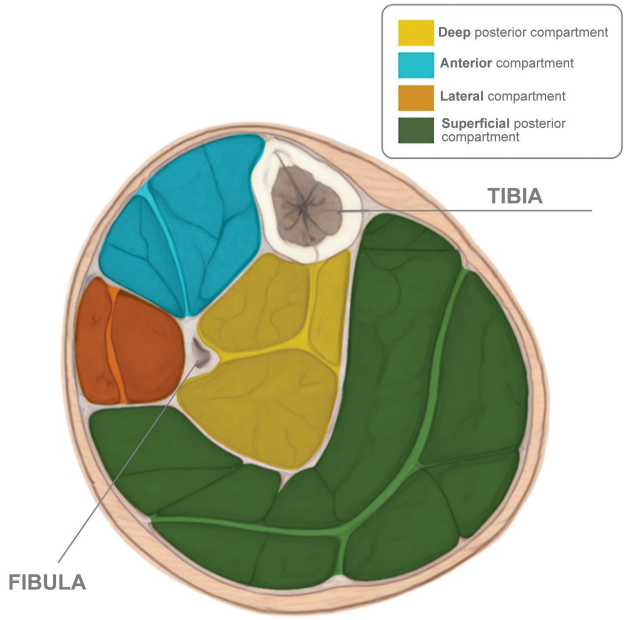


Fig. 1 A transverse section of the leg shows the four compartments, namely, the anterior compartment (containing the tibialis anterior, extensor digitorum longus, extensor hallucis longus, and fibularis tertius muscles), the lateral compartment (composed of the peroneus longus and brevis muscles), the superficial posterior compartment (containing the gastrocnemius, soleus, and plantaris muscles), and the deep posterior compartment (containing the tibialis posterior and the flexor digitorum longus muscles).

Diagnosis

The diagnosis of CCS relies on a detailed history and thorough physical examination. It is vital to document training frequency, volume, duration, and intensity, along with any patterns for the onset and resolution of reported symptoms. Although patients may not experience symptoms at rest, exertion can trigger significant symptoms that limit activity. The top five symptoms frequently reported by patients with CCS include pain, tightness, cramping, weakness, and decreased sensation in the dorsum of the foot.[4]

Recently, Vogels et al.[15] proposed five key criteria for CCS diagnosis. Study panel members agreed that CCS was likely if the patient (I) participates in activities requiring repetitive activation of the same muscles, (II) reports pain during exercise, (III) reports stiffness/tightness during exercise, (IV) stops specific activities earlier or avoids them, and (V) presents symptoms induced by provocative activities at the physical examination.[15]

During the physical examination, passive compartment stretching may elicit pain if the patient has recently exercised, although pain is uncommon at rest. Palpation of the affected area can reveal fascial defects in 39 to 46% of subjects with CCS.[4]

Although there is much ongoing debate, the historical standard for diagnosing CCS has been intracompartmental pressure measurement. Whitesides et al.[16] pioneered the development of a technique for this measurement in a revolutionary study using objects such as a syringe, needle, saline solution, and plastic tubes connected to a manometer. Current intracompartmental pressure monitoring can employ several commercially available devices inspired by Whitesides' invention.[16] This monitoring allows a comparison between affected and unaffected compartments in both lower limbs. In the diagnostic process, patients undergo a physical stress test before and after a series of manometry measurements to analyze trends in intracompartmental pressures in symptomatic compartments. Typical resting intracompartmental pressure in the leg is usually lower than 10 mmHg, although measurements can vary considerably between patients and suffer influence by the operator performing the procedure.[4]

A study by Davis et al.[17] monitored 17 patients with CCS during physical stress tests. Analysis revealed that these subjects experienced leg pain after, on average, 11 minutes of exertion, rating the pain as an 8 out of 10 on the Visual Analog Scale. Symptoms subsided after about 45 minutes of rest. Approximately 36% of subjects reported numbness or tingling in addition to pain after exertion. Objective pressure measurements showed significant increases in the anterior, lateral, deep posterior, and superficial posterior compartments following physical stress testing.[4]

Pedowitz et al.[18] established diagnostic criteria to confirm exercise-induced CCS. According to them, the diagnosis requires meeting the following criteria: 1) preexercise pressure higher than 15 mmHg; (2) pressure 1 minute after exercise higher than 30 mmHg; or 3) pressure 5 minutes after exercise higher than 20 mmHg.

However, it is worth highlighting that diagnostic cut-off criteria differ substantially depending on the author,[15] and pressure measurements are not always reliable due to factors such as patient tolerance, operator technique, and use of different measuring devices. Furthermore, the invasive nature of the test may be associated with risks of incorrect needle placement, bruising, and nerve damage.[15]

Aweid et al.[4] reviewed several studies evaluating the usefulness of intracompartmental pressure measurements for CCS diagnosis. These authors concluded that although pressure measurement use is widely available, there is limited evidence to validate their accuracy, and the clinical presentation should be further considered for CCS diagnosis.

Regarding the applicability and diagnostic value of measuring intracompartmental pressure, it is essential to remember that the clinical history, physical examination, and exclusion of differential diagnoses are indispensable to the diagnostic process. To overcome these limitations of the needle technique, new diagnostic protocols have been suggested, with the recommended systematic use of conventional MRI to exclude differential diagnoses.[19]

Magnetic resonance imaging is the best imaging method for evaluating exercise-related leg pain, as it detects conditions such as tibial stress syndrome, tibial stress fracture, neural compressions, muscle and tendon injuries, exercise-related thrombosis, and fascial hernias.[19]

In clinical practice, conventional MRI sequences initially exclude differential diagnoses. Subsequently, patients run (or walk) on a treadmill, according to their physical capabilities, until they can no longer tolerate the activity due to pain.

Immediately after stopping the activity, patients undergo a new MRI for fluid-sensitive and fat-suppressed axial sequence (T2-weighted/short tau inversion recovery, STIR) acquisition. Some studies have confirmed the validity of postexercise MRI for CCS diagnosis, using a 1.54-fold increase in signal intensity as a diagnostic cut-off value with a 96% sensitivity and 87 to 90% specificity.[19]

Therefore, MRI is a non-invasive method, readily accepted by patients, with good availability in large medical centers, the best imaging test to rule out differential diagnoses, and a scientifically validated option for CCS diagnosis.[19]

Treatment

Surgical Treatment

The treatment for CCS comprises several surgical and non-operative management strategies. Traditionally, surgical treatment has more reports and better outcomes, but there is increasing evidence that conservative treatment may be an option in selected cases. In athletes, management consists of surgical intervention. Non-surgical treatment failure, paresthesia, exertion-induced pain that disappears with rest, tightness, cramps, ischemia, foot drop, and the patient's desire are the main indications for surgical treatment.[9,20]

In a systematic review of the surgical management of CCS[9] including 1,495 patients from 24 studies, the most used techniques were compartment-specific open fasciotomy (86%), fasciotomy with partial fasciectomy (12%), and endoscopic fasciotomy ($< 2\%$). For the anterior compartment, the most commonly affected by CSS, a single longitudinal incision between the anterior tibial crest and fibula through the skin and subcutaneous tissue was the most frequent procedure (207 out of 240). However, the outcomes of this review did not demonstrate a superiority between the techniques described. Concerning the posterior compartment, the most used surgical technique was a longitudinal incision slightly medial to the tibial crest with the release of the solar bridge of the tibia to approach the deep fascia. The success rate of this intervention was 61% for the deep posterior compartment (44 out of 72) and 100% for the superficial posterior (3 out of 3). The authors suggested that this compartment is prone to lower surgical success.

A systematic review including seven articles on surgical intervention in the posterior compartment found that the techniques differed slightly throughout the studies. However, the review reached no conclusions since the researchers used different methods for outcome measurement.[21]

New procedures, such as minimally-invasive or endoscopic procedures, have been gaining relevance in recent decades. A review by Lohrer et al.[13] concluded the lack of statistical difference between these techniques since the unweighted average success rate was 86.3% for the endoscopic technique and 80.0% for the minimally invasive CCS release. D'Amore et al.[22] compared endoscopic procedures and open fasciotomy in elite and amateur athletes with lower limb CCS. Their results showed that the return to sport rate was 84.6% in patients undergoing an endoscopic procedure and 72.7% in those undergoing open fasciotomy, with symptom recurrence rates of 69.2% and 72.7%, respectively, with no statistical difference. Neither group presented complications or severe outcomes.

The endoscopic technique would have benefits over open fasciotomy, such as lower risk of infection, shorter time to activity return due to the lower soft-tissue manipulation, less postoperative hematoma, limited fibrosis, better visualization of compartmental structures, and fascial release extension.[9,22] It is an adequate alternative treatment for CCS release from the anterior and lateral compartments, with a good success rate and no inferiority in the literature.[22]

Conservative Treatment

Exercise-induced CCS conservative treatment remains poorly documented in scientific research. Rest, interrupting symptom-triggering activity, and analgesic agents seem essential. However, few documented guidelines or specific procedures describe how to optimize them and the population most benefited from those interventions. In a systematic review of the literature on new non-surgical management, Rajasekaran et al.[6] found little evidence of techniques, which included gait shifting, chemodenervation, ultrasound-guided fascia fenestration, and massage.

Nevertheless, a case series by Diebal et al.[23] on different running techniques and how they affect compartment pressure and pain in CCS patients showed promise, and it was included in a military non-surgical management program.[23,24] This protocol involves several treatments described in the literature, with a greater focus on walking and running re-education. In one study, these authors reported that, after a 2-year follow-up in a population of 50 patients undergoing their protocol, 57% were still on active duty without surgery, 43% returned to their original military post, 36% left military service, 48% remained with symptoms, and 12% of patients underwent fasciotomy.[24] This study showed moderate outcomes, which could decrease the need for surgical procedures. Although there is little evidence on the results of gait retraining in athletes, this research's focus may be an alternative to fasciotomy or an attempt to prevent it.

In 2022, a clinical consensus panel of experts discussed conservative CCS treatment and its efficacy. It concluded that gait retraining and cessation of provocative activities are critical when attempting a non-surgical approach. The literature cites physical therapy, botulinum injections, and shoe modifications as less significant and mainly adjacent measures depending on the patient's symptoms.[15]

Conservative versus Surgical Treatment

Although there are no randomized clinical trials to compare surgical and conservative treatments, some studies reported a superiority of interventional procedures, mainly in patients with CCS of the anterior compartment and amateur and elite athletes. In a retrospective cohort, Vogels et al.[25] found that the success rate considered by patients was significantly higher in those who underwent fasciotomy (42% compared with a 17% success rate in the group undergoing conservative treatment), and a lower frequency of pain

and tightness during sports was also noted. However, there was no difference between these two groups regarding the return to the same level of performance before each intervention.

In contrast to these findings, Thein et al.[26] observed significantly better outcomes in returning to sports and maintaining the same physical activity level per the Tegner score in patients undergoing surgical treatment. The rate of return to presymptomatic athletic level was 25% in patients who did not undergo fasciotomy and 77.4% for those who did, with $p = 0.001$.

It is worth highlighting that none of these studies have the gold standard regarding the methodological procedure, with several inherent biases in their conduction, and no standardized conservative treatment, which was mostly performed by physical therapists or clinicians. However, they corroborate the hypothesis that the surgical procedure seems to be a better treatment, with higher patient satisfaction, in athletes.[25,26]

Final Considerations

Chronic CS is the second most common cause of exertion-induced lower limb pain, followed by MTSS. Although it is rarely urgent and symptoms are relieved by rest and cessation of triggering activities, accurate assessment of intracompartmental pressure remains challenging, and gold-standard treatment is imprecise. Furthermore, the authors suggest that untreated CCS can lead to neural compression and irreversible damage due to elevated intracompartmental pressures.

The true prevalence of CCS remains uncertain, but it is estimated to account for approximately 14 to 34% of physical activity-related leg pain. Intense exercise, particularly running, has been linked to an increased incidence of CCS. However, military personnel are also usually affected by CCS.

Financial Support
The authors declare that they have not received financial support from agencies in the public, private, or non-profit sectors to conduct the present study.

Conflict of Interests
The authors have no conflict of interests to declare.

References

1 Alexander W, Low N, Pratt G. Acute lumbar paraspinal compartment syndrome: a systematic review. ANZ J Surg 2018;88(09): 854–859
2 Mattiassich G, Larcher L, Leitinger M, Trinka E, Wechselberger G, Schubert H. Paravertebral compartment syndrome after training causing severe back pain in an amateur rugby player: report of a rare case and review of the literature. BMC Musculoskelet Disord 2013;14:259
3 Willick SE, Deluigi AJ, Taskaynatan M, Petron DJ, Coleman D. Bilateral chronic exertional compartment syndrome of the forearm: a case report and review of the literature. Curr Sports Med Rep 2013;12(03):170–174
4 Dunn JC, Waterman BR. Chronic exertional compartment syndrome of the leg in the military. Clin Sports Med 2014;33(04): 693–705
5 American Academy of Orthopaedic Surgeons. Compartment Syndrome. Available from: https://orthoinfo.aaos.org/en/diseases–conditions/compartment-syndrome/
6 Rajasekaran S, Hall MM. Nonoperative Management of Chronic Exertional Compartment Syndrome: A Systematic Review. Curr Sports Med Rep 2016;15(03):191–198
7 McLaughlin N, Heard H, Kelham S. Acute and chronic compartment syndromes: know when to act fast. JAAPA 2014;27(06):23–26
8 Buerba RA, Fretes NF, Devana SK, Beck JJ. Chronic exertional compartment syndrome: current management strategies. Open Access J Sports Med 2019;10(10):71–79
9 Campano D, Robaina JA, Kusnezov N, Dunn JC, Waterman BR. Surgical Management for Chronic Exertional Compartment Syndrome of the Leg: A Systematic Review of the Literature. Arthroscopy 2016;32(07):1478–1486
10 Shadgan B, Menon M, Sanders D, et al. Current thinking about acute compartment syndrome of the lower extremity. Can J Surg 2010;53(05):329–334
11 Rothman R, Berke C, Jivanelli B, Casey E, Cheng J. Sex and gender differences in lower limb chronic exertional compartment syndrome: a systematic review. [published online ahead of print, 2023 Feb 7]Phys Sportsmed 2024;52(01):1–11
12 Hiramatsu K, Yonetani Y, Kinugasa K, et al. Deep peroneal nerve palsy with isolated lateral compartment syndrome secondary to peroneus longus tear: a report of two cases and a review of the literature. J Orthop Traumatol 2016;17(02):181–185
13 Lohrer H, Nauck T, Lohrer L. Endoscopic-assisted Release of Lower Leg Chronic Exertional Compartment Syndromes: Results of a Systematic Literature Review. Sports Med Arthrosc Rev 2016;24 (01):19–23
14 Tucker AK. Chronic exertional compartment syndrome of the leg. Curr Rev Musculoskelet Med 2010;3(1-4):32–37
15 Vogels S, Ritchie ED, van der Burg BLSB, Scheltinga MRM, Zimmermann WO, Hoencamp R. Clinical Consensus on Diagnosis and Treatment of Patients with Chronic Exertional Compartment Syndrome of the Leg: A Delphi Analysis. Sports Med 2022;52 (12):3055–3064
16 Whitesides TE Jr, Haney TC, Harada H, Holmes HE, Morimoto K. A simple method for tissue pressure determination. Arch Surg 1975;110(11):1311–1313
17 Davis DE, Raikin S, Garras DN, Vitanzo P, Labrador H, Espandar R. Characteristics of patients with chronic exertional compartment syndrome. Foot Ankle Int 2013;34(10):1349–1354
18 Pedowitz RA, Hargens AR, Mubarak SJ, Gershuni DH. Modified criteria for the objective diagnosis of chronic compartment syndrome of the leg. Am J Sports Med 1990;18(01):35–40
19 Nico MAC, Carneiro BC, Zorzenoni FO, Ormond Filho AG, Guimarães JB. The Role of Magnetic Resonance in the Diagnosis of Chronic Exertional Compartment Syndrome. Rev Bras Ortop 2020;55(06): 673–680
20 Vajapey S, Miller TL. Evaluation, diagnosis, and treatment of chronic exertional compartment syndrome: a review of current literature. Phys Sportsmed 2017;45(04):391–398
21 Winkes MB, Hoogeveen AR, Scheltinga MR. Is surgery effective for deep posterior compartment syndrome of the leg? A systematic review. J Vasc Surg 2014;59(06):1677–1686

22 D'Amore T, Rao S, Gawel RJ, et al. Return to Sport Rates and Subjective Outcomes Are Similar After Open or Endoscopically Assisted Compartment Release for Chronic Lower-Extremity Exertional Compartment Syndrome. Arthrosc Sports Med Rehabil 2022;4(06):e1953–e1959
23 Diebal AR, Gregory R, Alitz C, Gerber JP. Forefoot running improves pain and disability associated with chronic exertional compartment syndrome. Am J Sports Med 2012;40(05):1060–1067
24 Zimmermann WO, Hutchinson MR, Van den Berg R, Hoencamp R, Backx FJG, Bakker EWP. Conservative treatment of anterior chronic exertional compartment syndrome in the military, with a mid-term follow-up. BMJ Open Sport Exerc Med 2019;5(01):e000532
25 Vogels S, Ritchie ED, Hundscheid HP, et al. Chronic Exertional Compartment Syndrome in the Leg: Comparing Surgery to Conservative Therapy. Int J Sports Med 2021;42(06):559–565
26 Thein R, Tilbor I, Rom E, et al. Return to sports after chronic anterior exertional compartment syndrome of the leg: Conservative treatment versus surgery. J Orthop Surg (Hong Kong) 2019;27(02):2309499019835651

Thermography as a Supporting Tool for the Diagnosis of Patellar Tendon Dysfunctions: A Systematic Review

A termografia no apoio ao diagnóstico de disfunções no tendão patelar: Uma revisão sistemática

Sálvio Tadeu Correia de Barros[1] Eduardo Borba Neves[2] Marcos Leal Brioschi[3]

[1] Universidade Federal de Alagoas (UFAL), Maceió, AL, Brazil
[2] Postgraduate Program in Biomedical Engineering, Universidade Tecnológica Federal do Paraná (PPGEB/UTFPR), Curitiba, PR, Brazil
[3] Postgraduate Program in Medical Thermology and Thermography, Faculty of Medicine, Universidade de São Paulo (FMUSP), São Paulo, SP, Brazil

Address for correspondence Eduardo Borba Neves, PhD, Av. Nossa Senhora de Copacabana 120, apto 601, Copacabana, Rio de Janeiro, RJ, CEP:22020-001, Brazil (e-mail: borbaneves@hotmail.com; neveseb@gmail.com).

Rev Bras Ortop 2024;59(5):e657–e662.

Abstract

Objective The present study aimed to analyze the use of thermal images as a tool to aid in the diagnosis of dysfunctions in the patellar tendon.

Methods A systematic review of the literature was carried out, following the PRISMA protocol with a search in international databases: Web of Science, SCOPUS, and Pubmed. Descriptors in English were used with the following combination ("thermal imaging" OR thermography OR "Infrared image" OR "Skin Temperature" OR "thermal image" OR "Infrared imaging") AND ("patellar tendon"). The evaluation of the methodological quality of the selected works was carried out by two evaluators independently, using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) tool.

Results Six original articles were selected. Three papers evaluated changes in skin temperature in pathological situations. Two other works evaluated the reliability and reproducibility of thermography specifically in the patellar tendon region, and one article monitored skin temperature before and after two physical training protocols.

Conclusion It can be concluded that the use of thermal images proved to be an excellent tool to support the diagnosis of dysfunctions in the patellar tendon region, as well as for monitoring the physiological changes in this region also in non-pathological conditions, such as during physical training.

Keywords
- diagnosis
- knee
- patellar tendon
- thermography

received
March 28, 2022
accepted after revision
December 16, 2022

DOI https://doi.org/10.1055/s-0043-1770971.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Resumo

Objetivo O presente trabalho teve como objetivo analisar o uso das imagens térmicas como ferramenta de auxílio ao diagnóstico de disfunções no tendão patelar.

Métodos Realizou-se uma revisão sistemática da literatura, seguindo o protocolo PRISMA com busca nas bases de dados internacionais: *Web of Science, SCOPUS, e Pubmed*. Foram utilizados descritores em Inglês com a seguinte combinação *("thermal imaging" OR thermography OR "Infrared image" OR "Skin Temperature" OR "thermal image" OR "Infrared imaging") AND ("patellar tendon")*. A avaliação da qualidade metodológica dos trabalhos selecionados foi realizada por dois avaliadores de forma independente pelo instrumento *Quality Assessment of Diagnostic Accuracy Studies* (QUADAS-2).

Resultados Foram selecionados seis artigos originais. Três trabalhos avaliaram as alterações da temperatura da pele em situações patológicas. Outros dois trabalhos avaliaram a confiabilidade e reprodutibilidade da termografia especificamente na região do tendão patelar, e um artigo monitorou a temperatura da pele antes e após dois protocolos de treinamento físico.

Conclusão Pode-se concluir que o uso das imagens térmicas se mostrou uma excelente ferramenta de apoio ao diagnóstico a disfunções na região do tendão patelar, bem como para o monitoramento das alterações fisiológicas dessa região também em condições não patológicas, como durante a prática de treinamento físico.

Palavras-chave

- diagnóstico
- joelho
- tendão patelar
- termografia

Introduction

The knee is the joint most commonly injured by athletes. Millions of adult amateur athletes of both sexes are affected by knee injuries every year. Non-contact knee injuries account for more than two-thirds of knee injuries when data from team sports athletes is analyzed. These injuries result in profound consequences, including physical disability, substantial treatment costs, and even depression in some cases.[1]

Lyons et al.[2] analyzed the epidemiological data of injuries of the knee extensor mechanism, using the database of emergency departments in the United States in the period from 2001 to 2020. The authors observed that ruptures of the patellar tendon are the second most frequent type of injury (13.5% of all injuries, overall incidence rate: 0.48), second only to patellar fractures (77.5% of all injuries, overall incidence rate: 2.69).

Patellar tendon dysfunction is usually the result of a chronic process or an acute trauma. Chronic inflammation, such as patellar tendonitis, weakens the tendon and increases the likelihood of rupture, either partial or complete. In addition, some systemic pathologies (systemic lupus erythematosus, chronic kidney disease, and diabetes mellitus, among others) can lead to a weakened tendon that is predisposed to rupture.[3]

Patellar tendinopathy is a degenerative condition marked by histopathological changes in the tendon. Patellar tendinopathy, also commonly called jumper's knee, most commonly occurs in active individuals between the ages of 14 and 40.[4] The clinical diagnosis of patellar tendinopathy is based on the patient's symptoms, and can be characterized by pain on palpation at the lower pole of the patella and adjacent areas and, in more advanced cases, a palpable nodule and associated edema may be present.[5] Complementary exams, such as radiography, ultrasonography (US) and magnetic resonance imaging (MRI) help the diagnosis, as they can define the exact location of the lesion, its extent, as well as allow the visualization of degenerative changes, when present.[5]

Magnetic resonance imaging is the method with the best resolution to support the diagnosis of patellar tendon injury, as it allows observation and evaluation of bone structures and soft tissues.[3] Recently, the use of thermal imaging in the evaluation and follow-up of patients with musculoskeletal injuries has shown great relevance in clinical practice.[6–8] Medical thermography allows a non-invasive, low-cost and non-radioactive analysis,[9] resulting in a functional and visual measurement of skin temperature distribution. In this sense, the present work aimed to analyze the use of thermal images as a tool to aid in the diagnosis of dysfunctions in the patellar tendon.

Methodology

A literature review was carried out, which followed the PRISMA protocol for systematic review studies. Therefore, we used a search in 3 of the largest international databases (Web of Science, SCOPUS, and Pubmed), according to the keywords and database presented in ►**Table 1**, and the selection flow presented in ►**Fig. 1**.

After the initial search, using the search phrases mentioned in ►**Table 1**, two independent evaluators carried out the selection of studies. In cases of disagreement between the evaluators, a third researcher gave his opinion.

This systematic review included studies that assessed skin temperature in dysfunctions in the patellar tendon region. Studies from systematic reviews, reviews with meta-analysis, case studies, and studies without full text were excluded. Studies with a publication date prior to 1985 were also excluded, in view of the low resolution of older camera images.

Table 1 Presentation of databases and search phrases used in this systematic review

Databases	Search phrases
Web of Science	All fields ("patellar tendon") AND All fields ("thermal imaging" OR thermography OR "Infrared image" OR "Skin Temperature" OR "thermal image" OR "Infrared imaging")
Scopus	TITLE-ABS-KEY ("patellar tendon") AND TITLE-ABS-KEY ("thermal imaging" OR thermography OR "Infrared image" OR "Skin Temperature" OR "thermal image" OR "Infrared imaging")
PubMed	("thermal imaging" OR thermography OR "Infrared image" OR "Skin Temperature" OR "thermal image" OR "Infrared imaging") AND ("patellar tendon")

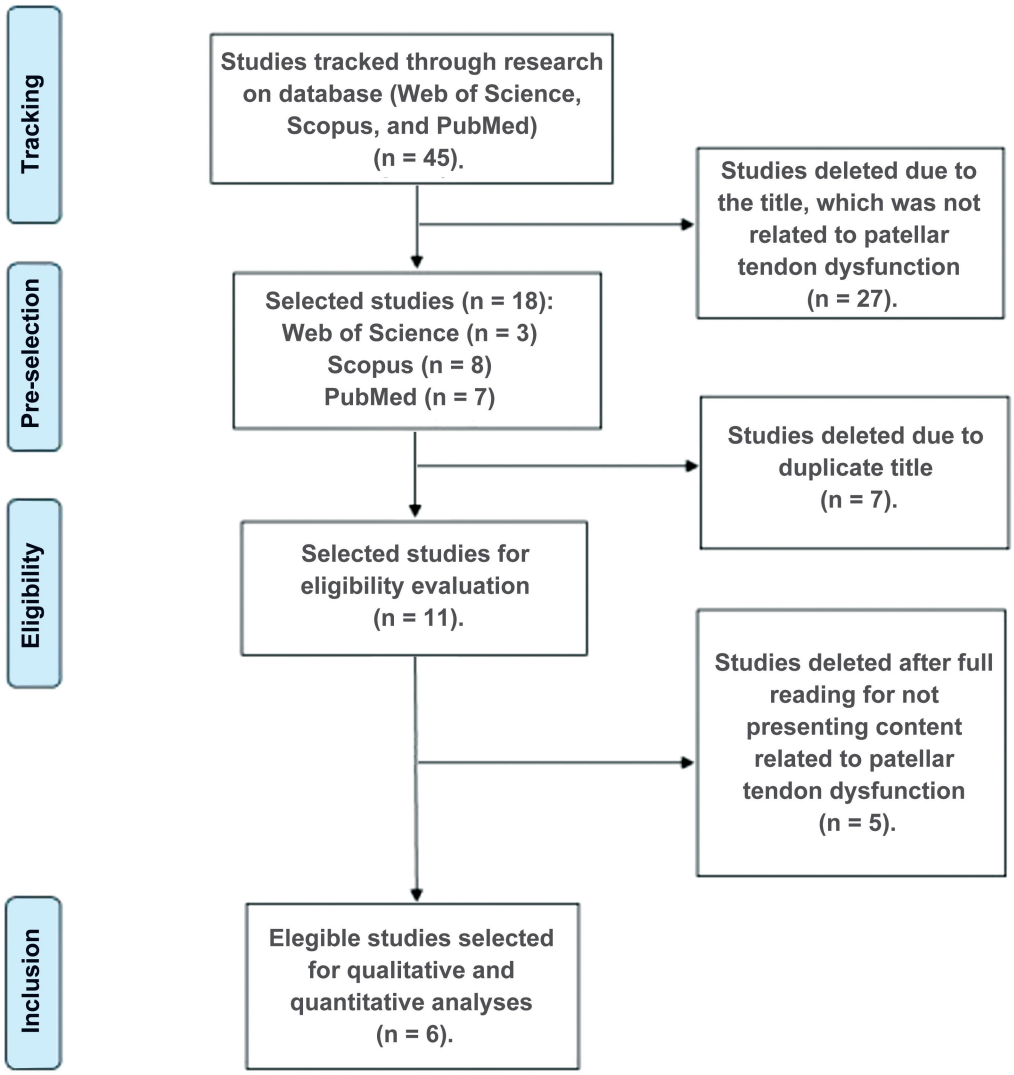


Fig. 1 Flowchart of the search and selection process of articles included in this systematic review.

The following data were extracted from the studies: sample profile, type of intervention, main results, and delta temperature observed by infrared thermography.

The evaluation of the methodological quality of the selected works was carried out by two evaluators independently using the Quality Assessment of Diagnostic Accuracy Studies instrument[10] (►**Table 2** - Quadas-2).[11–16]

Results

Six original articles were selected to compose the corpus of this review. Three papers evaluated changes in skin temperature in pathological situations. Two other works evaluated the reliability and reproducibility of thermography specifically in the patellar tendon region, and one article monitored skin temperature before and after two physical training

Table 2 Assessment of methodological quality and risk of bias of studies selected by the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) tool

	Risk of bias				Applicability concerns		
Study	Selection of participants	Index test	Reference standard	Flow and timing	Patient selection	Index test	Reference standard
Molina-Payá et al. 2021[11]	+	+	+	+	+	+	+
Dos Anjos et al.[12]	+	+	+	+	+	+	+
Alfieri, 2020[13]	+	+	+	+	+	+	+
Sanz-López et al., 2016[14]	+	+	+	+	+	+	+
Gross et al. 1989[15]	+	+	−	+	+	+	−
Mangine et al. 1987[16]	+	+	+	+	+	+	+

+: High risk; -: Low risk.

protocols. The flowchart illustrating the article selection process is shown in ►**Fig. 1**. ►**Table 3** presents the data of interest extracted from each of the analyzed studies.[11–16]

Discussion

This study aimed to analyze the use of thermal images as a tool to aid in the diagnosis of dysfunctions in the patellar tendon. Therefore, we started the discussion of the results by analyzing the reliability and reproducibility of thermography in the region of the patellar tendon.

Gross et al.[15] and Molina-Payá et al.[11] reported excellent reliability and reproducibility values. Molina-Payá et al.[11] reported ICC values between 0.904 and 0.998. These values correspond to a difference in temperature of the order of 0.006°C (Limits of Agreement: -0.10 to 0.10) intra-examiner, and 0.001°C (Limits of Agreement: -0.13 to 0.13) inter-examiner. In the study by Gross et al.[15] the Pearson correlation coefficient was used to assess reliability, reporting intra-examiner reliability values of 0.99 and inter-examiner (two investigators) of 0.88. Inter-examiner reliability was also investigated in the study by Selfe et al.[17] involving patients with pain in the anterior region of the knee, indicating good results. They observed ICC values between 0.82 and 0.97 when using thermally inert markers, placed in specific anatomical locations, defining an area on the anterior aspect of the knee.

The reliability values and reproducibility of thermography in the patellar tendon region are in line with what is observed in other body regions, allowing its safe use in clinical practice. Dos Santos Moraes et al.[18] aimed to evaluate the inter- and intra-examiner reliability of infrared thermography in the analysis of skin temperature in people complaining of pain in the upper trapezius muscle. Eighty-two individuals of both sexes who had moderate or severe pain in the upper trapezius muscle were evaluated. Area evaluation indicated a very strong overall intraclass correlation coefficient (ICC) for both intra-examiner (between 0.936 and 0.979) and inter-examiner (between 0.933 and 0.979).

Dos Anjos et al.,[12] Alfieri[13] and Mangine et al.[16] reported significant variations in skin temperature (►**Table 3**) over the patellar tendon region in conditions of pathophysiological changes diagnosed by gold standard methods. The studies analyzed in this review suggest that thermography is capable of documenting thermal variations at the level of the skin, resulting from pathophysiological changes in the region of the patellar tendon.[12,13,16]

This ability to capture thermal changes resulting from alterations in human physiology has allowed the use of thermal images in several medical applications, such as: diagnosis of musculoskeletal injuries,[8] monitoring changes in the feet of diabetics,[19] aiding in the diagnosis of Osgood-schlatter disease[20], and others. In this sense, it can be said that thermography has been consolidated in medical practice as a reliable tool with a clinical application that permeates several specialties.

In addition to the applications more directed to the medical area, Sanz-López et al.[14] involved the practice of physical training and the monitoring of the thermal response at the level of the patellar tendon. The authors observed significant changes in skin temperature over the patellar tendon after continuous running training and eccentric strength training associated with continuous running training. Bandeira et al.[6] and Neves et al.[21] had already reported similar findings in other body regions. These observations corroborate the applicability of using thermal images to assess the patellar tendon region even in non-pathological situations, such as monitoring physical training,[6,21] whether for injury prevention or even for workload assessment.

As limitations of the present review, the low number of studies that used thermal imaging of the patellar tendon region available in the literature, and the heterogeneity of the patients of the analyzed studies, variables and interventions used can be mentioned. However, on the other hand, this aforementioned heterogeneity allowed a holistic approach to the applicability of the tool to the evaluation of the patellar tendon.

Conclusion

After analyzing the corpus of works selected in this systematic literature review, it can be concluded that the use of

Table 3 Distribution of selected articles according to author (year), sample, intervention, delta temperature and results found

Author (year)	Sample	Intervention	Difference observed in skin temperature	Results
Molina-Payá et al. 2021[11]	17 participants (7 women and 10 men) aged between 18 and 62 years (mean: 32.2 years; SD: 10.9 years)	Static position for assessing intra- and inter-examiner reliability and reproducibility	Intra-examiner differences were 0.006°C (Limits of Agreement: -0.10 to 0.10), and inter-examiner differences were 0.001°C (Limits of Agreement: -0.13 to 0.13).	Skin temperature was similar at intra-examiner ($F1.33 = 0.488$; $p = 0.490$) and inter-examiner ($F1.33 = 0.011$; $p = 0.917$).
Dos Anjos et al.[12]	25 subjects with bilateral osteoarthritis (OA), aged 54 to 78 years.	Comparisons between symptomatic and asymptomatic knees did not reveal differences according to Kellgren-Lawrence classification, knee surface temperature or Pressure Pain Threshold (PPT)	Symptomatic knees $= 31.2 \pm 1.4$; asymptomatic knees $= 31.1 \pm 1.5$, (p value for paired t test $= 0.379$)	Patients with bilateral knee OA showed no difference in symptomatic and asymptomatic knees in relation to Kellgren-Lawrence rating scale, knee temperature, and pain tolerance.
Alfieri, 2020[13]	11 volunteers of both genders (63.1 ± 9.5 years) participated in this study. All with unilateral osteoarthritis of the knee	Voluntary thermographic evaluation by an infrared sensor (FLIR T650SC). The anterior region of the thigh, leg and knee were evaluated. Pain pressure threshold (PPT) were evaluated by algometry in the vastus medialis, vastus lateralis, rectus femoris and patellar tendon.	When comparing skin temperature, only the knee region showed a significant difference between the sides (affected knees $= 31.2 \pm 1.4$; unaffected knees $= 29.2 \pm 1.2$, (p value for paired t test $= 0.03$)	Individuals with knee osteoarthritis had higher temperature in the affected knee when compared to the contralateral one, but this was not associated with pain pressure thresholds.
Sanz-López et al., 2016[14]	20 male volunteers, aged between 18 and 25 years were divided into 2 groups with 10 subjects each.	A group trained with eccentric overload and 3 sessions of continuous running, and another group trained only with 3 sessions of continuous running. Infrared thermography (IRT) was used to assess skin temperature over the patellar tendon before, shortly after, and after 10 minutes of running.	Skin temperature measurements, in the region of the patellar tendon, taken 10 minutes after the running intervention in the group trained with eccentric overload showed statistically higher values than those obtained before running in the first and third (differences $= 0.81$ °C and 1. 91 °C, $p < 0.05$, respectively)	The thermographic images of the patellar tendon did not show any statistically different behavior between the groups. Although significant differences were observed between the evaluation times, within each group.
Gross et al., 1989[15]	17 volunteers, six men and eleven women, aged between 19 and 65 years.	The study had two purposes. The first was to evaluate the reliability of a method for quantitative assessment of thermograms. The second objective was to test the hypotheses of difference in skin temperature over the patellar tendon between dominant and non-dominant limbs.	Intra-rater reliability was $r = 0.99$. Inter-rater reliability (two investigators) was $r = 0.88$. The average temperature measured on the patellar tendon for the dominant and non-dominant limbs did not show statistically significant differences. (dominant $= 29.61 \pm 0.52$; non-dominant $= 29.60 \pm 0.96$).	The presented thermogram analysis method can be used reliably. There is no change in the thermal pattern of the patellar tendon as a function of limb dominance.
Mangine, 1987[16]	17 patients diagnosed with patellar tendinitis, seven men and ten women aged between 12 and 28 years.	The intent of this study was to determine whether the thermal pattern of tendinitis can be distinguished using infrared thermography. Infrared heat emissions were recorded with a resolution of 0.05°C. With legs open and elevated, subjects were thermalized for a period of 10 minutes at the temperature of the image acquisition room. The ambient temperature was maintained free from drafts at 20.0 ± 1.0°C.	In volunteers who had unilateral dysfunction, the mean difference in skin temperature over the patellar tendon between the two sides was 1.23 °C.	An identifiable thermal pattern associated with patellar tendonitis was found in most of the evaluated subjects (78%). Thermography seems useful as a non-invasive and objective method of detecting soft tissue inflammation around the patellar tendon, and also helps to differentiate this disease from other pathologies of the knee.

thermal images proved to be an excellent tool to support the diagnosis of dysfunctions in the patellar tendon region, as well as for monitoring the physiological changes in this region also under non-pathological conditions, such as during physical training.

The use of thermography in the clinical practice of health professionals who need to monitor and/or evaluate the patellar tendon is recommended, as well as the development of more original studies, which address other pathologies and non-pathological situations, in order to expand the knowledge of the thermal physiology of this specific region.

Financial Support
The authors declare that there was no financial support from any public, commercial, or non-profit sources.

Conflict of Interests
The authors have no conflict of interest to declare.

References

1 Clark NC, Heebner NR, Lephart SM, Sell TC. Specificity of isokinetic assessment in noncontact knee injury prevention screening: A novel assessment procedure with relationships between variables in amateur adult agility-sport athletes. Phys Ther Sport 2022; 53:105–114
2 Lyons JG, Mian HM, Via GG, Brueggeman DA, Krishnamurthy AB. Trends and epidemiology of knee extensor mechanism injuries presenting to United States emergency departments from 2001 to 2020. [published online ahead of print, 2022 Jan 6]Phys Sportsmed 2022;•••:1–10
3 Hsu H, Siwiec RM. Patellar Tendon Rupture. In: StatPearls. Treasure Island (FL): StatPearls Publishing; February 17, 2022
4 Hutchison MK, Houck J, Cuddeford T, Dorociak R, Brumitt J. Prevalence of Patellar Tendinopathy and Patellar Tendon Abnormality in Male Collegiate Basketball Players: A Cross-Sectional Study. J Athl Train 2019;54(09):953–958
5 Cohen M, Ferretti M, Marcondes FB, Amaro JT, Ejnisman B. Tendinopatia patelar. Rev Bras Ortop 2008;43(08):309–318
6 Bandeira F, Moura MAM, Souza MA, Nohama P, Neves EB. Pode a termografia auxiliar no diagnóstico de lesões musculares em atletas de futebol? Rev Bras Med Esporte 2012;18(04): 246–251
7 Bandeira F, Neves EB, de Moura MAM, Nohama P. The thermography in support for diagnosis of muscle injury in sport. Rev Bras Med Esporte 2014;20(01):59–64
8 dos Santos Bunn P, Miranda MEK, Rodrigues AI, de Souza Sodré R, Neves EB, da Silva EB. Infrared thermography and musculoskeletal injuries: a systematic review with meta-analysis. Infrared Phys Technol 2020;109:103435. Doi: 10.1016/j.infrared.2020.103435
9 Côrte Ae, Hernandez AJ. Termografia médica infravermelha aplicada à medicina do esporte. Rev Bras Med Esporte 2016;22(04): 315–319
10 Whiting PF, Rutjes AW, Westwood ME, et al; QUADAS-2 Group. QUADAS-2: a revised tool for the quality assessment of diagnostic accuracy studies. Ann Intern Med 2011;155(08):529–536
11 Molina-Payá J, Ríos-Díaz J, Martínez-Payá J Inter and intraexaminer reliability of a new method of infrared thermography analysis of patellar tendon. Quant Infrared Thermogr J 2021;18 (02):127–139
12 Vargas E Silva NCO, Dos Anjos RL, Santana MMC, Battistella LR, Marcon Alfieri F. Discordance between radiographic findings, pain, and superficial temperature in knee osteoarthritis. Reumatologia 2020;58(06):375–380
13 Alfieri FM, Vargas E Silva NCO, Dos Santos ACA, Battistella LR. Cutaneous temperature and pressure pain threshold in individuals with knee osteoarthritis. Reumatologia 2020;58(05):272–276
14 Sanz-López F, Martínez-Amat A, Hita-Contreras F, Valero-Campo C, Berzosa C. Thermographic Assessment of Eccentric Overload Training Within Three Days of a Running Session. J Strength Cond Res 2016;30(02):504–511
15 Gross MT, Schuch CP, Huber E, Scoggins JF, Sullivan SH. Method for quantifying assessment of contact thermography: effect of extremity dominance on temperature distribution patterns. J Orthop Sports Phys Ther 1989;10(10):412–417
16 Mangine RE, Siqueland KA, Noyes FR. The use of thermography for the diagnosis and management of patellar tendinitis. J Orthop Sports Phys Ther 1987;9(04):132–140
17 Selfe J, Hardaker N, Thewlis D, Karki A. An accurate and reliable method of thermal data analysis in thermal imaging of the anterior knee for use in cryotherapy research. Arch Phys Med Rehabil 2006;87(12):1630–1635
18 dos Santos Moraes TL, Lustosa LS, Santos Ramos LM, et al. Is Infrared Thermography Reliable to Assess Pain in the Trapezius Muscle Region? Open Sports Sci J 2021;14(01):25–29
19 Mendes R, Sousa N, Almeida A, Vilaça-Alves J, Reis VM, Neves EB. Thermography: a technique for assessing the risk of developing diabetic foot disorders. Postgrad Med J 2015;91(1079):538
20 Capitani G, Sehnem E, Rosa C, Matos F, Reis VM, Neves EB. Osgood-schlatter Disease Diagnosis by Algometry and Infrared Thermography. Open Sports Sci J 2017;10(Suppl 2-M2):223–228
21 Neves EB, Moreira TR, Canário-Lemos R, Vilaça-Alves J, Rosa C, Reis VM. Using skin temperature and muscle thickness to assess muscle response to strength training. Rev Bras Med Esporte 2015; 21(05):350–354

Comparison of External Circular Fixation and Plate and Screw Fixation Methods in Tibial Pilon Fractures

Comparação entre métodos de fixação externa circular e de fixação com placa e parafuso nas fraturas de pilão tibial

Marco Antonio Schueda[1,2] Leonardo Maranhão Gubert[2,3] Yan Celuppi Dal Vesco[2] Fernanda Fossa Dal Piva[2] Felipe Guglielmi Niada[1,2] Ryad Fayez Mehanna[2]

[1] Orthopedics and Traumatology Service, Hospital do Coração Balneário Camboriú, Balneário Camboriú, SC, Brazil
[2] Orthopedics and Traumatology Service, Hospital e Maternidade Marieta Konder Bornhausen, Itajaí, SC, Brazil
[3] Orthopedics Service, Hospital Unimed Litoral, Balneário Camboriú, SC, Brazil,

Address for correspondence Ryad Fayez Mehanna, Serviço de Ortopedia e Traumatologia, Hospital e Maternidade Marieta Konder Bornhausen, Itajaí, SC, Brazil (e-mail: ryad.mehanna@hotmail.com).

Rev Bras Ortop 2024;59(5):e663–e671.

Abstract

Objective To compare the fixation methods for tibial pilon fractures among patients treated in a hospital.

Methods We analyzed the medical records of 28 patients who underwent a surgical procedure for tibial pilon fracture, among whom 15 subjects received a circular external fixator, and 13 underwent internal fixation using a plate and screws. We assessed age, sex, aggravating factors, trauma energy (high or low), presence of soft tissue injuries, associated fractures, and clinical outcomes.

Results Most patients were male, aging between 40 and 60 years. The most common trauma mechanism was car accident, and the associated injury was a fracture of the distal third of the fibula. The fracture patterns in patients treated with a circular external fixator were AO 43C3 and 43C2. As for the prevalent fracture patterns in the internal fixation group, we identified AO 43C1, 43C2, and 43C3.

Conclusion An individualized therapeutic choice is critical for a better functional outcome. Additionally, it is essential to highlight that the profile of fractures and patients in the circular external fixator and internal fixation groups tends to be quite heterogeneous, because the treatment of fractures with the worst classification and most frequently associated with soft tissue injuries often uses circular external fixation;

Keywords
- external fixators
- Ilizarov technique
- tibial fractures

Work carried out at the Orthopedics and Traumatology Service, Hospital e Maternidade Marieta Konder Bornhausen, Itajaí, SC, Brazil.

received
November 6, 2023
accepted
June 23, 2024

DOI https://doi.org/10.1055/s-0044-1790213.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

meanwhile, those with less severe fractures and a lower incidence of soft tissue injuries are usually managed with open reduction and internal fixation. We noted that the clinical and radiographic outcomes tended to be similar between both groups despite the particularities of each method.

Resumo

Objetivo Comparar os métodos de fixação de fraturas do pilão tibial de pacientes atendidos em um hospital.

Métodos Foram analisados os prontuários de 28 pacientes que realizaram procedimento cirúrgico para fratura do pilão tibial, sendo 15 deles tratados com fixador externo circular e 13 com fixação interna por placa e parafusos. Foram analisados idade, sexo, fatores agravantes, energia do trauma (alta ou baixa), presença de lesão de tecidos moles, ocorrência de fraturas associadas e desfechos clínicos.

Resultados O sexo mais acometido foi o masculino, na faixa etária entre 40 e 60 anos. O mecanismo de trauma em sua maioria foi acidentes automobilísticos e a lesão associada em 100% dos casos foi a fratura do terço distal da fíbula. O padrão de fratura observado nos pacientes tratados com fixador externo circular foram AO 43C3 e 43C2. Já os padrões de fratura prevalentes observado no grupo de fixação interna foram AO 43C1, 43C2 e 43C3.

Conclusão A escolha terapêutica individualizada é de extrema importância para um melhor desfecho funcional. Também é imprescindível ressaltar que o perfil da fratura e dos pacientes que do grupo fixador externo circular e de grupo fixação interna por placa e parafusos tende a ser bastante heterogêneo, pois as fraturas de pior classificação e mais frequentemente associadas a lesões de partes moles costumam ser manejadas com fixação externa circular, enquanto aqueles com fraturas de menor gravidade e menor incidência de lesão de partes moles tendem a ser manejados por redução aberta e fixação interna. Observa-se que os desfechos clínicos e radiográficos tendem a ser similares entre ambos os grupos apesar das particularidades de cada método.

Palavras-chave
- fixadores externos
- fraturas da tíbia
- técnica de Ilizarov

Introduction

The term tibial pilon was introduced in 1911 by the French radiologist Destot, who described fractures involving the weight-bearing joint surface of the distal third of the tibia but not necessarily affecting it.[1] Radiographic evaluation requires three views: anteroposterior (AP), lateral (L), and AP with 20° of internal rotation (mortise). In cases of doubt, one may request an oblique or stress radiograph. Additionally, one may ask for a radiograph of the contralateral ankle for comparison. In cases of joint involvement, especially in fractures caused by high-energy trauma, computed tomography (CT) helps to evaluate the fracture pattern and joint comminution degree, as well as preoperative planning.[2]

Tibial pilon fractures predominantly affect young men between 30 and 40-years-old, and high-energy trauma accounts for 10 to 30% of open fractures.[3] Currently these fractures are common because of high-energy traumas, such as traffic accidents or falls from height. Other fractures, including in the talus, calcaneus, tibial plateau, pelvis, acetabulum, and spine, may accompany tibial pilon fractures.[4]

The trauma mechanism is longitudinal compression of the talus on the distal surface of the tibia, potentially associated with rotational forces. The fracture pattern results from the direction and speed of the damaging energy, along with the foot's positioning during load application.[5]

Furthermore, it is important to assess soft tissue involvement and consider whether the fracture is open or closed. We know many factors deserve consideration when choosing the definitive treatment[6] since the soft tissue involvement may suffer exacerbation by major surgical procedures involving large incisions, bone deperiostization, and separation of its soft components, which can lead to necrosis of the overlying tissue and increase the risk of pseudarthrosis, infection, or both.[7]

Materials and Methods

Our institution approved this study under CAAE number 71275623.0.0000.0120.

This cross-sectional and observational study analyzed the medical records of patients hospitalized with a tibial pilon fracture who underwent surgical treatment from

January 1st, 2021, to January 1st, 2023. Using the medical records, we assessed age, sex, aggravating factors, trauma energy, presence of soft tissue injury, and occurrence of associated fractures. We analyzed imaging tests (AP, L, and oblique radiographs of the ankle and preoperative CTs), transoperative, immediate postoperative, and postoperative follow-up radiographies in ambulatory. For the functional analysis, the American Association for Foot and Ankle Surgery's (AFOS) functional scores were used.

Polytrauma patients underwent damage control treatment with mono or biplanar fixation and a review for internal or external circular fixation within 7 days of their emergency treatment.

Results

We analyzed the medical records from 30 patients operated on for tibial pilon fracture, including 15 treated with a circular external fixator and 15 treated with internal fixation using a plate and screws. We lost 2 patients from the internal fixation group at follow-up and excluded them from the analyses. Thus, this subgroup had 13 patients, and the total research sample comprised 28 subjects.

The patients included 21 males and 7 females (►**Fig. 1**). The external fixation subgroup treated using the method proposed by Ilizarov had 15 patients, including 10 males and 5 females. The internal fixation subgroup treated using a nonlocking trefoil plate and screws had 13 patients, with 11 males and 2 females.

We observed a high prevalence of patients in the age group from 40 to 60-years-old, with an average of 44 (►**Fig. 2**). The average age was 43 in males and 46 in females.

Regarding the mechanism of trauma in the circular external fixator group, we observed a higher tendency for high-energy trauma (11 patients). Car accidents accounted for 7 of the 11 cases, while the remaining 4 resulted from falls from height. From that last group, all 4 patients suffered lower-energy trauma resulting from falls from their height. Among patients from the circular external fixator group, there were 60 open and 40% closed fractures.

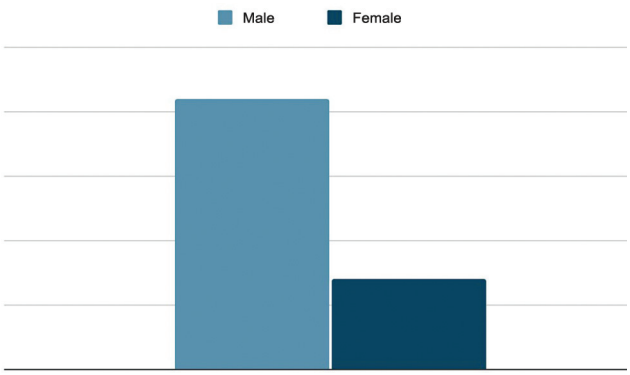


Fig. 1 Sex of the participants.

Regarding the trauma mechanism in the internal fixation group, a high tendency towards high-energy trauma was noted (10 patients). Car accidents accounted for 5 of the 10 cases, while another 4 cases resulted from falls from height, and 1 involved a gunshot wound. Among the 3 patients suffering low-energy trauma, 2 had fractures from physical aggression, and 1 case was due to a fall from their level (►**Fig. 3**). Therefore, the internal fixation group had approximately 77% closed and 23% open fractures.

According to the AO group classification for fracture patterns, we noted that 60% of patients treated with a circular external fixator had 43C3 fractures with frank joint comminution, and another 40% had 43C2. No subject treated with the circular external fixation method had 43C1 fractures.

Using the same classification, we observed that patients treated with internal fixation included 5 subjects with 43C1 fractures, 5 with 43C2 fractures, and 3 with 43C3 fractures.

In both groups, the associated injury in 100% of cases was a fracture of the distal third of the fibula. Other injuries in the circular external fixation group included tibial plateau (4 cases), calcaneus (2 cases), tibial diaphysis, contralateral ankle, and hand bone fractures (1 case each). A clavicle fracture was the single other injury observed in the internal fixation group.

Regarding the outcomes of the circular external fixator group, 5 patients presented complete fracture consolidation, 1 had pseudarthrosis, and 2 malunions. ►**Figs. 4**–**7** show examples of the circular external (I) and internal fixation (II) groups.

A total of 6 patients still remain in follow-up, but their progress is satisfactory, with radiographic consolidation signs. A single patient was lost at follow-up (►**Fig. 8**).

As for the outcomes of the open reduction and internal fixation group, 10 patients presented complete fracture consolidation, 1 had pseudarthrosis, 1 presented with malunion. Finally, one of the cases had a frank infection in the topography requiring synthetic material removal and multiple surgical interventions (►**Fig. 9**).

To facilitate the functional assessment of patients according to the American Orthopedic Foot & Ankle Society (AOFAS) score for the ankle and hindfoot (►**Fig. 10**), we subdivided the patients as follows:

- Group 1: 0 to 20 points
- Group 2: 20 to 40 points
- Group 3: 40 to 60 points
- Group 4: 60 to 80 points
- Group 5: 80 to 100 points

As such, we noted that the distribution of the groups was as follows: group 1–2 patients; group 2–6 patients; group 3–7 patients; group 4–8 patients (this group presented the highest prevalence); and group 5–5 patients.

The group treated with the Ilizarov external fixator contained 15 patients, distributed as follows: group 1–1 patient;

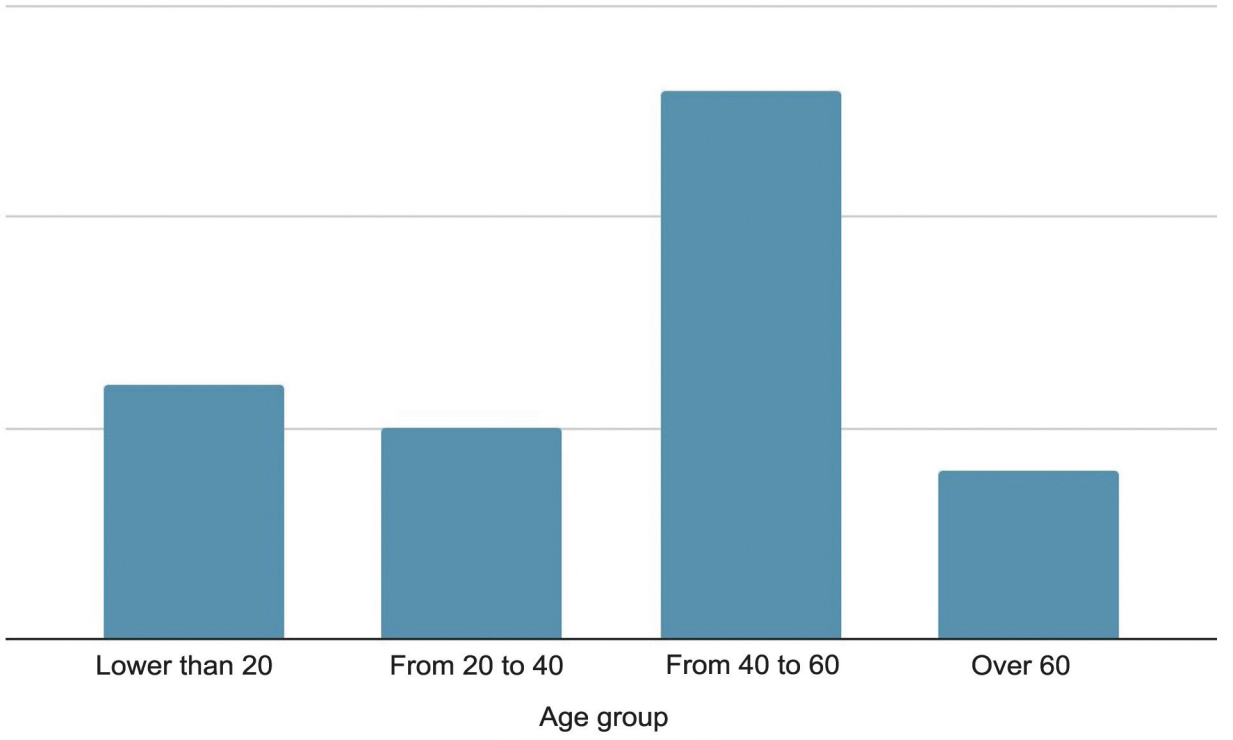


Fig. 2 Age of the patients.

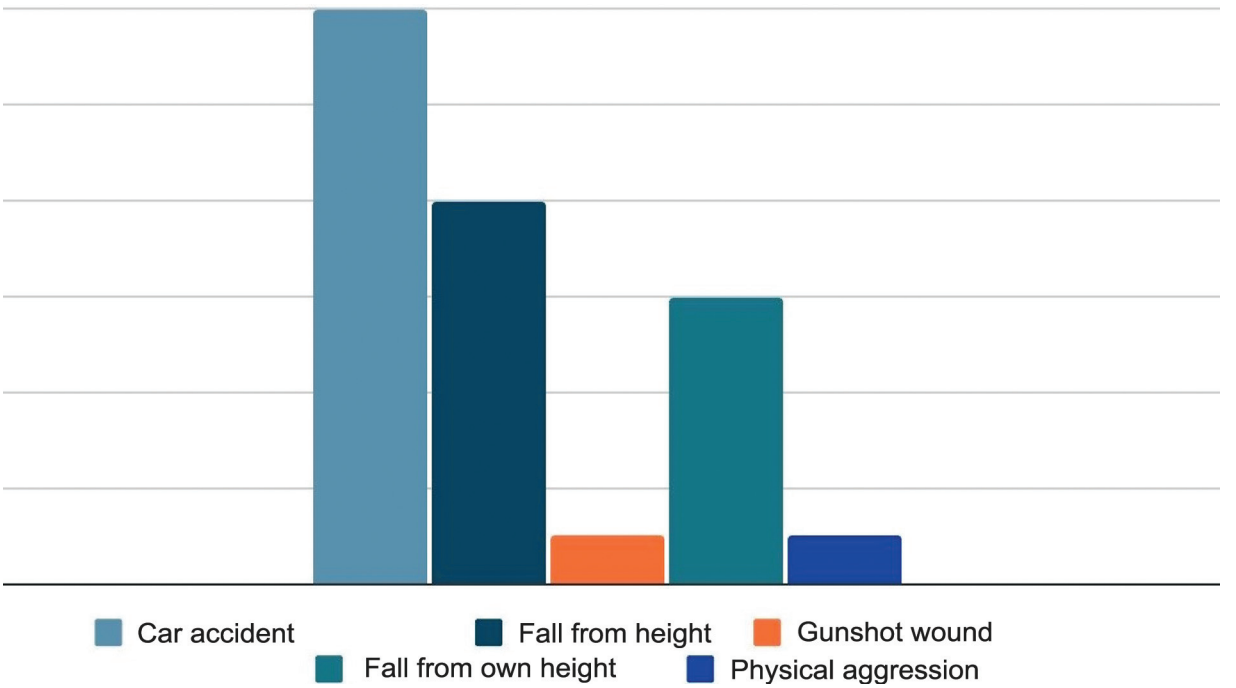


Fig. 3 Mechanism of trauma.

group 2–3 patients; group 3–4 patients; group 4–4 patients; and group 5–3 patients.

In contrast, the group treated with internal fixation (plate and screws) comprised 13 patients with the following distribution: group 1–1 patient; group 2–3 patients; group 3–3 patients; group 4–4 patients; and group 5–2 patients.

Discussion

Our study revealed a prevalence of males, which is consistent with the literature. However, the prevalent age group was older than the one reported by Marsh and Saltzaman.[5] Pimenta et al.[8] observed an average age of 42, similar to our study.



Fig. 4 Tibial pilon fracture (AO 43C2) before internal fixation with plate and screw.

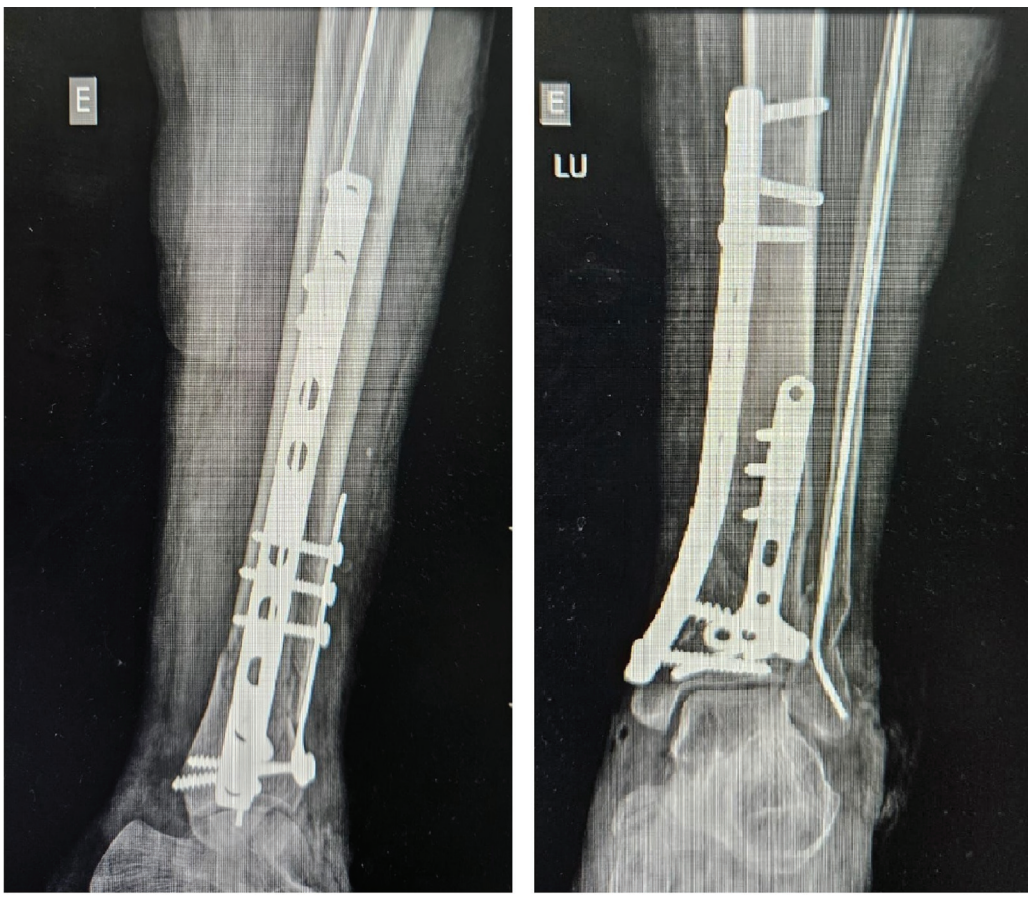


Fig. 5 Tibial pilon fracture (AO 43C2) after internal fixation with plate and screw.

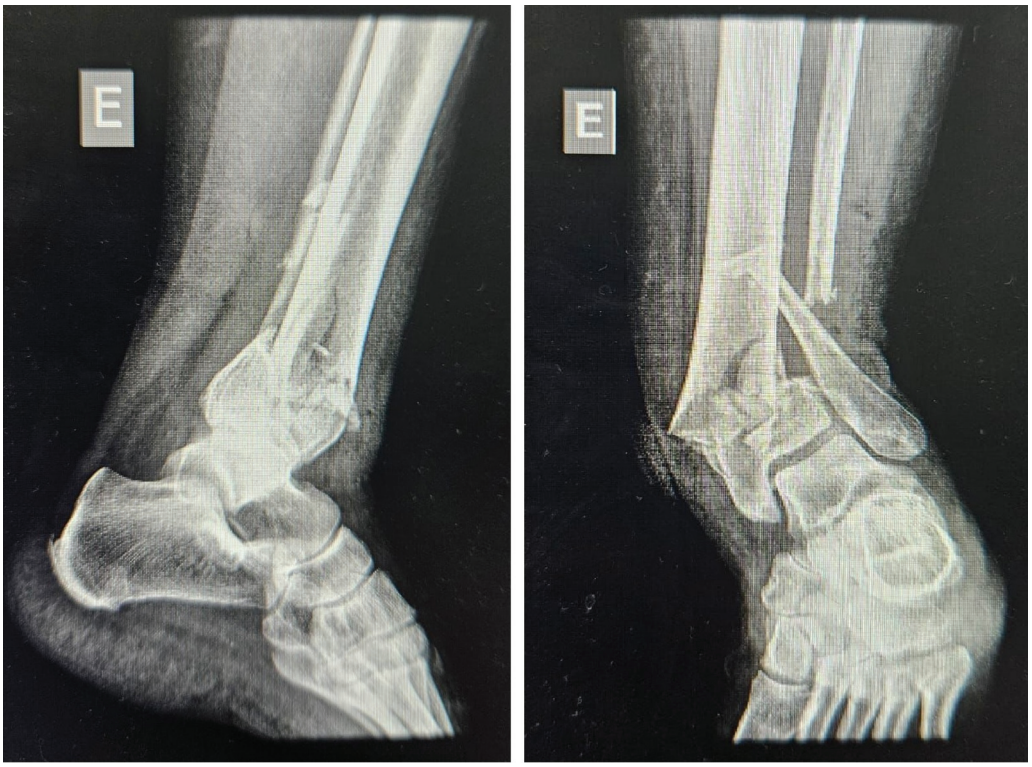


Fig. 6 Tibial pilon fracture (AO 43C2) before circular external fixation.

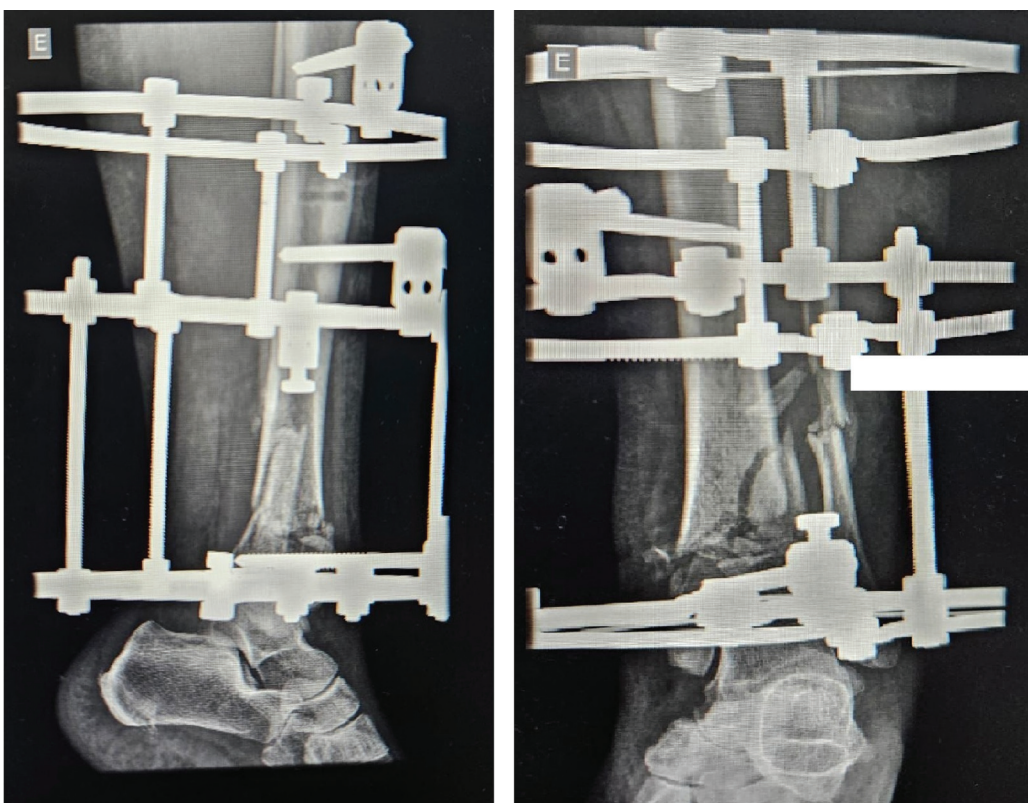


Fig. 7 Tibial pilon fracture (AO 43C2) after circular external fixation.

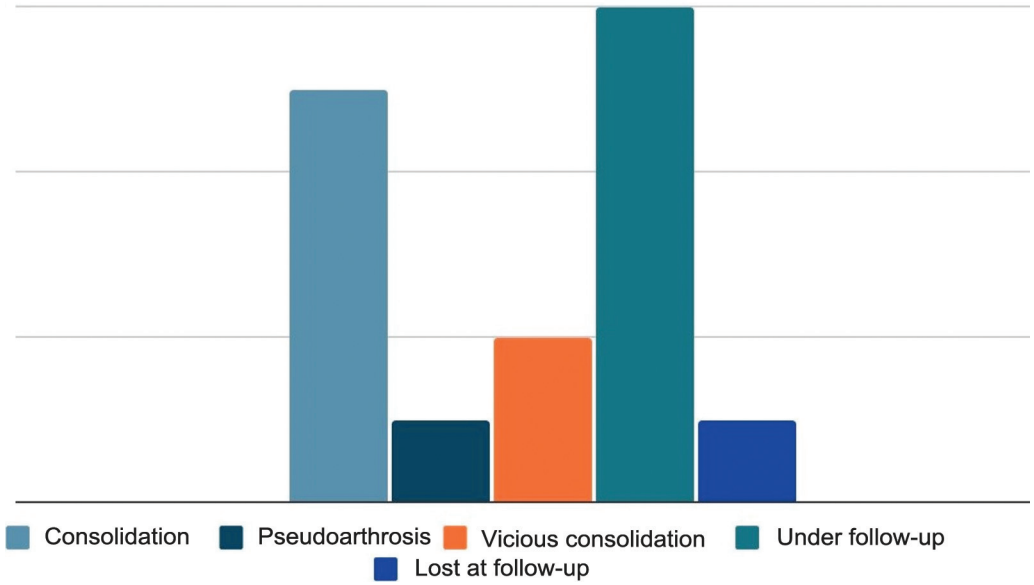


Fig. 8 Circular external fixation outcome.

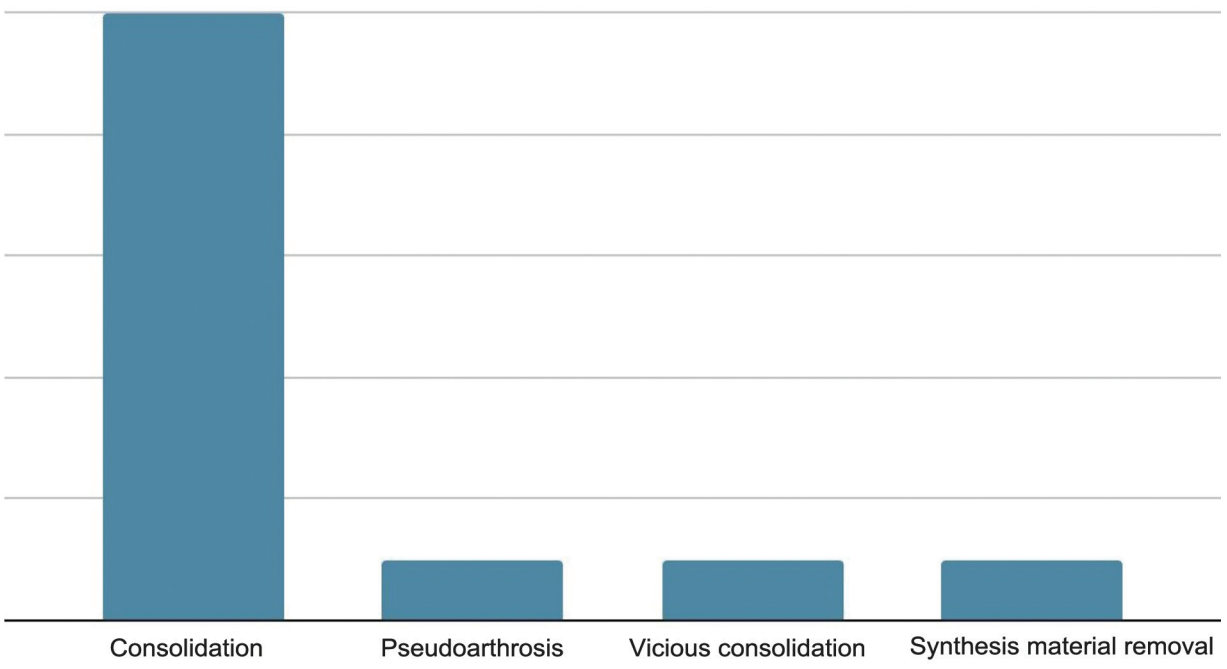


Fig. 9 Internal fixation (plate and screw) outcome.

In the circular external fixator group, the rate of open fractures was above the percentiles found in the literature.[9] In contrast, the internal fixation group had a rate of soft tissue injuries with fracture exposure well below the literature, in which open fracture rates are at around 50%.

In our service, the main mechanism of trauma was car accidents, followed by falls from a height, which is consistent with the literature. Furthermore, it was observed that the highest rate of fracture exposure among the 28 patients occurred in the group classified as AO 43C2, representing 60% of subjects, compared to 38% in the AO 43C3 group. These rates differ from the literature, which reports a higher percentile of open fractures in the group with the most complex fractures, classified as AO 43C3.[2]

We detected no statistically significant difference when evaluating the presence of a fibula fracture and correlating it

AOFAS score for the ankle and hindfoot (total: 100 points)

Pain (40 points)
- None 0
- Mild, occasional 30
- Moderate, daily 20
- Severe, virtually always present 0

Function (50 points)
Activity limitations, requiring support
- No limitations, no support 10
- No daily activity limitation, recreational activity limitation, no support 7
- Limited daily and recreational activities, cane 4
- Severe limitation of daily and recreational activities, walker, crutches, wheelchair, orthoses (ankle bracer/immobilizer) 0

Maximum walking distance, blocks
- Over 6 5
- 4 to 6 4
- 1 to 3 2
- Less than 1 0

Walking surfaces
- No difficulty on any surface 5
- Some difficulty on uneven terrain, stairs, inclines, ladders 3
- Severe difficulty on uneven terrain, stairs, inclines, ladders 0

Gait abnormality
- None, slight 8
- Obvious 4
- Marked 0

Sagittal motion (flexion + extension)
- Normal or mild restriction (30° or more) 8
- Moderate restriction (15–29°) 4
- Severe restriction (lower than 15°) 0

Hindfoot motion (inversion + eversion)
- Normal or mild restriction (75–100% from normal) 6
- Moderate restriction (25–74% from normal) 3
- Marked restriction (lower than 25% from normal) 0

Ankle-hindfoot stability (anteroposterior, varusvalgus)
- Stable 8
- Unstable 0

Alignment (10 points)
- Good, plantigrade foot, ankle-hindfoot well aligned 10
- Fair, plantigrade foot, some degree of ankle-hindfoot malalignment, no symptoms 5
- Poor, nonplantigrade foot, severe malalignment, with symptoms 0

TOTAL SCORE : _____

Fig. 10 American Orthopedic Foot & Ankle Society's (AOFAS) score for the ankle and hindfoot (total: 100 points).

with high- and low-energy traumas. This lack of difference occurred because, in our study, all patients presented an associated distal fibula fracture, even those suffering low-energy traumas. Furthermore, the literature reports that ipsilateral talus and calcaneal fractures accompanying tibial pilon fractures are extremely rare. However, we had 2 patients with concomitant calcaneal fractures, which may negatively influence long-term outcomes.[9,10]

Regarding radiographic outcomes, it appears that studies evaluated them differently. Here, we concluded that among patients receiving a circular external fixator and with a definitive radiographic outcome, 62.5% presented fracture consolidation, 25 had malunion, and 12.5 presented nonunion. Among those undergoing internal fixation, 84% presented union, 8% had malunion, and 8% presented pseudarthrosis. The full assessment of the remaining subjects was not feasible, leading to their exclusion.

As for this series' general median, considering all 28 patients, the average AFAOS score was 55.7 points (circular external fixator group: 56.6; internal fixation: 54.6). This score is lower than the average of 65 points reported by Moura Junior et al.[2]

Conclusion

The present study retrospectively assessed 28 cases of tibial pilon fracture, including 15 patients undergoing surgical treatment with a circular external fixator and 13 with internal plate fixation (simple, cloverleaf type, with no locking mechanism). There was a wide range of variants directly influencing the characteristics of each fracture and its clinical-radiographic outcome.

Although there are many therapeutic alternatives for tibial pilon fractures, the internal fixation methods using unlocked plates and screws, as well as the circular external fixation method, remain the most available, mainly in hospitals within the public health system. Therefore, discussing these methods is critical and inevitable.

It is essential to highlight that the profile of fractures and patients in the circular external fixator and internal fixation groups tended to be quite heterogeneous. This occurs because the treatment of fractures with worst AO classifications and more frequent association with soft tissue injuries (resulting from open fractures or presenting significant edema or blistering) often employs circular external fixation. Meanwhile, management of less-severe fractures, with a lower incidence of soft tissue injuries, usually relies on open reduction and internal fixation. Clinical and radiographic outcomes tended to be similar between both groups, despite the particularities of each method.

We conclude that it is critical to perform an attentive, individualized, and detailed assessment. This will enable a more assertive therapeutic choice, leading to better functional outcomes for the particularities of each case and lower rates of socioeconomic impact for those with a tibial pilon fracture.

Financial Support
This authors declare that they did not receive financial support from agencies in the public, private, or non-profit sectors to conduct the present study.

Conflict of Interests
The authors have no conflict of interests to declare.

References

1 Netter FH. Atlas de Anatomia Humana. 7ª. ed. Rio de Janeiro: Elsevier; 2019

2 Moura Júnior AF, Machado Filho AA, Campos ET, Martins JS. Tibial pilon fractures: functional results and evaluation of quality of life. Sci J Foot Ankle 2018;12(01):42–48
3 Koval KJ, Zucherman JD. Fraturas: Manual para consulta rápida. 3ª. ed. Rio de Janeiro: Di Livros Editora Ltda; 2008
4 Pozzi I, Reginaldo S, de Almeida MV, Cristante AF. Manual de Trauma Ortopédico. São Paulo: Sociedade Brasileira de Ortopedia e Traumatologia; 2011
5 Marsh JL, Saltzaman CL. Fraturas do Tornozelo. In: Bucholz RW, Heckman JD, editors. Fraturas em adultos de Rockwood e Green. 5° ed. Barueri: Manole; 2006:2051–2078
6 Catagni MA, Carvalho Filho G. Tratamento da fratura tibial em pilão com fixador externo circular de Ilizarov. Rev Bras Ortop 1996;31(08):643–648
7 Matias VEG, Brito GV, Spósito AL, Zamboni C, Mercadante M, Christian RW. "Preliminary evaluation of a prospective randomized case series comparing plate and screws versus Ilizarov circular external fixator for distal tibial fractures" [Internet]. SciELO Preprints. 2023 [cited 2023 Nov. 9]. Available from: https://preprints.scielo.org/index.php/scielo/preprint/view/6785
8 Pimenta LSM, Costa ARF, Baptista MV, Daher SS. Fraturas do pilão tibial: avaliação do tratamento em 25 pacientes. Rev Bras Ortop 1997;32(07):497–502
9 Borges VQ, Moraes LVM, Ferraz GF, Stéfani KC. Fraturas de pilão tibial tipo AO 43C – o que influencia o resultado funcional? Sci J Foot Ankle 2018;12(03):233–239
10 Gobezie R, Ponce B, Vrahas M. Pilon fractures: Use of the posterolateral approach for ORIF. Oper Tech Orthop 2003;13(02):113–119

Doctor, Will My Surgical Hardware Set Off Metal Detector in the Airport?

Doutor, meus implantes irão ativar o detector de metais no aeroporto?

Igor Guedes Nogueira Reis[1] Beatriz Marinho Guimarães[1] Samuel Henrique Ferreira de Souza[1] Marco Antônio Percope de Andrade[2] Robinson Esteves Pires[2]

[1] Orthopedic Surgery Residency, Locomotor System Department, Hospital das Clínicas, Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil
[2] Locomotor System Department, Hospital das Clínicas, Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil

Address for correspondence Igor Guedes Nogueira Reis, Departamento do Aparelho Locomotor, Hospital das Clínicas, Universidade Federal de Minas Gerais. Endereço: Av. Prof. Alfredo Balena, 190–Santa Efigênia, Belo Horizonte, MG, 30130-100, Brazil (e-mail: dr.igorgnreis@gmail.com).

Rev Bras Ortop 2024;59(5):e672–e681.

Abstract

Objective Verify if routinely used metallic implants (stainless steel, aluminum alloy, cobalt-chromium-molybdenum, and titanium made) will be detected in an international airport of Brazil and generate helpful information to prevent patient inconvenience and to support the security regulatory agencies.

Methods An experimental, non-randomized, controlled, cross-over study was performed by recruiting two individuals, one male and one female, to pass through a standard airport metal detector with orthopedic implants attached to the body. Implants with different compositions, weight, and in various parts of the body were tested.

Results From all implants tested, there was no detection of implants for internal fixation, whether steel or titanium. The external fixator was detected and the only difference in composition is that the external fixator tested have aluminum alloy. All hip replacement implants tested were detected. Two knee replacement implants were tested, and both were made of cobalt-chromium-molybdenum, but with different specifications and only one of them was detected.

Conclusions In this study with ex-vivo orthopedic implants, we have found that osteosynthesis implants composed by Stainless Steel ISO 5832-1 did not trigger the airport walk-through metal detector. However, external fixator and total joint prostheses were more frequently detected.

Keywords
- airports
- internal fracture fixation
- metals
- patient education as topic
- prosthesis and implants

Work carried out at the Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil.

received
October 9, 2022
accepted after revision
December 2, 2022

DOI https://doi.org/10.1055/s-0043-1771493.
ISSN 0102-3616.

© 2023. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Resumo

Objetivo Verificar se implantes metálicos de uso rotineiro (aço inoxidável, liga de alumínio, cobalto-cromo-molibdênio e feitos de titânio) serão detectados em um aeroporto internacional do Brasil e gerar informações úteis para evitar transtornos ao paciente e apoiar os órgãos reguladores de segurança.

Métodos Estudo experimental, não randomizado, controlado e cruzado foi realizado recrutando dois indivíduos, um homem e uma mulher, para passar por um detector de metais padrão do aeroporto com implantes ortopédicos presos ao corpo. Foram testados implantes com diferentes composições, pesos e em várias partes do corpo.

Resultados De todos os implantes testados, não houve detecção de implantes para fixação interna, sejam de aço ou de titânio. O fixador externo foi detectado e a única diferença na composição é que o fixador externo testado é de liga de alumínio. Todos os implantes de artroplastia do quadril testados foram detectados. Dois implantes de artroplastia do joelho foram testados, e ambos eram feitos de cobalto-cromo-molibdênio, mas com especificações diferentes, e apenas um deles foi detectado.

Conclusões Neste estudo com implantes ortopédicos ex-vivo, verificamos que os implantes de osteossíntese compostos por aço inoxidável ISO 5832-1 não acionaram o arco detector de metais do aeroporto. No entanto, o fixador externo e as próteses articulares totais foram mais frequentemente detectadas.

Palavras-chave

- aeroportos
- educação de pacientes como assunto
- fixação interna de fraturas
- metais
- próteses e implantes

Introduction

An agreement on what are the recommendations for patients with implants in regard to air travel still lacks in current literature. However, due to the catastrophic incident of September 11th, 2001, data on this topic has arisen progressively.[1–4] This historical tragedy stimulated travel restrictions and sensitivity of airport metal detectors were increased, leading to inconvenience, such as thorough and prolonged body search reported by patients during national and international air travels.[5–9]

It is still a matter of controversy the factors that influence detection of some implants, but some hypothesis were generated by observational studies, surveys and experimental studies.[4] Metal composition, metal weight, amount of body mass, distance from metal to detector, and speed when crossing the detector are potential elements that can influence the metal detection. It is noteworthy that we did not find any study on this topic in the Brazilian literature, which confirms that the topic is worthy of investigation.

Therefore, we have performed this experimental study to foment the discussion in the Brazilian scientific community, investigate possible factors associated to orthopedic implant detection in airports and generate useful data for a better guidance to patients and to the air-security agencies.

Materials and Methods

Prior approval was obtained from the responsible research ethics committee in our institution (CAAE: 57064422.0.0000.5149) and from the airport security. Informed consent was obtained from participants. An experimental, non-randomized, controlled, cross-over study was carried out on August 12, 2022 at the Tancredo Neves International Airport in Belo Horizonte (MG), Brazil.

The airport walk-through metal detector (►**Fig. 1**) used was CEIA SMD600 PLUS (2021 model), device universally used in international airports. The experiment was performed in a device set for regular airport daily routine. Before starting, we made sure the device was working appropriately (►**Fig. 2**) by testing with metallic objects (belts and cellphones) and, at all times, the tests were performed under supervision of the responsible technician to ensure perfect functioning.

Two healthy volunteers, one male (172 cm in height) and one female (156 cm in height), who had no metal device in their body, were recruited. The volunteers walked in two different speeds each, one test at 2 km/hr and one at 6 km/hr. Initially, as a control, the volunteers walked across the metal detector without implants. Afterwards, we strapped orthopedic implants to the volunteers (►**Figs. 3** and **4**), using an adhesive tape, respecting as much as possible the true location of the implant in the body. All the tests were performed twice to ratify the results of the first pass.

Implants (►**Table 1**) used for fracture fixation and for joint replacement were assessed in different combinations (-unilateral/bilateral, left/right limbs or associated fractures) and always respecting the anatomic location (shoulder, arm, elbow, forearm, wrist, hip, thigh, knee, leg, and ankle). The implants for internal fixation were manufactured by Hexagon® (Itapira, SP, Brazil), Smith & Nephew (Memphis, TN, USA) and Tóride (Mogi Mirim, SP, Brazil), the external fixator by Baumer (Mogi Mirim, SP, Brazil), the hip prostheses by Baumer (Mogi Mirim, SP, Brazil) and Víncula (Rio Claro, SP,



Fig. 1 Airport walk-through metal detector (CEIA SMD600 PLUS, 2021 model).

Brazil), and the knee prostheses by Aesculap AG (Tuttlingen, Alemanha) and Baumer (Mogi Mirim, SP, Brazil).

Results

The results are presented in ►**Table 1**. From all osteosynthesis devices tested, the external fixator was the only one detected and its difference from the other devices was in its composition – it was made of aluminum alloy. All hip replacement implants tested were detected. Two knee replacement implants were tested, and both were made of cobalt-chromium-molybdenum, but with different specifications (►**Table 1**) and, only one of them was detected.

Discussion

Patients frequently ask about practical aspects of daily living and how certain types of surgery will affect their routine and for how long. Many of these questions still do not have a



Fig. 2 Control test to certify appropriate functioning of the arch detector using cellphone in the pocket.

definite answer based on scientific studies. An extremely common question is if retained orthopedic implants will trigger airport walk-through metal detectors. This has been a hot topic since September 11, 2001, when the World was shocked by airplanes terrorist attacks, after which airport security has increased to prevent such acts. The main concerns usually are the inconvenient of being body searched after triggering the metal detector, anxiety about being detained at the airport, and the possibility of delaying a travel or losing a flight. After 21 years of the terrorist attacks, to the best of our knowledge, there is still no official and universally accepted document that the patient can carry to prove the existence of an orthopedic metallic implant. Therefore, the standard procedure is further screening if an individual triggers a walk-through metal detector despite carrying a medical report issued by the orthopedic surgeon.[10] In Brazil, this is the first study to investigate orthopedic implant detection by airport walk-through metal detector. Additionally, all of the existing published researches were performed in arch detectors with more



Fig. 3 Total knee prosthesis strapped to the anterior surface of the right knee before testing.

than 5 years of manufacture, while in this study, a 2021 device, universally adopted in international airports, was used. It is noteworthy that this metal detector fully complies the current security level of the Tancredo Neves International Airport (Confins), under regulation of the ANAC (National Agency of Civil Aviation), and consequently of the International Civil Aviation Organization.

Our findings were completely unexpected, as none of the osteosynthesis sets were detected, except the external fixator device. No differences were observed between the two distinct transit speeds assessed. All tests were performed with implants on both right and left sides, to minimize the potential bias of the distance from the metal to the detector, and no differences were observed. All osteosynthesis sets tested were made of Stainless Steel NBR ISO 5832-1, titanium F-67 (distal radius plate) and titanium Ti-6Al-4V (Cephalomedullary femoral nail), except the external fixator which had aluminum alloy in its composition. The only Stainless Steel NBR ISO 5832-1 implant detected was the Thompson hip prosthesis, which suggests that implant mass concentration might increase detection. All other types of hip prosthesis tested also triggered the alarm. An interesting finding was the difference in detection between the two types of total knee prosthesis tested. Although both knee prostheses were made of cobalt-chromium-molybdenum, the detected one was manufactured in Brazil, while the other one in Germany. This difference among the knee prostheses tested raise a suspicion about the composition of the alloy, which could possibly have interfered on the arch detector triggering.

Considering all combinations of implants tested and presented in ►**Table 1**, our study corroborates with the findings of Chan et al.,[11] in which all patients with foot and ankle implants alone passed undetected. This study is consonant with several others of the literature, which state that total joint prostheses will be frequently detected, such as the hip prostheses in our study.[2,3,12] Kimura et al.[5] found that implant detection rate was higher during international flights, which might explain why all hip prostheses were detected in our study, since the device used was set for international standards, probably a more sensitive configuration.

Previous researches suggested some factors that might influence the probability of detection, such as implant mass, combinations, composition, location within the body, laterality, transit speed, detector model, sensitivity settings according to the security level of the airport, and tissue masking.[4,8,11] In our study, we were only capable to observe the probable interference of implant mass, density and material.

An interesting information about airport walk-through metal detectors is the fact that they record every individual that passes throw the arch even if there is no metal device in situ. This data is used in a randomizing internal software, which triggers a sound alarm to select a random passenger to be thoroughly body searched by the airport security. This sound alarm is different from the standard sound triggered when a metallic device is identified. This mechanism of selecting random passengers to be searched might be the reason why some patients with orthopedic implants report being body searched, which is a potential bias of previous research using retrospective information.[8]

The limitations of our study include the fact that none of the orthopedic implants were inside the volunteers tested and we still do not know if a bone-implant or soft tissues-implant interaction would affect detection. Previous researches tried to assess how the soft tissue envelope affect metal detection, however results were conflicting.[4,11] Another limitation is that we were not able to test all the available orthopedic implants. However, we judge that the most frequent situations were assessed. Our study also did not assess detection by portable wand metal detector, which is supposed to be more sensitive. Our findings were based on the current security level of the Confins International Airport. If, for some reason, the airport security level increases, the device's settings also change, and the detection sensitivity will improve. Although the tests were performed in a real environment of an international airport, following all the security requirements and under ANAC and ICAO rules, we cannot affirm that our findings will be faithfully reproducible if carried out at other airports, using a different detector device or a different security level.

However, some strengths deserve to be highlighted. This is the first study performed in Brazil aiming to clarify



Fig. 4 Bilateral retrograde femoral nail strapped to the lateral surface of the thighs before testing.

information regarding detection of orthopedic implants in an airport. We provided helpful information to patients, since the implants for internal fixation probably will not be detected in normal conditions. On the other hand, external fixators and prostheses will probably be detected. We also tried to minimize potential biases observed in similar studies. We tested different metal compositions in two healthy volunteers, under two different speeds to pass the detector arch, with implants attached in both sides (right and left) of the body, to minimize the bias of the distance from the detector to the implant.

Conclusions

In this study with ex-vivo orthopedic implants, we verified that osteosynthesis implants for internal fixation, composed by Stainless Steel ISO 5832-1 and titanium, were not detected by the airport walk-through metal detector and should not cause inconvenient to patients while travelling. However, external fixators and total joint prostheses will more frequently be detected.

It is important to highlight the limitations of our study and the need to further investigate this matter including in-vivo

Rev Bras Ortop Vol. 59 No. 5/2024 © 2023. The Author(s).

Table 1 Orthopedic implants sets and combinations tested

Implant	Male volunteer				Female volunteer				Alloy
	2 km/h		6 km/h		2 km/h		6 km/h		
	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	
Cellphone (control)	P	P	P	P	P	P	P	P	–
None (control)	N	N	N	N	N	N	N	N	–
Small fragment one-third tubular plate + 6 screws (unilateral)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Medial distal tibial locking compression plate + 6 screws (unilateral)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Medial and anterolateral distal tibial locking compression plate + 12 screws (unilateral)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Small fragment calcaneus plate + 6 screws (unilateral)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Intramedullary tibial nail + 4 locking screws (unilateral)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Intramedullary retrograde femoral nail + 3 locking screws (unilateral)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Intramedullary retrograde femoral nail + 3 locking screws (unilateral)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Bilateral intramedullary retrograde femoral nail + 6 locking screws + unilateral intramedullary tibial nail + 3 screws	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Cephalomedullary femoral nail + 1 sliding hip screw + 2 locking screws (unilateral)	N	N	N	N	N	N	N	N	Titanium Ti-6Al-4V (ASTM F1472)
Cephalomedullary femoral nail + 1 sliding hip screw + 2 locking screws (bilateral)	N	N	N	N	N	N	N	N	Titanium Ti-6Al-4V (ASTM F1472)
DCS with screws(unilateral)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
DHS with screws (unilateral)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Proximal humeral locking compression plate + 8 screws (unilateral)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Two 3.5 mm anchor screws on the shoulder (unilateral)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Intramedullary humeral nail + 3 locking screws (unilateral)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1

Table 1 (*Continued*)

Implant	Male volunteer				Female volunteer				Alloy
	2 km/h		6 km/h		2 km/h		6 km/h		
	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	
Clavicle locking compression plate + 6 screws (unilateral)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Clavicle locking compression plate + 6 screws (bilateral)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
12 holes DCP + 4 screws (unilateral humerus)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Two 3.5 mm cannulated screws + cerclage wire (1.0 mm) (unilateral knee)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Two 3.5 mm cannulated screws + cerclage wire (1.0 mm) (bilateral knee)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Two 7.0 mm cannulated screws + 1 cerclage wire (1.0 mm) (unilateral knee)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Two 7.0 mm cannulated screws + 1 cerclage wire (1.0 mm) (bilateral knee)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Distal radius locking compression plate + 11 screws (unilateral)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Distal radius locking compression plate + 11 screws (bilateral)	N	N	N	N	N	N	N	N	Stainless steel NBR ISO 5832-1
Distal radius locking compression plate + 11 screws (unilateral)	N	N	N	N	N	N	N	N	Titanium (ASTM F-67)
Distal radius locking compression plate + 11 screws (bilateral)	N	N	N	N	N	N	N	N	Titanium (ASTM F-67)
Cemented primary total knee prosthesis (unilateral)	P	P	P	P	P	P	P	P	Cobalt-chromium-molybdenum (ISO 5832-4)
Cemented primary total knee prosthesis (unilateral)	N	N	N	N	N	N	N	N	Cobalt-chromium-molybdenum (ISO 5832-4)
Thompson hip prosthesis (unilateral)	P	P	P	P	P	P	P	P	Stainless steel NBR ISO 5832-1

(*Continued*)

Rev Bras Ortop Vol. 59 No. 5/2024 © 2023. The Author(s).

Table 1 (*Continued*)

Implant	Male volunteer				Female volunteer				Alloy
	2 km/h		6 km/h		2 km/h		6 km/h		
	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	
Uncemented acetabulum + uncemented femoral stem (unilateral)	P	P	P	P	P	P	P	P	Titanium (ASTM F-67) (acetabulum) + Titanium Ti-6A-4V (ASTM F-136) and titanium porous coating (ASTM F-1580) (femoral component)
Uncemented acetabulum + cemented primary femoral stem (unilateral)	P	P	P	P	P	P	P	P	Titanium (ASTM F-67) (acetabulum) + Stainless steel (NBR ISO 5832-9/ ASTM F-1586)
External fixator (4 Schanz screws + 2 bars + 8 self-holding clamps)	P	P	P	P	P	P	P	P	Stainless steel (ISO 5832-1, ASTM F-138) and aluminum alloy

Abbreviations: ASTM, American Society for Testing and Materials; N, negative; NBR ISO, Norma Brasileira Regulamentadora - International Organization for Standardization; P, positive.

orthopedic implants and testing prostheses with different sizes, weights and materials.

Financial Support
The authors declare that this study did not receive any financial support from public funding, commercial or non-profit organization.

Conflict of Interests
IGNR declares no conflicts of interest. BMG declares no conflicts of interest. SHFZ declares no conflicts of interest. MAPA is speaker and lecturer of Zimmer-Biomet and AO Foundation. RESP is speaker and lecturer of Zimmer Biomet, Smith & Nephew and AO Foundation.

Acknowledgments
We would like to thank the Tancredo Neves International Airport of Belo Horizonte, the company BH Airport, the ANAC and all the security agencies of the airport, and specially to Mr. Wesley Dias Santos for the availability and for the help to perform the tests in the airport premises, providing all the technical information to this study possible. Additionally, we would like to thank AMGS Comércio e Representações Ltda and Mr. Ricardo Julião for providing the orthopedic implants and the technical information about the implants to be tested in this study and, Ms. Elen Rocha for helping to assemble the kits to be tested.

References

1 Dines JS, Elkousy H, Edwards TB, Gartsman GM, Dines DM. Effect of total shoulder replacements on airport security screening in the post-9/11 era. J Shoulder Elbow Surg 2007;16(04):434–437
2 Obremskey WT, Austin T, Crosby C, et al. Detection of orthopaedic implants by airport metal detectors. J Orthop Trauma 2007;21 (02):129–132
3 Ramirez MA, Rodriguez EK, Zurakowski D, Richardson LC. Detection of orthopaedic implants in vivo by enhanced-sensitivity, walk-through metal detectors. J Bone Joint Surg Am 2007;89 (04):742–746
4 Kuczmarski AS, Harris AP, Gil JA, Owens BD. Sensitivity of Airport Metal Detectors to Orthopaedic Implants. JBJS Rev 2018;6(07):e7
5 Kimura A, Jinno T, Tsukada S, Matsubara M, Koga H. Detection of total hip prostheses at airport security checkpoints. J Orthop Sci 2020;25(02):255–260
6 Issa K, Pierce TP, Gwam C, Festa A, Scillia AJ, Mont MA. Detection of total hip arthroplasties at airport security checkpoints - how do updated security measures affect patients? Hip Int 2018;28(02): 122–124
7 Issa K, Pierce TP, Gwam C, et al. Detection of Total Knee Arthroplasties at Airport Security Checkpoints: How Do Updated Security Measures Affect Patients? J Knee Surg 2017;30(06):532–534
8 Johnson AJ, Naziri Q, Hooper HA, Mont MA. Detection of total hip prostheses at airport security checkpoints: how has heightened security affected patients? J Bone Joint Surg Am 2012;94(07):e44
9 Abbassian A, Datla B, Brooks RA. Detection of orthopaedic implants by airport metal detectors. Ann R Coll Surg Engl 2007; 89(03):285–287
10 TSA. What are the procedures if I have an internal or external medical device, such as a pacemaker or metal implant? [accessed 13th September, 2022]. Available from: https://www.tsa.gov/travel/frequently-asked-questions/what-are-procedures-if-i-have-internal-or-external-medical-device
11 Chan JY, Mani SB, Williams PN, et al. Detection of In Vivo Foot and Ankle Implants by Walkthrough Metal Detectors. Foot Ankle Int 2014;35(08):789–795
12 Naziri Q, Johnson AJ, Hooper HA, Sana SH, Mont MA. Detection of total knee prostheses at airport security checkpoints. J Arthroplasty 2012;27(06):1228–1233

Ankle Sprains in Brazilian Professional Soccer: Epidemiological Analysis of 126,357 Match Hours

Entorses do tornozelo no futebol profissional brasileiro: Análise epidemiológica de 126.357 horas de jogo

Ewerton Borges de Souza Lima[1] Gabriel de Melo Salgado[2] Eduardo Patrício Mello[2]
Paulo Henrique Schmidt Lara[1] Gustavo Gonçalves Arliani[1] Moisés Cohen[2]

[1] Department of Orthopedics and Traumatology, Sports Traumatology Center, Escola Paulista de Medicina, Universidade Federal de São Paulo, São Paulo, SP, Brazil
[2] Department of Orthopedics and Traumatology, Escola Paulista de Medicina, Universidade Federal de São Paulo, São Paulo, SP, Brazil

Address for correspondence Ewerton Borges de Souza Lima, MD, Department of Orthopedics and Traumatology, Sports Traumatology Center, Escola Paulista de Medicina, Universidade Federal de São Paulo, R. Estado de Israel, 713 - Vila Clementino, 04022-00, 1São Paulo, SP, Brazil (e-mail: ewertonbslima@gmail.com).

Rev Bras Ortop 2024;59(5):e682–e688.

Abstract

Objective This study aimed to perform an epidemiological analysis of ankle sprains in professional soccer players in Brazil.

Methods This prospective epidemiological study analyzed ankle sprains in professional male soccer athletes during the Brazilian Championship and the Paulista Football Championship from 2016 to 2019. All on-pitch medical care provided in official matches was recorded. The variables evaluated included the age and position of the player, injury diagnosis, pitch site where the injury occurred, playing time, imaging tests performed, surgical treatment, time away from competitions, and injury recurrence. We assessed the incidence of injuries according to the *Federation Internationale de Football Association* (FIFA) incidence formula.

Results Ankle sprains represented 10.17% of total injuries, with a FIFA index equal to 2,002. Lateral ligament injuries represented 53.75% of all sprains. The forwards were the most injured athletes, with 86 lesions. The midfield had the highest number of sprains (75.50%). Almost half (47.04%) of sprains occurred in the final 15 minutes of each half-time. Injuries recurred in 31.22% of cases, and 7.11% of injuries underwent surgical treatment. The average time away from competitions was 13.95 days.

Conclusions Ankle sprains are common injuries in soccer. Although the average time to return to sport is brief, these injuries have a high recurrence rate and are potentially surgical, leading to a longer time off competitions.

Keywords
- ankle injuries
- epidemiology
- soccer
- sports
- sports medicine

Work carried out at the Sports Traumatology Center, Department of Orthopedics and Traumatology, Escola Paulista de Medicina, Universidade Federal de São Paulo, São Paulo, SP, Brazil.

received
May 30, 2023
accepted
September 25, 2023

DOI https://doi.org/10.1055/s-0044-1785660.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Resumo

Objetivo Realizar análise epidemiológica das entorses de tornozelo em jogadores profissionais de futebol no Brasil.

Métodos Estudo epidemiológico prospectivo das entorses de tornozelo em atletas profissionais de futebol masculino ocorridas no Campeonato Brasileiro e no Campeonato Paulista de Futebol, entre 2016 e 2019. Foram registrados todos os atendimentos médicos em campo realizados durante partidas oficiais. As variáveis avaliadas foram: idade e posição do jogador, diagnóstico da lesão, lateralidade, local em campo onde ocorreu a lesão, tempo de jogo, exames de imagem realizados, realização de tratamento cirúrgico, tempo de afastamento e recorrência da lesão. A incidência das lesões foi avaliada de acordo com a fórmula de incidência da *Federation Internationale de Football Association* (FIFA).

Resultados As entorses de tornozelo representaram 10,17% do total de lesões, com índice FIFA = 2.002. As lesões ligamentares laterais representaram 53,75% do total das entorses. Os atacantes foram os mais lesionados, com 86 lesões. O meio de campo foi o local com maior número de entorses (75,50%). Nos 15 minutos finais de cada tempo, ocorreram 47,04% das entorses. As lesões foram reincidentes em 31,22% dos casos, e 7,11% das lesões foram tratadas cirurgicamente. O tempo médio de afastamento foi de 13,95 dias.

Conclusões As entorses de tornozelo são lesões frequentes no futebol. Apesar do tempo médio para retorno ao esporte ser breve, essas lesões apresentam grande taxa de reincidência e são potencialmente cirúrgicas, o que está associado a maior tempo de afastamento.

Palavras-chave

- epidemiologia
- esportes
- futebol
- medicina do esporte
- traumatismos do tornozelo

Introduction

Football is the most popular sport in the world, with 240 million amateur athletes and around 200,000 professional ones.[1] Added to its popularity, it has a high rate of injuries. In recent years, the physical demands have increased, forcing athletes to work close to their maximum exhaustion limits, increasing the predisposition to injuries.

Several movements occur during a football match, requiring sudden changes in direction, on average, every 6 seconds.[2] In this scenario, the injury mechanisms favor the involvement of the lower limbs, especially the ankles. These lesions correspond to around 13% of injuries in football, only behind thigh and knee injuries.[3] In addition to the impact on the athlete's career, these injuries result in high costs for clubs due to treatment and rehabilitation. Understanding the epidemiology and incidence of ankle injuries can help clubs prepare their athletes in a targeted manner. Therefore, this study aimed to perform an epidemiological analysis of ankle sprains in professional football players in the main Brazilian championships from 2016 to 2019.

Materials and Methods

This prospective epidemiological study evaluated ankle sprains in professional male football athletes in two divisions of two men's football championships with significant social and economic relevance in Brazil, that is, the Brazilian Football Championship (CBF, for Campeonato Brasileiro de Futebol in Portuguese) and Paulista Football Championship (CPF, for Campeonato Paulista de Futebol), from 2016 to 2019. The Research Ethics Committee approved this study under registration CAAE 56723616.3.0000.5505. All participants included in the study signed the informed consent form.

All on-pitch medical care provided during official matches was recorded. Club doctors received training to fill out two forms on two online platforms, Transfermarkt (Transfermarkt GmbH & Co. KG, Hamburg, Germany) and SurveyMonkey (Momentive AI., San Mateo, CA, USA). The first form was filled out immediately after each match, and the second form was filled out after the athlete returned to the sport. The collection occurred throughout the championship, and we contacted the doctors monthly to remind them to fill out the forms.

All players with injuries resulting from ankle sprains were included in the study, regardless of age. The variables evaluated were age and position of the player, injury diagnosis, laterality, pitch site where the injury occurred, playing time, imaging tests performed, surgical treatment, time away from the competition, and injury recurrence. For this study, injury was defined as a musculoskeletal complaint occurring during a match that resulted in a player missing at least one match or training session. We assessed the incidence of injuries using the FIFA incidence formula = (total injuries x 1,000)/total hours played.

The descriptive statistical analysis of quantitative variables was performed in Excel 2016 (Microsoft Corporation, Redmond, WA, USA). We used the IBM SPSS Statistics for

Rev Bras Ortop Vol. 59 No. 5/2024 © 2024. The Author(s).

Table 1 Main characteristics, pitch site where the injuries occurred, and their relationships with the diagnoses and positions of the players

Diagnosis	n (%)	FIFA index	Recurrence	Surgery	Time away	Pitch site			
						Attack area	Attack midfield	Defense midfield	Defensive area
Simple sprain	73 (28.85%)	0.578	28 (11.07%)	0	6.78	19 (7.51%)	21 (8.30%)	22 (8.70%)	45 (17.79%)
Unimalleolar ankle fracture	8 (3.16%)	0.016	0	6 (2.37%)	105	3 (1.19%)	6 (2.37%)	3 (1.19%)	9 (3.56%)
Bimalleolar ankle fracture	2 (0.79%)	0.063	0	2 (0.79%)	89	0	2 (0.79%)	0	0
Lateral ligament lesion	136 (53.75%)	1.076	44 (17.39%)	5 (1.98%)	10.44	1 (0.40%)	0	0	1 (0.40%)
Medial ligament lesion	26 (10.28%)	0.206	6 (2.37%)	2 (0.79%)	16.27	0	0	1 (0.40%)	3 (1.19%)
Syndesmosis injury	8 (3.16%)	0.063	1 (0.40%)	3 (1.19%)	37.75	8 (3.16%)	7 (2.77%)	8 (3.16%)	15 (5.93%)
Position									
Striker	86 (33.99%)	0.680	23 (9.09%)	5 (1.98%)	10.92	23 (9.09%)	32 (12.65%)	30 (11.86%)	3 (1.19%)
Midfielder	44 (17.39%)	0.348	17 (6.72%)	4 (1.58%)	15.86	1 (0.40%)	16 (6.32%)	23 (9.09%)	4 (1.58%)
Defensive midfielder	33 (13.04%)	0.261	8 (3.16%)	2 (0.79%)	13.52	0	7 (2.77%)	25 (9.88%)	1 (0.40%)
Wing	50 (19.76%)	0.396	17 (6.72%)	4 (1.58%)	14.32	4 (1.58%)	4 (1.58%)	25 (9.88%)	17 (6.72%)
Defender	30 (11.85%)	0.237	9 (3.56%)	3 (1.19%)	22.50	1 (0.40%)	10 (3.95%)	15 (5.93%)	4 (1.58%)
Goalkeeper	10 (3.95%)	0.079	5 (1.98%)	0 (0%)	5.6	0	1 (0.40%)	3 (1.19%)	6 (2.37%)

Note: Percentages referred to the total number of ankle injuries assessed. The average age is given in years. The average time away from competition is given in days.

Windows Version 20.0 software (IBM Corp., Armonk, NY, USA) for the statistical inference of continuous variables. Qualitative variables were analyzed using the chi-square test, and the analysis of variance (ANOVA) test was used for multivariate analysis, defining a 95% confidence interval and a 5% significance ($p < 0.05$). The Shapiro-Wilk test determined the normality of the sample.

The study took place during 4 CBF seasons, with the participation of 20 clubs per year in each division. Each club played 38 matches per season. In the same period, there were 4 CPF seasons, with the participation of 16 to 20 clubs per year in each division. Each club played 17 to 22 matches per season. In total, we analyzed 15 seasons from 2016 to 2019 (there was no record from the CBF second division in 2019), totaling 3,828 matches and 126,357 match hours.

Results

During the study, there were 7,899 on-pitch care visits, of which 2,486 resulted in the diagnosis of injuries. Of these, 253 ankle sprains were recorded (10.17% of total injuries) with a FIFA index equal to 2,002. Over the years, the total number of injuries progressively dropped from 86 in 2016 to 38 in 2019.

Diagnoses, Age, and Supplementary Tests

We identified six different diagnoses of ankle sprain injuries during the championships. The most common injuries were lateral ligament lesions (LLLs), which represented 53.75% of total sprains, followed by simple sprains (sprains with no diagnosis of ligament injury, fractures, or other associated injuries), accounting for 28.85% of cases. Other diagnoses include medial ligament lesions (MLLs), unimalleolar fractures, bimalleolar fractures, and syndesmosis injuries (►**Table 1**).

The average age of the injured players was 25.94 years old. Different injuries had a similar distribution between age groups. Imaging exams were requested in 94.07% of the lesions, totaling 391 exams performed (►**Table 2**).

Player Position, Pitch Site, and Time of Injury

The position with the highest number of injuries was striker, followed by wings. The positions with the lowest number of ankle injuries were goalkeepers and defenders (►**Table 1**). Regarding the total number of injured players from the same position, ankle sprains were more prevalent in midfielders (►**Table 3**).

The midfield had the highest number of sprains (75.50%). Only 13.04% of injuries occurred in the defense area, and 11.46% in the attack area (►**Table 1**). The player's position was statistically associated with the place on the pitch where the injury occurred ($p < 0.001$), with the defensive midfield being the most common place for sprains for all positions, except for strikers (who presented more sprains in the attack area) and goalkeepers (who presented more sprains in the defensive area). The end of each half-time had the highest number of injuries, and 47.04% of lesions occurred between 31 and 45 minutes and 75 and 90 minutes (►**Table 4**).

Table 2 Imaging tests requested for each injury diagnosis

Diagnosis	None	MRI	X-ray	X-ray + MRI	X-ray + MRI + CT	Total
Simple sprain	15	9	48	1	0	73
Unimalleolar ankle fracture	0	0	2	0	0	2
Bimalleolar ankle fracture	0	0	8	0	0	8
Lateral ligament lesion	0	8	0	127	1	136
Medial ligament lesion	0	4	0	22	0	26
Syndesmosis injury	0	3	4	1	0	8
Total	15	24	62	151	1	253

Abbreviations: MRI, magnetic resonance imaging; X-ray, radiography; CT, computed tomography.

Table 3 Position of players with ankle injuries

Diagnosis	Position					
	Striker	Midfielder	Defensive midfielder	Wing	Defender	Goalkeeper
Simple sprain	25 (9.88%)	12 (4.74%)	6 (2.37%)	16 (6.32%)	8 (3.16%)	6 (2.37%)
Bimalleolar ankle fracture	0	1 (0.40%)	6 (5.61%)	0	1 (0.40%)	0
Unimalleolar ankle fracture	2 (0.79%)	1 (0.40%)	0	3 (1.19%)	1 (0.40%)	0
Lateral ligament lesion	46 (18.18%)	21 (8.30%)	0	26 (10.28%)	16 (6.32%)	3 (1.19%)
Medial ligament lesion	11 (4.35%)	3 (1.19%)	0	3 (1.19%)	4 (1.58%)	1 (0.40%)
Syndesmosis injury	2 (0.79%)	1 (0.40%)	5 (1.98%)	2 (0.79%)	0	0

Table 4 Relationship between match time at injury occurrence and player position. Min, Minutes.

Position	Match time							
	0–15 min	16–30 min	31–45 min	1st extra time	46–60 min	61–75 min	76–90 min	2nd extra time
Striker	4 (1.58%)	14 (5.53%)	20 (7.91%)	10 (3.95%)	4 (1.58%)	10 (3.95%)	22 (8.70%)	2 (0.79%)
Midfielder	6 (2.37%)	8 (3.16%)	9 (3.56%)	1 (0.40%)	3 (1.19%)	6 (2.37%)	9 (3.56%)	0
Defensive midfielder	2 (0.79%)	5 (1.98%)	6 (2.37%)	0	6 (2.37%)	1 (0.40%)	12 (4.74%)	0
Wing	5 (1.98%)	6 (2.37%)	16 (6.32%)	5 (1.98%)	4 (1.58%)	4 (1.58%)	9 (3.56%)	1 (0.40%)
Defended	4 (1.58%)	2 (0.79%)	5 (1.98%)	3 (1.19%)	3 (1.19%)	8 (3.16%)	5 (1.98%)	0
Goalkeeper	1 (0.40%)	1 (0.40%)	1 (0.40%)	1 (0.40%)	1 (0.40%)	0	5 (1.98%)	0
Total	22 (8.70%)	36 (14.23%)	57 (22.53%)	20 (7.91%)	21 (8.30%)	25 (9.88%	62 (24.51%)	3 (1.19%

Table 5 Severity of ankle injuries

Diagnosis	Severity				
	Mild	Minor	Moderate	Major	Severe
Simple sprain	38 (15.02%)	15 (5.93%)	20 (7.91%)	0	0
Bimalleolar ankle fracture	0	0	0	0	2 (0.79%)
Unimalleolar ankle fracture	0	1 (0.40%)	0	1 (0.40%)	6 (2.37%)
Lateral ligament lesion	32 (12.65%)	44 (17.39%)	55 (21.74%)	4 (1.58)	1 (0.40%)
Medial ligament lesion	4 (1.58%)	10 (3.95%)	0	1 (0.40%)	1 (0.40%)
Syndesmosis injury	0	0	3 (1.19%)	4 (1.58%)	1 (0.40%)
Total	74 (29.25%)	70 (27.67%)	78 (30.83%)	10 (3.95%)	11 (4.35%)

Recurrence, Surgery, and Time Away from Competitions

Injuries recurred in 31.22% of cases. Simple sprains (38.36%) and LLLs (32.35%) had the highest recurrence rates, while fractures did not recur (►**Table 1**).

Injuries underwent surgical treatment in 7.11% of cases. Unimalleolar ankle fractures represented 33.33% of surgeries. No simple ankle sprain received surgical treatment, and only 3.68% of LLLs and 7.69% of LLMs required surgery. Recurrent injuries were treated surgically in 12.65% of cases, in contrast to 80% of non-recurrent injuries (►**Table 1**).

Injuries were classified per severity according to the athlete's absence time, as follows: mild (< 3 days), minor (3–7 days), moderate (8–28 days), major (4–8 weeks), and severe (> 8 weeks) injuries. The average time off competition was 13.95 days, with severe and major injuries accounting for 4.34% and 3.56% of total injuries, respectively (►**Table 5**).

Discussion

The main findings of the present study were the high incidence of ankle sprains over 4 years. Furthermore, sprains mainly affected strikers and midfielders, with higher occurrence in midfield and the final 15 minutes of each half-time. The recurrence rate was high (31.22%), and the average time away from competitions was around 2 weeks.

Ekstrand et al.[4] stated that ankle sprains accounted for 17 to 21% of all sports injuries, showing their great representation. Our study identified a FIFA index of 2.00 for ankle sprains, a value higher than upper limb injuries (FIFA index = 1.34)[5] and ruptures of the anterior cruciate ligament (FIFA index = 0.41),[6] but lower than muscle injuries (FIFA index = 7.66).[7]

A German study with Bundesliga (the German professional football league) athletes observed 280 episodes of ankle sprains (5.17% of total injuries) from the 2008 to 2014 seasons. This study reported a rate of 46.66 injuries per year, which represents a difference of 35.55% concerning our study.[3] Árnason et al.[8] evaluated 10 elite Icelandic football clubs, and 82% of the injuries occurred in the lower limbs.

Dauty et al.[9] found no difference in the incidence of injuries during the 15 seasons analyzed between 1995 and 2010, contrasting with our results. There is no reported reason for the lower number of injuries in our study. However, over the years, the quality of prematch physical preparation, physical therapy, pitch quality, and injury prevention treatments significantly improved in Brazilian football, potentially contributing to a reduction in injuries.[2,10]

Evaluating the distribution of injuries by month, Kofotolis et al.[11] observed that 47.48% of ankle sprains happened in August and September. Morgan and Oberlander[12] observed that 24% of lesions occurred in the first third of the season, 25% in the second third, and 29% in the last third of the season, which also conflicts with our data.

For Nery et al.,[13] medial and lateral ligament injuries represented 66.8% of the total number of ankle injuries during the 2 seasons evaluated. Compared with our study, 63.93% of all ankle injuries were medial and lateral complex lesions, consistent with the statement that medial and lateral complex injuries are common in ankle sprains.

Árnason et al.[8] noted that 29% of injuries resulted from muscle lesions, 22% from ligament lesions, and 20% from direct blunt trauma. Most ankle injuries presented lateral ankle complex lesions.

In a systematic review of all ankle injuries in football, 76.8% were ankle sprains, which is the most common cause of ankle injuries, consistent with our study.[4] Nery et al.[13] indicated that the most common mechanism of trauma in professional football athletes was direct player-to-player trauma (32%), with excessive use (intense joint mobility at the extreme of the range of motion) associated with 26% of the causes of ankle injuries. Kofotolis et al.[11] also stated that most ankle injuries occurred through direct contact with another athlete, with a 63.3% rate, while 36.7% of lesions did not result from contact. At the 2014 World Cup, 64.4% of athletes' injuries were due to contact.[14]

Striker was the athlete's position on the pitch with most ankle sprains. However, considering midfielders and defensive midfielders together, the rate of simple sprains is higher (7.11%). Cohen et al.[2] compared athletes' total body injuries and observed that the midfield position had the highest number of injuries Leventer et al.[15] and Morgan and Oberlander[12] showed that midfielders had 37.6% of total body injuries in the Major League of Soccer (MLS).

Dauty et al.[9] found no difference in the number of any injury type regarding pitch positions; however, there was a slight tendency towards defenders. Kofotolis et al. observed more injuries in defenders and wings (42.4%) compared to midfielders (32.3%) and strikers (20.8%).[11]

Kofotolis et al.[11] analyzed that 61.1% of ankle injuries occurred in the final 15 minutes of both half-times, agreeing with our data. Hawkins et al.[16] observed this same pattern.

In the present study, 31.22% of injuries were recurrent. Árnason et al.[8] observed that 35% of injuries were recurrent, with 8% occurring less than 1 month after the previous lesion. Kofotolis et al. found that 60.5% of athletes had recurrent injuries.[11] Football players with a history of previous ankle sprains are 4.9 times more likely to have a recurrent lesion.[13]

Cohen et al.[2] evaluated episodes of sprain, with 5.2% ($n = 9$) of the cases progressing to some surgical procedure from a total of 173 cases. According to Nery et al.,[13] 20% of athletes with acute ankle sprains will develop mechanical or functional ankle instability, resulting in chronic ankle instability and requiring surgical treatment.

Kofotolis et al.[11] also evaluated the time away from competitions. These authors noted that simple sprains represented the most common injury with less than seven missed sessions. Injury to the anterior tibiotalar ligament resulted in the highest absence rate and 58.7% of total time lost due to lesion.

Morgan and Oberlander[12] classified the severity of the injury into three categories. Of the 256 injuries found, 60% were mild, 26% were moderate, and 14% were severe. Árnason et al.[8] classified injuries into 4 categories according to the time away from competition, and most athletes returned to the sport in less than 2 weeks. Cohen et al.[2] observed that sprains resulted in absence for less than 7 days in 49.7% of cases, from 7 to 30 days in 45%, and over 30 days in 5.2% of cases. All these latter injuries underwent surgical treatment.

The main limitation of this study is the potential data collection bias inherent to epidemiological studies since club doctors were responsible for filling in the data on the platform. During this period, there were some changes of doctors in clubs. To reduce data collection bias, all doctors received training to complete the survey. We were aware of all club doctors' replacements and trained the new doctors. Another limitation is the lack of consensus on the definition of injury in the literature, hindering the comparison of our results with those of other studies. Furthermore, we did not collect data from injuries occurring during training sessions. Lastly, the failure to evaluate the pitch quality and their relationship with sprains was another limitation of the study. Despite these limitations, this is an extensive prospective study lasting 4 years and with a large sample of athletes and injuries which collected unprecedented data from two major professional football championships in Brazil.

Conclusion

Ankle sprains are common injuries in football. Although the average time to return to sport is brief, these injuries have a high recurrence rate and are potentially surgical, leading to a longer time away from competitions. The most common injuries were LLLs and simple sprains. The most affected positions were striker and midfielder, with higher occurrence in the midfield and the final 15 minutes of each half-time.

Authors' Contribution

All authors contributed to the conception and design of the study. EBSL and PHSL prepared the material preparation, collected data, and performed the analysis. GGA and MC coordinated the research. EBSL, GMS, and EPM wrote the first version of the manuscript. All authors participated in writing the final manuscript and approved it for submission.

Financial Support

The authors declare that they did not receive any financial support from public, commercial, or not-for-profit sources.

Conflict of Interests

The authors have no conflict of interests to declare.

Acknowledgments

We thank all club doctors for their contributions to data collection and the Brazilian Football Confederation (CBF) and the Paulista Football Federation (FPF) for supporting this research.

References

1 Junge A, Rösch D, Peterson L, Graf-Baumann T, Dvorak J. Prevention of soccer injuries: a prospective intervention study in youth amateur players. Am J Sports Med 2002;30(05):652–659
2 Cohen M, Abdalla RJ, Ejnisman B, Amaro JT. Lesões ortopédicas no futebol. Rev Bras Ortop 1997;32(12):940–944
3 Aus der Fünten K, Tröß T, Hadji A, Beaudouin F, Steendahl IB, Meyer T. Epidemiology of Football Injuries of the German Bundesliga: A Media-Based, Prospective Analysis over 7 Consecutive Seasons. Sports Med Open 2023;9(01):20
4 Ekstrand J, Tropp H. The incidence of ankle sprains in soccer. Foot Ankle 1990;11(01):41–44
5 de Souza Lima EB, de Godoy GP, Osés GL, et al. Epidemiology of Upper Limb Injuries in two major Brazilian Soccer Championships from 2016 to 2019. J Exp Orthop 2022;9(01):120
6 Nitta CT, Baldan AR, Costa LPB, Cohen M, Pagura JR, Arliani GG. Epidemiology of anterior cruciate ligament injury in soccer players in the Brazilian Championship. Acta Ortop Bras 2021;29(01): 45–48
7 Arliani GG, Lara PHS, Margato GF, Cristiano D, Cohen M, Pagura JR. Prospective study of injuries occurred during Brazilian Football Championship in 2019. Acta Ortop Bras 2021;29(04): 207–210
8 Arnason A, Gudmundsson A, Dahl HA, Jóhannsson E. Soccer injuries in Iceland. Scand J Med Sci Sports 1996;6(01):40–45
9 Dauty M, Collon S. Incidence of injuries in French professional soccer players. Int J Sports Med 2011;32(12):965–969
10 Sadigursky D, Braid JA, De Lira DNL, Machado BAB, Carneiro RJF, Colavolpe PO. The FIFA 11+ injury prevention program for soccer players: a systematic review. BMC Sports Sci Med Rehabil 2017; 9:18
11 Kofotolis ND, Kellis E, Vlachopoulos SP. Ankle sprain injuries and risk factors in amateur soccer players during a 2-year period. Am J Sports Med 2007;35(03):458–466
12 Morgan BE, Oberlander MA. An examination of injuries in major league soccer. The inaugural season. Am J Sports Med 2001;29 (04):426–430
13 Nery C, Raduan F, Baumfeld D. Foot and ankle injuries in professional soccer players: diagnosis, treatment, and expectations. Foot Ankle Clin 2016;21(02):391–403
14 Junge A, Dvořák J. Football injuries during the 2014 FIFA World Cup. Br J Sports Med 2015;49(09):599–602
15 Leventer L, Eek F, Hofstetter S, Lames M. Injury patterns among elite football players: A media-based analysis over 6 seasons with emphasis on playing position. Int J Sports Med 2016;37(11): 898–908
16 Hawkins RD, Hulse MA, Wilkinson C, Hodson A, Gibson M. The association football medical research programme: an audit of injuries in professional football. Br J Sports Med 2001;35(01): 43–47

Convolutional Neural Networks in the Diagnosis of Cervical Myelopathy

Redes neurais convolucionais no diagnóstico de mielopatia cervical

Murat Korkmaz[1] Hakan Yılmaz[2] Merve Damla Korkmaz[3] Turgut Akgül[1]

[1] Department of Orthopedics and Traumatology, Istanbul Faculty of Medicine, Istanbul University, Istanbul, Turkey
[2] Department of Medical Engineering, Faculty of Engineering, Karabuk University, Karabuk, Turkey
[3] Department of Physical Medicine and Rehabilitation, Istanbul Kanuni Sultan Suleyman Training and Research Hospital, University of Health Sciences, Istanbul, Turkey

Address for correspondence Merve Damla Korkmaz, MD, Associate Professor, Department of Physical Medicine and Rehabilitation, Istanbul Kanuni Sultan Suleyman Training and Research Hospital, University of Health Sciences, Atakent mh. Turgut Özal Blv. No: 46/1, 34303, Kucukcekmece, Istanbul, Turkey (e-mail: mervedml@gmail.com).

Rev Bras Ortop 2024;59(5):e689–e695.

Abstract

Objective Artificial intelligence technologies have been used increasingly in spine surgery as a diagnostic tool. The aim of the present study was to evaluate the effectiveness of the convolutional neural networks in the diagnosis of cervical myelopathy (CM) compared with conventional cervical magnetic resonance imaging (MRI).

Methods This was a cross-sectional descriptive analytical study. A total of 125 participants with clinical and radiological diagnosis of CM were included in the study. Sagittal and axial MRI images in the T2 sequence of the cervical spine were used. All image parts were obtained as 8 bytes/pixel in 2 different categories, CM and normal, both in axial and sagittal views.

Results Triple cross validation was performed to prevent overfitting during the training process. A total of 242 sample images were used for training and testing the model created for axial views. In the axial view, the calculated values are 97.44% for sensitivity and 97.56% for specificity. A total of 249 sample images were used for training and testing the model created for sagittal views. The calculated values are 97.50% for sensitivity and 97.67% for specificity. After the training, the average accuracy value was 96.7% (±1.53) for the axial view and 97.19% (±1.2) for the sagittal view.

Keywords
- artificial neural networks
- cervical vertebrae
- deep learning
- magnetic resonance imaging
- myelopathy

Work carried out at the Department of Physical Medicine and Rehabilitation, University of Health Sciences, Istanbul Kanuni Sultan Suleyman Training and Research Hospital, Istanbul, Turkey.

received
March 8, 2023
accepted
May 5, 2023

DOI https://doi.org/10.1055/s-0044-1779317.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Conclusion Deep learning (DL) has shown a great improvement especially in spine surgery. We found that DL technology works with a higher accuracy than other studies in the literature for the diagnosis of CM.

Resumo

Objetivo As tecnologias de inteligência artificial são cada vez mais utilizadas em cirurgias de coluna como ferramentas diagnósticas. O objetivo do presente estudo foi avaliar a eficácia das redes neurais convolucionais no diagnóstico da mielopatia cervical (MC) em comparação à ressonância magnética (RM) cervical convencional.

Métodos O presente estudo foi transversal, descritivo e analítico. Cento e vinte e cinco participantes com diagnóstico clínico e radiológico de MC foram incluídos no estudo. Foram utilizadas imagens de RM sagital e axial em sequência ponderada em T2 da coluna cervical. Todas as imagens foram obtidas em 8 bits/pixel em duas categorias diferentes (MC e normal), tanto em vistas axiais quanto sagitais.

Resultados A validação transversal tripla evitou o sobreajuste (*overfitting*) durante o processo de treinamento. Duzentas e quarenta e duas imagens foram utilizadas para treinamento e teste do modelo criado para vistas axiais, que apresentou 97,44% de sensibilidade e 97,56% de especificidade. Duzentas e quarenta e nove imagens foram utilizadas para treinamento e teste do modelo criado para vistas sagitais, que apresentou 97,50% de sensibilidade e 97,67% de especificidade. Após o treinamento, a acurácia média foi de 96,7% (±1,53) para a vista axial e de 97,19% (±1,2) para a vista sagital.

Conclusão O *deep learning* (DL) apresentou grande melhora, especialmente na cirurgia de coluna. Observamos que a tecnologia de DL trabalha com maior acurácia do que em outros estudos na literatura para diagnóstico de MC.

Palavras-chave
- aprendizado profundo
- imagem por ressonância magnética
- mielopatia
- redes neurais artificiais
- vértebras cervicais

Introduction

Cervical myelopathy (CM) is a common degenerative disease of the cervical spine caused by spinal cord compression.[1] The decrease in the volume of the spinal canal is usually due to disc degeneration, osteophytes or ossified posterior longitudinal ligament results with ischemic changes. The clinical findings of the CM vary with the severity and location of the spinal cord compression.[2] Patients generally present with numbness and pain in the extremities and neurological symptoms such as loss of coordination and balance. The clinical and radiological modalities of the patient should be evaluated together in the evaluation of this disease and in determining the treatment options.[3]

The imaging procedures for CM are plain radiography, magnetic resonance imaging (MRI) and computed tomography (CT). Magnetic resonance imaging in CM is more valuable in evaluating the spinal cord, disc and other soft tissues compared with other imaging methods.[4,5] As a result of advances in MRI technology such as MR spectroscopy and diffusion tensor imaging, resolution and image quality have greatly improved. In parallel with these developments, new imaging methods are being developed with many studies in the diagnosis of CM.[6]

Convolutional neural networks (CNNs), a machine learning (ML) technique, are increasingly used in various industrial and research fields.[7] Deep learning (DL) is a multilayered neural network in which feature extraction is done automatically. It extends traditional neural networks by adding more hidden layers to the network architecture between the input and output layers to model more complex and nonlinear relationships.

Machine learning technologies are also used in many health applications such as medical image analysis, biological signal analysis, prediction of medical events, computer-aided detection and diagnosis, aiding in treatment selection, and analysis of health records for recent years.[8]

Machine learning technology has been used increasingly in spine surgery as well as in many medical fields. However, it is noticed that most of the studies about this subject in the literature have been conducted except of the cervical spine.[9] In the present study, we aimed to demonstrate the effectiveness of the CNN in the diagnosis of CM compared with conventional cervical MRI.

Materials and Methods

Participants and MRI Samples

Participants aged between 18 and 75 years old diagnosed as CM were included in the study. All images were obtained with a 3.0 Tesla Siemens MR scanner (Siemens, Erlangen, Germany) with a standard cervical collar. Radiological

images of the cervical spine were evaluated by three investigators experienced with a minimum experience of 5 years in spinal surgery. Axial and sagittal MRI images of the cervical spine were used. Magnetic resonance imaging scans in Digital Imaging and Communications in Medicine (DICOM) format (8 bits/pixel) have been converted to one of the raster formats (png). Thereafter, the 'region of interest' selection was made, and the regions were labeled as CM and normal, both in axial and sagittal views (►**Fig. 1**).

The inclusion criteria for the study were the participants with classical CM symptoms such as weakness and clumsiness at the upper extremities, hyperreflexia, and/or gait difficulties; radiological findings of spinal compression; scores on the modified Japanese Orthopedic Association scale (mJOA) < 18. Participants with a previous history of cervical spinal surgery and those with a systematic disease (rheumatologic or neural disease) were excluded from the study. The present study was approved by the local ethical committee (KAEK/2020.07.129) and registered at Clinicaltrials.gov (NCT04796987).

Calculation Environment

A computer with 8 GB memory and Intel i7 processor was used to perform the calculations and train the DL model. Deep learning models were developed using the Python programming language. To assess the model performance, mean and median cross-validated accuracies, sensitivity, specificity, positive, and negative predictive value were used.

Neural Network Design

Significant developments in ML and image processing techniques enable medical images to be evaluated more accurately using DL methods.[7] The term "deep learning" has been used for many years in the classification of medical images. Convolutional neural network, one of the popular DL methods, was used to classify images in the present study. A simple CNN architecture consists of convolutional layer (Conv), pooling layer (for example, Max-pooling), nonlinear layer (for example, ReLU, TanH) and a loss function (for example, Sigmoid, Softmax) on the last fully connected (FC). Output can be of a

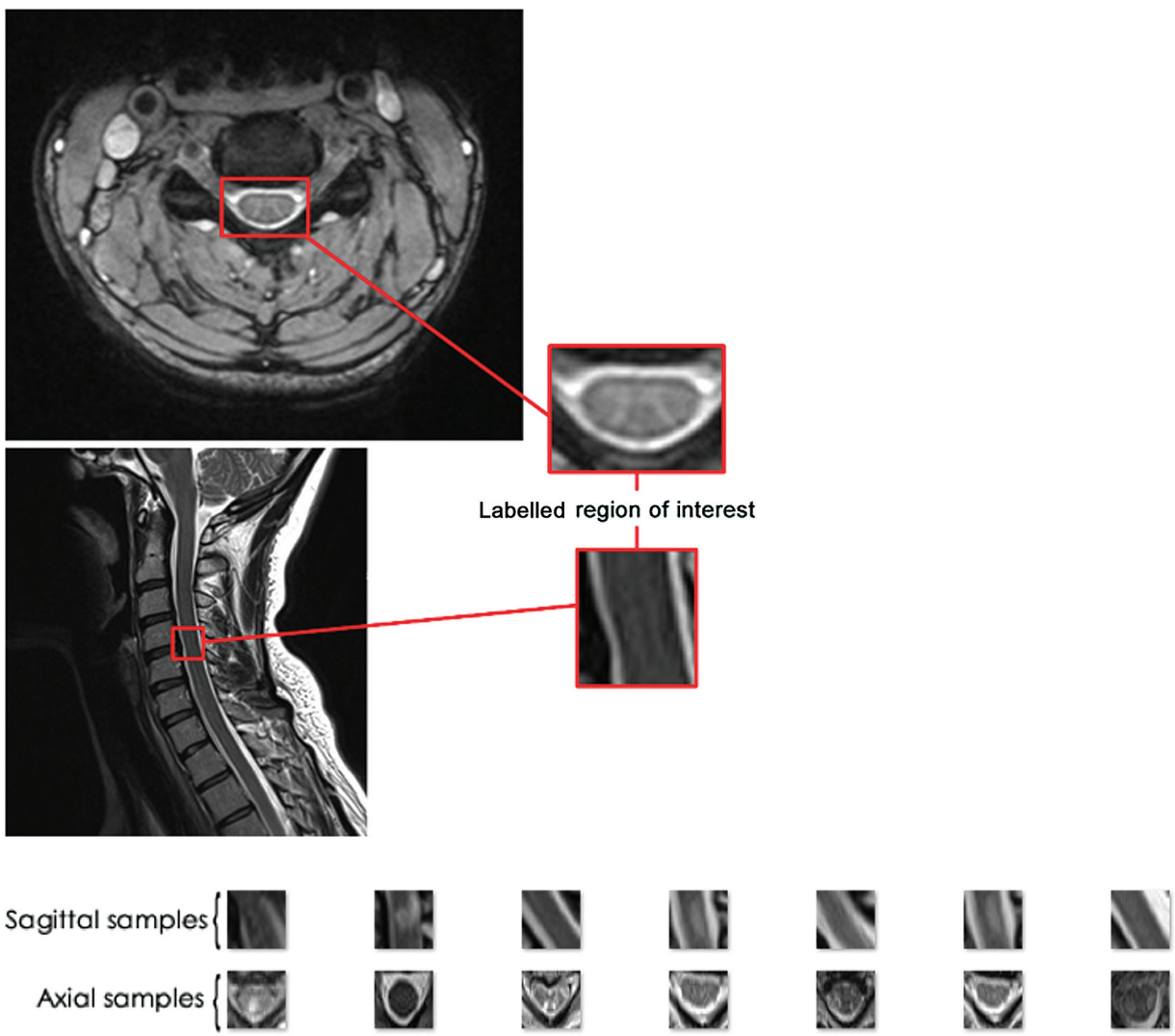


Fig. 1 Labeled region of interest of the axial and sagittal MRI section (top) and samples of input images (bottom).

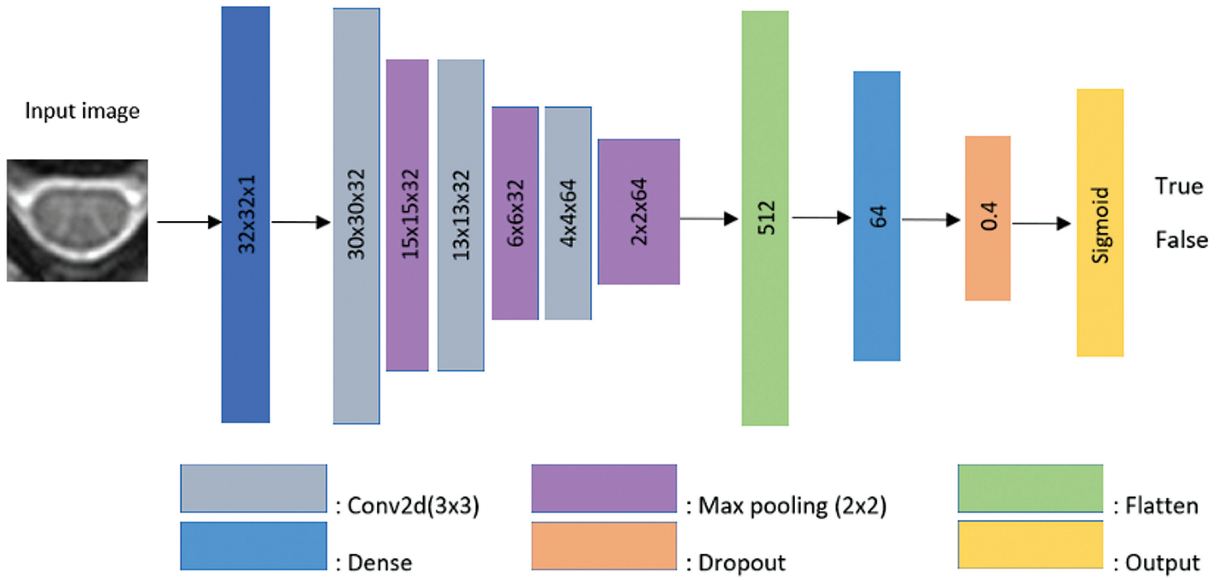


Fig. 2 The CNN architecture used in the study.

single class; however, it can also have multiple outputs.[10] The CNN architecture used in the study is presented in ►**Fig. 2**.

Results

A total of 125 participants (58 female and 67 male) with a mean age of 56.32 ± 6.77 years old who were diagnosed as CM were included in the study. The mean mJOA scores of the participants was 12.01 ± 2.46. Demographic characteristics of the participants are shown in ►**Table 1**. Normal and myelomalasic MRI layers of the participants were analyzed.

Table 1 Demographic and clinical characteristics of the participants

Variable	Participants ($n = 125$)
Age (in years) (mean ± SD)	56.32 ± 6.77
Gender (female/male) n (%)	58 (46.4%)/67 (53.6%)
Height (cm) (mean ± SD)	164.5 ± 8.52
Weight (kg) (mean ± SD)	74.96 ± 8.48
mJOA score	12.01 ± 2.46

Training Information

In the created network design, sample images taken in both axial and sagittal view were subjected to training. Thus, two different DL trainings were performed for both views; 67% of the images were used for training, and 33% for validation and testing. Triple cross validation was used to test the consistency of the results.

The models obtained for both views consist of 300 epochs. Triple cross validation was performed to prevent overfitting during the training process. After training, the average accuracy value was 96.7% (±1.53) for the axial view and 97.19% (±1.2) for the sagittal view. The graphs of the DL training process are shown in ►**Fig. 3**.

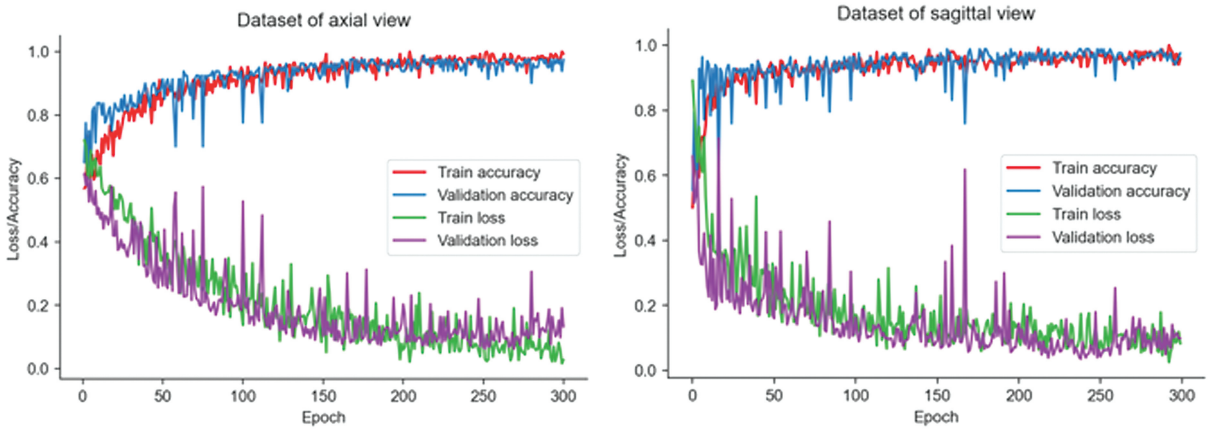


Fig. 3 Training information of the sagittal and axial view of the MRI.

Table 2 Details of the sagittal and axial images used for evaluation

Total population		Human (true condition)	
		Condition positive	*Condition negative*
Developed model (predicted condition) for sagittal images	*Predicted condition positive*	True positive = 39	False positive = 1 (type-I error)
	Predicted condition negative	False negative = 1 (type-II error)	True negative = 42
Developed model (predicted condition) for axial images	*Predicted condition positive*	True positive = 38	False positive = 1 (type-I error)
	Predicted condition negative	False negative = 1 (type-II error)	True negative = 40

Abbreviations: cm, centimeters; kg, kilogram; mJOA, modified Japanese Orthopedic Association scale; SD, standard deviation.

Evaluation Metrics of Training

Axial View

A total of 242 sample images were used for training and testing the model created for axial views. Of these images, 120 were labeled as CM, and 122 were labeled as normal. A total of 162 of these images were used for the training of the DL model, and 80 for the evaluation of the training. The true positive, true negative, false positive, and false negative values obtained from the evaluation of the training are shown in ►**Table 2**. The confusion matrix accuracy values formed by these values are shown in ►**Fig. 4**. After the evaluation, the overall accuracy value of the model was calculated as 97.50%.

The calculated values are 97.44% for true-positive rate (TPR, recall, sensitivity), 97.56% for true-negative rate (TNR, specificity), 2.56% for false-negative rate (FNR, miss rate), and 97.44% for positive predictive value (PPV, precision). Also, the F_1 score is calculated as 0.97, Matthew correlation coefficient (MCC) as 0.95, and Cohen kappa coherent as 0.95.

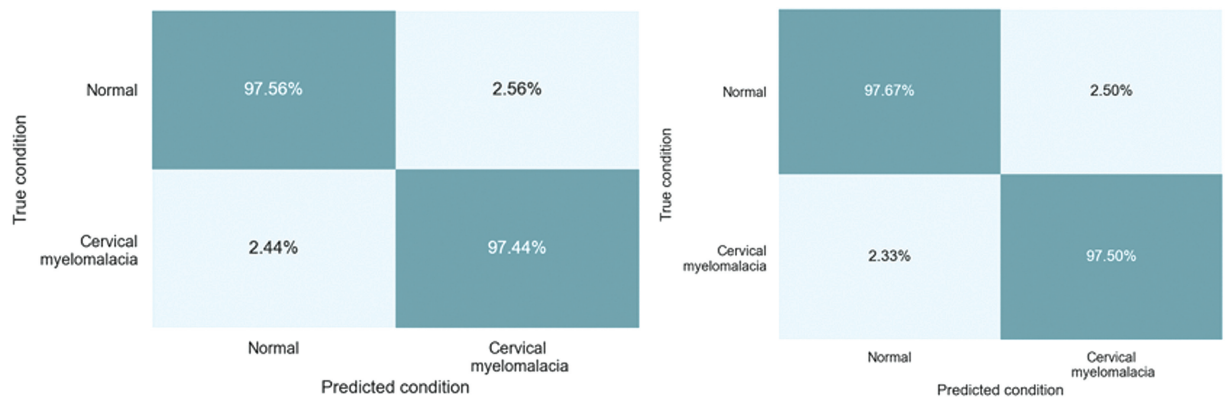


Fig. 4 Confusion matrix of axial view (left) and sagittal view (right).

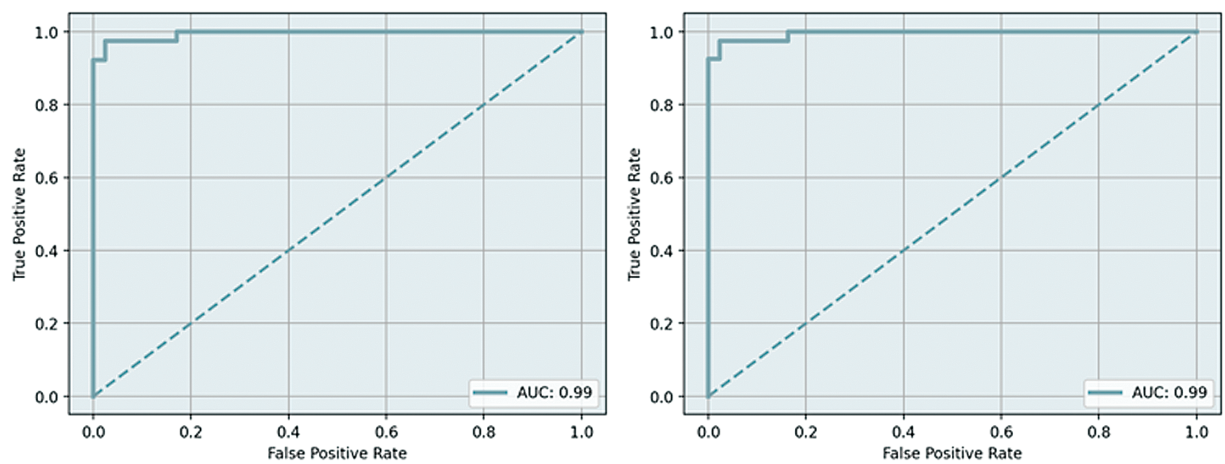


Fig. 5 ROC curve and AUC value of the axial view (left) and sagittal view (right).

After the evaluation, the receiver operating characteristic (ROC) curve was drawn, the area under the ROC curve[11] was calculated, and shown in ►**Fig. 5**.

Sagittal view

A total of 249 sample images from the MRI of the participants were selected for training and testing the model created for sagittal views. Of these images, 124 were labeled as CM, and 125 were labeled as normal. A total of 166 of these images were used for the training of the DL model, and 83 for the evaluation of the training. The true positive, true negative, false positive, and false negative values that occur after the evaluation of the training are shown in ►**Table 2**. The confusion matrix accuracy values formed by these values are given in ►**Fig. 4**. After the evaluation, the overall accuracy value of the model was calculated as 97.59%.

The calculated values are 97.50% for TPR (recall, sensitivity), 97.67% for TNR (specificity), 2.50% for FNR (miss rate), and 97.50% for PPV (precision). Also, the F_1 score is calculated as 0.98, MCC as 0.95, and Cohen kappa coherent as 0.95.

After the evaluation, the ROC curve was drawn, the AUC was calculated, and shown in ►**Fig. 5**.

Discussion

Machine learning technologies have started to be used in many areas with the development it has shown in recent years.[12] Deep learning, a sub-branch of ML, has shown a great improvement especially in the medical field. In parallel with this development, the use of DL in spine surgery has increased significantly in recent years and has brought a new breath to the determination of spine problems and the evaluation of treatment options.[9] Machine learning is currently used more frequently in the evaluation of diagnostic imaging, such as the location of vertebra and discs and the shape of the spine, with the information obtained from radiological imaging methods such as CT and MRI.[13] However, with the progress in ML studies, its use is gradually increasing in treatment protocols and predicting possible results.[14]

The diagnosis of CM is based on findings obtained in clinical examination and radiological imaging. Magnetic resonance imaging is the most effective diagnostic method in the radiological evaluation of patients with clinical myelopathic symptoms.[15] Spinal cord anatomy and medullary canal structures are better evaluated in sagittal and axial views.[16,17] Cervical myelopathy characteristically manifests itself as hypointense focal cord atrophy in the T1 sequence and hyperintense in the T2 sequence. However, it has been reported that the T2 sequence detects intramedullary changes better and is more valuable in terms of prognosis.[15] It has also been reported that between 58 and 85% of patients with clinical symptoms of CM have a hyperintense signal in the T2 sequence.[18] Evaluation of CM is primarily based on subjective judgements of the MRI findings of the spinal cord and is therefore limited by the training and expertise of the evaluator.[19] Therefore, in the present study, we tried to reveal the effectiveness of DL in the diagnosis of myelopathy to eliminate the subjection on the person at diagnosis.

In this respect, we evaluated the T2 sequence of the cervical MRI of participants with myelomalacia in the present study. In this sequence, sagittal and axial MR sections of the participants were obtained, normal and areas of myelomalacia in the intramedullary region were marked and the machine was trained. Cervical MRI of the participants were taken in a single center and with the same MRI device. However, because MRI scans may differ from patient to patient, normal images and those of the field of myelomalacia were obtained in the same section to standardize the scans.

In a pilot study, the effectiveness of ML in the diagnosis of CM was evaluated on 28 patients. In this study in which the cervical MRIs of participants with myelopathy symptoms were evaluated, the median accuracy was determined as 90%. The mean sensitivity was 90% and specificity was 85%.[20] Similarly, in another study investigating the effectiveness of ML in CM, diffusion tensor imaging was used. In this study, mean accuracy was 89.7%, sensitivity was 85%, and specificity was 92.4%.[21] In another study, the highest mean accuracy found at the end of the study was 77%, the mean sensitivity was 78%, and mean specificity was 80%.[22] In the present study, we used conventional cervical MRIs, which are used as a standard in diagnosis in a daily routine. Because the anatomy of the spinal cord is best evaluated in the axial and sagittal planes, we evaluated these two planes separately. At the end of the study, the median accuracy in the axial plane was found to be 97.50%. Average sensitivity was 97.44% and specificity was 97.56%. In the sagittal plane, mean accuracy was 97.59%, sensitivity was 97.50%, and specificity was 97.67%. In this respect, a statistically significant diagnosis of myelopathy was made in both axial and sagittal planes. However, it is seen that the rates of myelopathy detection in our study are higher than those of other studies in the literature.

The present study has some limitations. The retrospective nature of the study and small sample size can be considered as limitations. More participants could be included in the study and more accurate information could be obtained in determining the accuracy rate. On the other hand, there are also strengths of the study. The cervical MRIs of the participants with myelopathy symptoms taken in a single center and with the same MRI device were evaluated by two physicians experienced in spinal diseases. In this way, standardization of the images was tried to be kept at the maximum level. In addition, since there could be a difference between MRI sequences taken even in the same participant, normal and the area of myelomalacia images were compared on the same sections.

In the last half century, ML and artificial neural networks (ANN) are frequently preferred in solving nonlinear problems. The DL method, which is a multi-layered ANN, is widely used in the field of health, with the increasing computational power of computers and the easier digital acquisition of medical images. Human-induced errors can be reduced with high accuracy and fast prediagnosis

systems to be revealed. In subsequent studies based on the present study, a pre-diagnosis system can be established by automatic detection of the region with anomaly, staging and monitoring of the myelopathy status can be achieved.

Conclusion

Machine learning technologies are used in many health applications, especially in medical image analysis. Deep learning, a sub-branch of ML, has shown a great improvement especially in spine surgery. In the present study, we aimed to reveal the effectiveness of DL in the diagnosis of CM. As a result of our study, we observed that DL technology works with a higher accuracy than other studies in the literature for the diagnosis of CM. However, in subsequent studies, a prediagnosis system can be established by automatic detection of the region with anomaly, staging, and monitoring of the myelopathy status can be provided.

Financial Support
The authors declare that the present research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interests
The authors have no conflict of interests to declare.

References

1 Klineberg E. Cervical spondylotic myelopathy: a review of the evidence. Orthop Clin North Am 2010;41(02):193–202
2 Cook C, Brown C, Isaacs R, Roman M, Davis S, Richardson W. Clustered clinical findings for diagnosis of cervical spine myelopathy. J Manual Manip Ther 2010;18(04):175–180
3 Kadanka Z, Bednarík J, Vohánka S, Vlach O, Stejskal L, Chaloupka R, et al. Conservative treatment versus surgery in spondylotic cervical myelopathy: a prospective randomised study. Eur Spine J 2000;9(06):538–544
4 Nagata K, Kiyonaga K, Ohashi T, Sagara M, Miyazaki S, Inoue A. Clinical value of magnetic resonance imaging for cervical myelopathy. Spine 1990;15(11):1088–1096
5 Kanna RM, Kamal Y, Mahesh A, Venugopal P, Shetty AP, Rajasekaran S. The impact of routine whole spine MRI screening in the evaluation of spinal degenerative diseases. Eur Spine J 2017;26 (08):1993–1998
6 Maki S, Koda M, Kitamura M, Inada T, Kamiya K, Ota M, et al. Diffusion tensor imaging can predict surgical outcomes of patients with cervical compression myelopathy. Eur Spine J 2017;26(09):2459–2466
7 Lee JG, Jun S, Cho YW, Lee H, Kim GB, Seo JB, Kim N. Deep Learning in Medical Imaging: General Overview. Korean J Radiol 2017;18 (04):570–584
8 Lundervold AS, Lundervold A. An overview of deep learning in medical imaging focusing on MRI. Z Med Phys 2019;29(02): 102–127
9 Galbusera F, Casaroli G, Bassani T. Artificial intelligence and machine learning in spine research. JOR Spine 2019;2(01): e1044
10 Abdelhafiz D, Yang C, Ammar R, Nabavi S. Deep convolutional neural networks for mammography: advances, challenges and applications. BMC Bioinformatics 2019;20(Suppl 11):281
11 Zhang S, Fukunaga T, Oka S, Orita H, Kaji S, Yube Y, et al. Concerns of quality, utility, and reliability of laparoscopic gastrectomy for gastric cancer in public video sharing platform. Ann Transl Med 2020;8(05):196
12 Chang M, Canseco JA, Nicholson KJ, Patel N, Vaccaro AR. The role of machine learning in spine surgery: The future is now. Front Surg 2020;7:54
13 Schmidhuber J. Deep learning in neural networks: an overview. Neural Netw 2015;61:85–117
14 Kim JS, Merrill RK, Arvind V, Kaji D, Pasik SD, Nwachukwu CC, et al. Examining the ability of artificial neural networks machine learning models to accurately predict complications following posterior lumbar spine fusion. Spine 2018;43(12): 853–860
15 Al-Mefty O, Harkey LH, Middleton TH, Smith RR, Fox JL. Myelopathic cervical spondylotic lesions demonstrated by magnetic resonance imaging. J Neurosurg 1988;68(02):217–222
16 Zhou Y, Kim SD, Vo K, Riew KD. Prevalence of cervical myelomalacia in adult patients requiring a cervical magnetic resonance imaging. Spine 2015;40(04):E248–E252
17 Emery SE. Cervical spondylotic myelopathy: diagnosis and treatment. J Am Acad Orthop Surg 2001;9(06):376–388
18 Chen CJ, Lyu RK, Lee ST, Wong YC, Wang LJ. Intramedullary high signal intensity on T2-weighted MR images in cervical spondylotic myelopathy: prediction of prognosis with type of intensity. Radiology 2001;221(03):789–794
19 Rajasekaran S, Vaccaro AR, Kanna RM, Schroeder GD, Oner FC, Vialle L, et al. The value of CT and MRI in the classification and surgical decision-making among spine surgeons in thoracolumbar spinal injuries. Eur Spine J 2017;26(05):1463–1469
20 Hopkins BS, Weber KA II, Kesavabhotla K, Paliwal M, Cantrell DR, Smith ZA. Machine learning for the prediction of cervical spondylotic myelopathy: A post hoc pilot study of 28 participants. World Neurosurg 2019;127:e436–e442
21 Jin R, Luk KD, Cheung JPY, Hu Y. Prognosis of cervical myelopathy based on diffusion tensor imaging with artificial intelligence methods. NMR Biomed 2019;32(08):e4114
22 Merali ZG, Witiw CD, Badhiwala JH, Wilson JR, Fehlings MG. Using a machine learning approach to predict outcome after surgery for degenerative cervical myelopathy. PLoS One 2019;14(04): e0215133

Causes of Revision of Total Knee Arthroplasties in a Tertiary Hospital in Brazil

Causas de revisão de artroplastias totais do joelho em um hospital terciário no Brasil

Alan de Paula Mozella[1] Hugo Alexandre de Araújo Barros Cobra[1] Sandra Tie Nishibe Minamoto[1] Rodrigo Salim[2] Ana Carolina Leal[3]

[1] Department of Orthopedics and Traumatology, Knee Surgery Center, Instituto Nacional de Traumatologia e Ortopedia (INTO), Rio de Janeiro, RJ, Brazil
[2] Department of Orthopedics and Anesthesiology, Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo (USP), São Paulo, SP, Brazil
[3] Division of Teaching and Research, Instituto Nacional de Traumatologia e Ortopedia (INTO), Rio de Janeiro, RJ, Brazil

Address for correspondence Alan de Paula Mozella, Instituto Nacional de Traumatologia e Ortopedia, (INTO), Rio de Janeiro, RJ, Brazil (e-mail: apmozella@terra.com.br).

Rev Bras Ortop 2024;59(5):e696–e701.

Abstract

Objective To identify the causes of revision of total knee arthroplasty in a referral center in Brazil.

Methods This is a case series, with 80 patients undergoing revision surgery for total knee arthroplasty (RTKA) at a referral center for knee surgery, between August 2019 and November 2021, with a mean age of 69.6 years. Of these patients, 60.23% were female and 39.77% were male. The average body mass index (BMI) was 30.23 kg/m^2. The causes of TKA failure were defined as: periprosthetic infection according to the 2018 International Consensus Meeting criteria, ligament instability, range of motion limitation, periprosthetic fracture, malalignment, aseptic loosening, pain due to non-replacement of the patellar cartilage, polyethylene wear, fracture of implants, insufficiency of the extensor mechanism.

Results Periprosthetic joint infection (PJI) was the main cause of revision total knee arthroplasty (TKA), corresponding to 47.73% of cases. Aseptic loosening of one or more components represented the second most frequent reason for TKA failure, accounting for 35.23% of revisions. Range of motion limitation represented the third most frequent cause, accounting for 5.68% of surgeries. Instability was the fourth most frequent reason for RTKA, occurring in 4.55% of patients. The other causes of revision were: periprosthetic fracture (3.41%), failure due to rupture of the extensor mechanism (2.27%), and pain attributed to non-replacement of the patellar cartilage (1.14%).

Keywords
- arthroplasty
- arthroplasty, replacement, knee
- infections
- knee joint

Work carried out at the Instituto Nacional de Traumatologia e Ortopedia (INTO), Rio de Janeiro, RJ, Brazil.

received
April 19, 2022
accepted
August 17, 2022

DOI https://doi.org/10.1055/s-0042-1757304.
ISSN 0102-3616.

© 2022. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Conclusions Periprosthetic joint infection was the most frequent cause of TKA revision in our series. Other reasons for TKA failures were, in descending order: aseptic loosening, limited range of motion, and instability.

Resumo

Objetivo Identificar as causas de revisão de artroplastia total do joelho em um centro de referência no Brasil.

Métodos Trata-se de uma série de casos, com 80 pacientes submetidos à cirurgia de revisão de artroplastia total do joelho (RATJ) em um centro de referência em cirurgia do joelho, no período entre agosto de 2019 e novembro de 2021, com média de idade de 69,6 anos. Desses pacientes, 60,23% eram do sexo feminino e 39,77% do sexo masculino. O índice de massa corporal (IMC) médio foi de 30,23 kg/m^2. As causas de falha da ATJ foram definidas como: infecção periprotética conforme critérios do *2018 Internacional Consensus Meeting*, instabilidade ligamentar, limitação de arco de movimento, fratura periprotética, mal alinhamento, soltura asséptica, dor devido à não substituição da cartilagem patelar, desgaste do polietileno, fratura dos implantes, insuficiência do mecanismo extensor.

Resultados A infecção articular periprotética (IAP) foi a principal causa de revisão de artroplastia total do joelho (ATJ), correspondendo a 47,73% dos casos. A soltura asséptica de um ou mais componentes representou o segundo motivo mais frequente para causa de falha de ATJ, acarretando 35,23% das revisões. Limitação do arco de movimento representou a terceira mais frequente causa, sendo responsável por 5,68% das cirurgias. Instabilidade foi a 4ª razão mais frequente para RATJ, ocorrendo em 4,55% dos pacientes. As demais causas de revisão foram: fratura periprotética (3,41%), insuficiência por ruptura do mecanismo extensor (2,27%), dor atribuída à não substituição da cartilagem patelar (1,14%).

Conclusões A infecção articular periprotética foi a causa mais frequente de revisão de ATJ em nossa série. Outras razões de falhas de ATJ foram, em ordem decrescente: soltura asséptica, limitação do arco de movimento e instabilidade.

Palavras-chave
- articulação do joelho
- artroplastia
- artroplastia do joelho
- infecções

Introduction

Epidemiological data show that between 6 and 12% of total knee arthroplasties (TKA) evolve to failure, requiring revision surgery in the first 10 years.[1] Other recent studies have shown an increase in the number of revision surgeries of TKA (RTKA) performed in recent years.[2–5] There was a 144% increase in the number of RTKA performed in Germany between 2004 and 2014.[6] It is estimated that, for the year 2050, in the same country, there will be an increase of about 90% in the number of revision surgeries of knee arthroplasties.[4] In the United States, the increase in the number of such procedures was of 39% between 2006 and 2010.[7] And future estimates point to a continuous increase in the number of these surgeries by the year 2030.[8]

The etiology for increasing the number of RTKAs is, in fact, multifactorial, being influenced both by factors related to technical issues and evolution of implants and instruments, as well as by factors related to patients.[9,10] An example of this, the wear of the polyethylene component was a frequent cause of revision in the past; however, changes in the sterilization process of these components culminated in a significant reduction in the number of revisions for this reason.[11–13] At the same time, the expansion of primary prosthesis indications, especially for younger patients, and the higher incidence of obesity in the world population may, at least partially, also justify potential changes in the failure patterns of modern arthroplasties.[9,14,15] Meehan et al.[14] demonstrated that the risk of septic failure was 1.81 times higher in patients under 50 years of age when compared to patients older than 65 years. Similarly, among younger patients, the risk of revision for aseptic failure was 4.7 times higher.[14]

Knee prosthesis revision surgeries are procedures of high complexity, performed in a limited number of hospitals and, consequently, that require greater expenditure of technical and economic resources.[16,17] Compliance with technical principles is essential to obtain satisfactory results in this type of surgery.[18] Thus, preoperative planning, failure mode identification and adequate treatment of bone defects are of fundamental importance for obtaining satisfactory and long-lasting clinical results in this type of surgery.[18,19]

In this context, the identification of the cause of implant failure is significantly important for planning and obtaining satisfactory results.[20] Several series have demonstrated

changes in the causes of TKA failure over the years, possibly related to evolutions in implant design, as well as instrumental improvements.[11,12] Thus, this study aims to identify the causes of RTKA in a reference center in Brazil.

Materials and Methods

This is a series of cases of patients undergoing RTKA at the Center for Specialized Attention in Knee Surgery of Instituto Nacional de Traumatologia e Ortopedia (INTO) Jamil Haddad, in the period between August and November 2019 (CAAE-20309419.0.0000.5273.). There was no age limit, no restriction on the gender of the participants.

During the study period, 88 arthroplasty revision surgeries were performed. One patient underwent revision of the unicompartmental implant of the knee and was therefore excluded. Seven surgeries were excluded from the analysis because it was the second revision surgery. Thus, after the exclusion criteria, 80 surgeries (80 patients) were analyzed. The mean age of the patients in the procedures was 69.6 years (standard deviation (SD) = 9.85 years; variation = 29–87 years). Of these patients, 60.23% were female and 39.77% were male. The mean body mass index (BMI) was 30.23 kg/m^2 (SD = 5.92; variation = 18.20–42.46 kg/m^2).

Arthroplasty review was defined as reoperation after performing primary TKA in which it was necessary to add or replace one or more prosthetic components. Thus, patients submitted to reoperations, however without the addition or replacement of one or more primary prosthetic components, were excluded from the analysis. Patients submitted to unicompartmental knee implant (UKI) revision surgery were also excluded from the analysis, as well as patients submitted to the second revision surgery.

The following data were collected from medical records: age, gender, and BMI. Laboratory tests with analysis of hemosedimentation velocity (HSV), C-reactive protein (CRP), and D-dimer were performed in all patients on the day before surgery, as well as range of motion measurement using a goniometer by the orthopedist in training in the knee surgery improvement course at the institution. Radiographs of the knee at anteroposterior incidences with bipodal, profile, and axial support in 30 degrees were performed on the day before surgery. During surgery, synovial fluid was collected for the following analyses: total leukocyte count, polymorphonuclear percentage, leukocyte esterase, and culture in a blood culture vial. Six samples of bone tissue were also collected for extended tissue culture for 14 days and 2 periprosthetic membrane samples for histopathological examination.

In the surgical report, the following information were analyzed: surgical access performed, implant system used, Anderson Orthopaedic Research Institute (AORI) classification of bone loss, use of trabeculated metal cones and/or tissue bank grafts for the treatment of defects.

Regarding the surgical access used, the surgery was performed by conventional medial parapatellar access in 70 surgeries (87.5%). Extended access was performed in 10 surgeries (12.5%), with tibia anterior tuberosity (TAT) osteotomy in 7 cases (8.75%), quadriceps turndown in two cases (2.5%), and clipping of the thigh reskin (snip) in one patient (1.25%).

Table 1 Distribution of bone defects

Classification of defects	Tibia n (%)	Femur n (%)
Flawless	15 (20%)	16 (21.3%)
1	20 (26.7%)	15 (20%)
2a	19 (25.3%)	15 (20%)
2b	9 (12%)	8 (10.7%)
3	12 (16%)	21 (28%)

Source: Research data (INTO).

Implants with two different systems—Legacy Constrained Condylar Knee (Zimmer Biomet, Warsaw, IN, USA) or Legion Revision Knee (Smith & Nephew plc, London, UK)—were used in 40 surgeries (50%). In 24 surgeries (30%), constrictor implants (Rotating Hinge Knee – Zimmer Biomet) were used. Spacers were implanted in 14 patients (17.5%). In 2 patients (2.5%), only patellar implants were used.

Medical documentation of bone defects was incomplete in five surgeries. Thus, when analyzing 75 patients, the presence of bone defects was identified in 70% of the patients. The distribution and classification of bone failures are shown in ►**Table 1**. Tantalum metaphysary cones were necessary for the treatment of bone defects in 21 patients (26.25%). Of these, tissue bank grafting was also used in nine surgeries. In all, the homologous graft was used in 13 patients (16.25%).

The cause of RTKA was defined by the surgeon responsible for the procedure based on the following criteria: all patients were submitted to evaluation according to the criteria of the 2018 International Consensus Meeting (ICM 2018).[21,22] The diagnosis of periprosthetic infection was made when at least one of the major criteria was present, that is, the presence of a fistula communicating with the joint or presence of the same pathogen in two or more cultures of periimplant tissues. The diagnosis of periprosthetic infection using the lower criteria was confirmed when the score of the sum of the criteria was greater than or equal to six when the parameters of the tests recommended by the ICM 2018 were observed. In cases defined with aseptic failures, the surgeon in charge, after analysis of the physical examination, imaging and laboratory examinations defined the reason for failure between the following possible: ligament instability (when presence of dislocation or subluxation of prosthetic components, or when pathological ligament opening greater than 5 mm during physical examination, or ligament laxity greater than 5 mm in varus or varus stress tests during physical examination or ap radiographs of the knee with load), limitation of range of motion (when less than 50 degrees associated with physical disability declared by the patient), periprosthetic fracture, poor alignment, aseptic loosening, pain due to non-replacement of patellar cartilage, polyethylene wear, fracture of implants, or insufficiency of the extensor mechanism.

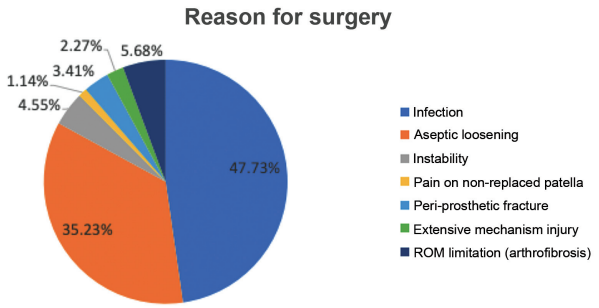


Fig. 1 Distribution of the causes of failure of total knee arthroplasty. Causa da Cirurgia = Reason for surgery, Infecção = Infection, Soltura Asséptica = Aseptic loosening, Instabilidade = Instability, Dor em patela não substituída = Pain on non-replaced patella, Fratura peri-protética = Peri-prosthetic fracture, Lesão do mecanismo extensor = Extensive mechanism injury, Limitação da ADM (artrofibrose) = ROM limitation (arthrofibrosis)

Results

Periprosthetic joint infection (PJI) was the main cause of RTKA, corresponding to 47.73% of cases. The aseptic loosening of one or more components represented the second most frequent cause of failure, resulting in 35.23% of revisions. Limitation of the range of motion represented the 3rd most frequent cause, accounting for 5.68% of surgeries. Instability was the 4th most frequent cause of failure, occurring in 4.55% of patients. The other causes of revision were: periprosthetic fracture (3.41%), insufficiency due to rupture of the extensor mechanism (2.27%), pain attributed to non-replacement of patellar cartilage (1.14%) (►**Fig. 1**).

Discussion

The main finding of our study was to identify that the main cause of failure in our series of primary TKAs was periprosthetic infection. Other reasons that led to the need for revision were, in decreasing order, aseptic loosening, limitation of the range of motion, and joint instability. Similarly, several recent studies have demonstrated periprosthetic infection as the most frequent mechanism of failure of primary prostheses, reaching 20 to 37.7% of surgeries.[2,23–25] In the study by Evangelopoulos et al.,[24] periprosthetic infection was the main mechanism of failure with an incidence of 26.3%. However, when analyzing only patients submitted to the second revision surgery, the authors identified that the incidence of periprosthetic infection remained the most frequent reason for TKA failure with approximately 50% of cases. We believe that this high incidence of revisions due to septic failure observed in our study may have been influenced, at least partially, by the fact that the surgeries were performed in the COVID-19 pandemic period. In this scenario, in several months, only emergency surgeries were performed, such as acute periprosthetic infections and, consequently, subsequent increase in the demand for reimplantation after treatment of infection in two times.

Aseptic loosening represented the 2nd most frequent reason for implant failure in our series, occurring in approximately 35% of cases. Similarly, Bozic et al.[7] demonstrated that periprosthetic infection and aseptic loosening were the two most frequent reasons for TKA revision. When analyzing more than 60,000 primary surgeries, the authors identified septic failure in 25.1% of patients and aseptic loosening in 16.7% of cases.[7] Our results are in agreement with those of Koh et al.[26] and Evangelopoulos et al.,[24] who demonstrated aseptic loosening as the 2nd main cause of review, affecting, respectively, 32.7% and 25% of the failures. Siqueira et al.,[1] when analyzing the arthroplasty registry of five countries, identified aseptic loosening as the first cause of revision, affecting 30% of surgeries. Several other studies have also reported aseptic loosening as the main mechanism of TKA failure with incidence ranging from 24 to 44%.[10,27,28] We identified that the incidence of aseptic loosening in our series is in accordance with the literature, although it is not the main mode of failure of our implants.

The limitation of the range of motion represented, in our series, the third most common indication for RTKA, with approximately 6% of surgeries. Similarly, in the study by Le et al., arthrofibrosis was the third most frequent indication for review, although the incidence presented corresponds to approximately three times that observed in our study. Pietrzak et al. [11] studied only the aseptic causes of revision and identified joint stiffness as the 2nd leading cause of revision with an incidence of 27.5%. Meanwhile, Le[29] and Koh et al.[26] showed an incidence that only 2.5% of patients required TKA revision due to functional limitation imposed by movement arc restriction. Such differences can be explained, at least partially, by the various definitions of joint stiffness, as well as being influenced by the functional demand and expectations of patients.[30–32] We should also observe that, in our series, we included only patients submitted to revision of prosthetic components; thus, patients submitted to manipulation under narcosis after TKA or even reoperation with joint release were not analyzed, which could have modified the incidence if we analyzed reoperations after knee prosthesis. In a study conducted in Brazil evaluating short-term complications (up to 1 year), the authors identified that joint stiffness was the most frequent complication affecting 7.5% of patients undergoing primary knee arthroplasty.[33]

In our study, component instability represented the 4th cause of RTKA, with approximately 5% of surgeries. Other studies have demonstrated an incidence of instability ranging from 18.7 to 30%, constituting the 2nd or 3rd most frequent reason for TKA review.[10,28,29] However, in the works of Kasahara et al.[27] and Koh et al.,[26] instability was identified in 9.3% and 6.5%, respectively. Post-TKA instability is usually indicated as a cause of early failure, that is, in implants with less than 2 years of evolution.[6,11] Thus, the reduction in the number of elective primary surgeries performed during the study period, due to the restrictions imposed by the COVID-19 pandemic, may justify, at least partially, the limited number of revisions due to post-TKA instability. Another potential explanation can be attributed to the waiting time for this type of surgery in the Brazilian public health service. Thus, any

initial cases of instability can potentially evolve with loosening of the implants, thus hindering the primary diagnosis of component instability.

Despite the importance of our series reporting the distribution of the different causes of RTKA in the national scenario, our study has significant limitations. We believe that restrictions on elective surgeries imposed during part of the COVID-19 pandemic period may influence the incidence of some modes of failure, such as suspension of elective aseptic revisions in certain periods. Another important limitation refers to the retrospective nature of our analysis. Thus, several patients submitted to revision surgery had been operated on primarily in other hospitals. Thus, we had no control over the evolution time from the implantation of the components to the occurrence of failure requiring revision surgery, nor did we perform analyses of the different systems of primary prostheses implanted. Schroer et al.[10] indicate that 35.3% of knee arthroplasties fail in the first 2 years after implantation, being more often related to factors influenced by the surgeon than by the performance of implants. However, we understand that such information is of high relevance for the planning of the Brazilian health system in view of the increase in the number of cases of RTKA, given, the impacts regarding the need for hospital beds, financial resources, and technical training of the teams. Similarly, we believe that the high number of revision surgeries performed due to septic failure observed in our series alerts us to the need to expand the measures to prevent these serious complications.

Therefore, we believe that the adoption of preventive measures of postoperative infection, such as: optimization of preoperative clinical conditions, adoption of risk stratification scores and investigation of patients colonized by *Methicillin-resistant Sthapylococcus aureus* may impact on the reduction of the number of RTKA surgeries performed in our hospital.

Conclusions

We identified periprosthetic joint infection as the most frequent cause of RTKA. The other TKA failure mechanisms were, in decreasing order: aseptic loosening, limitation of the range of motion, and instability. Periprosthetic fracture and extensor mechanism insufficiency were less frequent causes of primary prosthesis revision in our series.

Financial Support
The authors declare that there was no financial support from public, commercial, or non-profit sources.

Conflict of Interests
The authors declare that there is no conflict of interests.

References

1 Siqueira MBP, Klika AK, Higuera CA, Barsoum WK. Modes of failure of total knee arthroplasty: registries and realities. J Knee Surg 2015;28(02):127–138
2 Mathis DT, Lohrer L, Amsler F, Hirschmann MT. Reasons for failure in primary total knee arthroplasty - An analysis of prospectively collected registry data. J Orthop 2020;23:60–66
3 Geary MB, Macknet DM, Ransone MP, Odum SD, Springer BD. Why Do Revision Total Knee Arthroplasties Fail? A Single-Center Review of 1632 Revision Total Knees Comparing Historic and Modern Cohorts. J Arthroplasty 2020;35(10):2938–2943
4 Rupp M, Walter N, Lau E, Worlicek M, Kurtz SM, Alt V. Recent trends in revision knee arthroplasty in Germany. Sci Rep 2021;11 (01):15479
5 Klug A, Gramlich Y, Rudert M, et al. The projected volume of primary and revision total knee arthroplasty will place an immense burden on future health care systems over the next 30 years. Knee Surg Sports Traumatol Arthrosc 2021;29(10): 3287–3298
6 Boelch SP, Jakuscheit A, Doerries S, et al. Periprosthetic infection is the major indication for TKA revision - experiences from a university referral arthroplasty center. BMC Musculoskelet Disord 2018;19(01):395
7 Bozic KJ, Kurtz SM, Lau E, et al. The epidemiology of revision total knee arthroplasty in the United States. Clin Orthop Relat Res 2010;468(01):45–51
8 Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. J Bone Joint Surg Am 2007;89(04):780–785
9 Kamath AF, Ong KL, Lau E, et al. Quantifying the Burden of Revision Total Joint Arthroplasty for Periprosthetic Infection. J Arthroplasty 2015;30(09):1492–1497
10 Schroer WC, Berend KR, Lombardi AV, et al. Why are total knees failing today? Etiology of total knee revision in 2010 and 2011. J Arthroplasty 2013;28(8, Suppl)116–119
11 Pietrzak J, Common H, Migaud H, Pasquier G, Girard J, Putman S. Have the frequency of and reasons for revision total knee arthroplasty changed since 2000? Comparison of two cohorts from the same hospital: 255 cases (2013-2016) and 68 cases (1991-1998). Orthop Traumatol Surg Res 2019;105(04):639–645
12 Sharkey PF, Lichstein PM, Shen C, Tokarski AT, Parvizi J. Why are total knee arthroplasties failing today–has anything changed after 10 years? J Arthroplasty 2014;29(09):1774–1778
13 Thiele K, Perka C, Matziolis G, Mayr HO, Sostheim M, Hube R. Current failure mechanisms after knee arthroplasty have changed: polyethylene wear is less common in revision surgery. J Bone Joint Surg Am 2015;97(09):715–720
14 Meehan JP, Danielsen B, Kim SH, Jamali AA, White RH. Younger age is associated with a higher risk of early periprosthetic joint infection and aseptic mechanical failure after total knee arthroplasty. J Bone Joint Surg Am 2014;96(07):529–535
15 Jämsen E, Nevalainen P, Eskelinen A, Huotari K, Kalliovalkama J, Moilanen T. Obesity, diabetes, and preoperative hyperglycemia as predictors of periprosthetic joint infection: a single-center analysis of 7181 primary hip and knee replacements for osteoarthritis. J Bone Joint Surg Am 2012;94(14):e101
16 Morcos MW, Kooner P, Marsh J, Howard J, Lanting B, Vasarhelyi E. The economic impact of periprosthetic infection in total knee arthroplasty. Can J Surg 2021;64(02):E144–E148
17 Boddapati V, Fu MC, Mayman DJ, Su EP, Sculco PK, McLawhorn AS. Revision Total Knee Arthroplasty for Periprosthetic Joint Infection Is Associated With Increased Postoperative Morbidity and Mortality Relative to Noninfectious Revisions. J Arthroplasty 2018;33 (02):521–526
18 Mozella AP, Cobra HAAB. Bone Defects in Revision Total Knee Arthroplasty. Rev Bras Ortop 2021;56(02):138–146
19 Sheth NP, Bonadio MB, Demange MK. Bone Loss in Revision Total Knee Arthroplasty: Evaluation and Management. J Am Acad Orthop Surg 2017;25(05):348–357
20 Pitta M, Esposito CI, Li Z, Lee YY, Wright TM, Padgett DE. Failure After Modern Total Knee Arthroplasty: A Prospective Study of 18,065 Knees. J Arthroplasty 2018;33(02):407–414

21 Schwarz EM, Parvizi J, Gehrke T, et al. 2018 International Consensus Meeting on Musculoskeletal Infection: Research Priorities from the General Assembly Questions. J Orthop Res 2019;37(05):997–1006
22 Parvizi J, Tan TL, Goswami K, et al. The 2018 Definition of Periprosthetic Hip and Knee Infection: An Evidence-Based and Validated Criteria. J Arthroplasty 2018;33(05):1309–1314.e2
23 Delanois RE, Mistry JB, Gwam CU, Mohamed NS, Choksi US, Mont MA. Current Epidemiology of Revision Total Knee Arthroplasty in the United States. J Arthroplasty 2017;32(09):2663–2668
24 Evangelopoulos DS, Ahmad SS, Krismer AM, et al. Periprosthetic Infection: Major Cause of Early Failure of Primary and Revision Total Knee Arthroplasty. J Knee Surg 2019;32(10):941–946
25 Meyer JA, Zhu M, Cavadino A, Coleman B, Munro JT, Young SW. Infection and periprosthetic fracture are the leading causes of failure after aseptic revision total knee arthroplasty. Arch Orthop Trauma Surg 2021;141(08):1373–1383
26 Koh IJ, Cho WS, Choi NY, Kim TKKleos Korea Research Group. Causes, risk factors, and trends in failures after TKA in Korea over the past 5 years: a multicenter study. Clin Orthop Relat Res 2014;472(01):316–326
27 Kasahara Y, Majima T, Kimura S, Nishiike O, Uchida J. What are the causes of revision total knee arthroplasty in Japan? Clin Orthop Relat Res 2013;471(05):1533–1538
28 Mulhall KJ, Ghomrawi HM, Scully S, Callaghan JJ, Saleh KJ. Current etiologies and modes of failure in total knee arthroplasty revision. Clin Orthop Relat Res 2006;446(446):45–50
29 Le DH, Goodman SB, Maloney WJ, Huddleston JI. Current modes of failure in TKA: infection, instability, and stiffness predominate. Clin Orthop Relat Res 2014;472(07):2197–2200
30 Rutherford RW, Jennings JM, Levy DL, Parisi TJ, Martin JR, Dennis DA. Revision Total Knee Arthroplasty for Arthrofibrosis. J Arthroplasty 2018;33(7S):S177–S181
31 Cheuy VA, Foran JRH, Paxton RJ, Bade MJ, Zeni JA, Stevens-Lapsley JE. Arthrofibrosis Associated With Total Knee Arthroplasty. J Arthroplasty 2017;32(08):2604–2611
32 Thompson R, Novikov D, Cizmic Z, et al. Arthrofibrosis After Total Knee Arthroplasty: Pathophysiology, Diagnosis, and Management. Orthop Clin North Am 2019;50(03):269–279
33 Carvalho LH Junior, Castro CAC, Gonçalves MBJ, Rodrigues LCM, Lopes FL, Cunha FVP. Complicações de curto prazo da artroplastia total do joelho: avaliação de 120 casos. Rev Bras Ortop 2006;41(05):162–166

Meniscal Ramp Injury Diagnosis

Diagnóstico das lesões meniscais em rampa

Pedro Baches Jorge[1] Diego Escudeiro de Oliveira[1] Guilherme do Amaral Mussatto[1] Melanie Mayumi Horita[1] Victor Eduardo Roman Salas[1] Rafael Baches Jorge[1]

[1] Irmandade da Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brazil

Rev Bras Ortop 2024;59(5):e702–e706.

Address for correspondence Guilherme do Amaral Mussatto, Ortopedia e Traumatologia, Irmandade da Santa Casa de Misericórdia de São Paulo Rua: Dr. Cesário Mota Júnior, 112 - Vila Buarque, 01221-010; São Paulo, SP, Brazil (e-mail: guilhermeamussatto@gmail.com).

Abstract

Objective: This study compared diagnostic methods for meniscal ramp injury (magnetic resonance imaging [MRI], arthrotomography, and arthroscopy) to determine the most sensitive and the agreement level between them.

Method: We studied 21 patients, all young athletes with suspected anterior cruciate ligament (ACL) injury after trauma for at least 3 months and no evidence or history of other osteoarticular injuries in the knee. The patients underwent MRI and arthrotomography. Following ACL injury confirmation, they underwent arthroscopy for ligament reconstruction and evaluation of the medial meniscus to confirm or exclude a ramp injury. McNemar's agreement test compared the diagnostic methods. We also assessed specificity and sensitivity using arthroscopy as the gold standard with a 95% confidence interval and $p < 0.005$.

Result: The results were consistent with the literature. MRI had 73.3% sensitivity and 83.3% specificity, with 76.2% agreement with the gold standard. Arthrotomography sensitivity and specificity were 100% and 66.7%, respectively, with 90.5% agreement with arthroscopy.

Conclusion: In our study, arthrotomography was the most sensitive diagnostic method and had the highest agreement with the gold standard. We recommend its consideration for diagnosing ACL injuries.

Keywords

- anterior cruciate ligament injuries
- arthroscopy
- tibial meniscus injuries

Resumo

Objetivo: Comparar os métodos diagnósticos para lesão meniscal em rampa (ressonância magnética, artrotomografia e artroscopia) evidenciando qual o método mais sensível e qual o grau de concordância entre os métodos.

Método: Foram estudados 21 pacientes, sendo esses, jovens, atletas, com suspeita de lesão do LCA após trauma há pelo menos 3 meses, sem evidências ou histórico de outras lesoes osteoarticulares no joelho. Para isso os pacientes foram submetidos a ressonância magnética, artrotomografia e após a confirmação da lesão do LCA foi realizada artroscopia para reconstrução ligamentar e avaliação do menisco medial para confirmar ou excluir o diagnóstico de lesão em rampa. Os métodos diagnósticos foram

Work carried out at the Department of Orthopedics and Traumatology, Irmandade da Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brazil.

received
May 30, 2022
accepted
November 6, 2023

DOI https://doi.org/10.1055/s-0044-1791791.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

comparados pelo teste de concordância de McNemar, sendo também avaliada especificidade e sensibilidade, utilizando como padrão ouro a artroscopia, com intervalo de confiança de 95% e $p < 0,005$.

Resultado: Os resultados foram semelhantes com os já encontrados na literatura. A ressonância magnética apresentou sensibilidade de 73,3% e especificidade de 83,3%, com uma concordância de 76,2% com o padrão ouro. Já a artrotomografia apresentou sensibilidade e especificidade de 100% e 66,7% respectivamente, com uma concordância de 90,5% com a artroscopia.

Conclusão: Neste trabalho, a artrotomografia se apresentou como o método diagnóstico mais sensível e com maior concordância com o padrão ouro, devendo ser considerada na investigação diagnóstica de pacientes com lesão do LCA.

Palavras-chave
- artroscopia
- lesões do ligamento cruzado anterior
- lesões do menisco tibial

Introduction

Hamberg et al. described the meniscal ramp injury in the 1980s as a lesion of the posterior aspect of the medial meniscus in the topography shown by ►**Fig. 1**, and, later, Strober apud Sonnery-Cottet et al.[1] described it as a longitudinal lesion, 2.5 cm long, at the meniscocapsular junction. These lesions are more common in male patients with anterior cruciate ligament (ACL) rupture and a mean age of 30 years old. The classification of this type of injury relies on the affected area: type 1 includes meniscocapsular injuries in the outermost region of the synovial sheath; type 2 consists of upper partial injuries, which are stable and only diagnosed at a transoperative approach; type 3 includes lower partial or occult injuries, not visible at a transoperative approach; type 4 consists of complete injuries in the red-red zone; and type 5 includes double ruptures involving the meniscocapsular junction and the anterior portion of the posterior horn[2] (►**Fig. 1**).

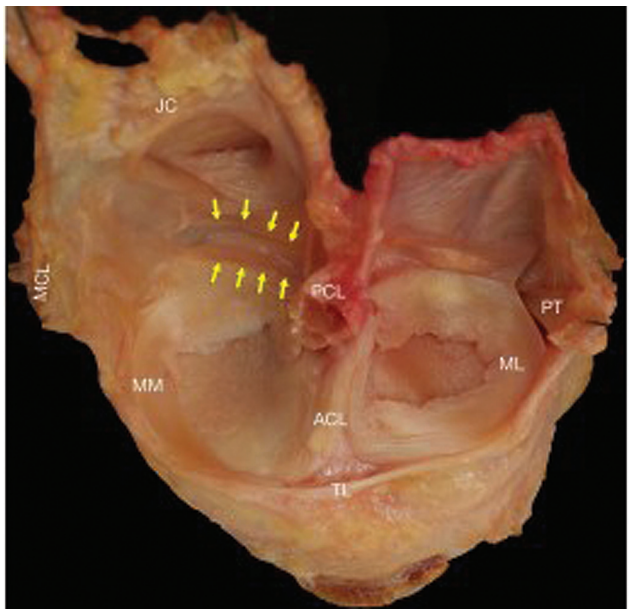


Fig. 1 Anatomical dissection of the left knee joint. Yellow arrows mark the posteromedial femoral recess. Medial collateral ligament (MCL), medial meniscus (MM), lateral meniscus (ML), joint capsule (JC), posterior cruciate ligament (PCL), anterior cruciate ligament (ACL), and enlargement of the posteromedial femoral recess. Source: Śmigielski R, Becker R, Zdanowicz U, Ciszek B. Medial meniscus anatomy from basic science to treatment. Knee Surg Sports Traumatol Arthrosc 2015;23(1): 8-14.

The literature has no consensus regarding the most sensitive and specific method for diagnosing a meniscal ramp injury.[3] One method is the intraoperative detection of the injury during arthroscopy for ACL repair due to clinical suspicion, specific physical examination tests (pivot shift grade III and Lachman grade III), and suggestive epidemiology, such as male gender and young age (30 years old).[4] Another possibility is magnetic resonance imaging (MRI) showing an injury with hyperintense signal on T2-weighted images in the posterior topography of the medial meniscus at the meniscocapsula junction and edema of the posterior medial tibial plateau.[5] A third diagnostic method is arthrotomography with intra-articular contrast injection; its sensitivity is consistent with MRI per the current literature. After diagnosis, treatment of these lesions can be conservative or surgical. Surgical repair is the most common treatment, with good clinical outcomes and a low failure rate.[6] Thaunat et al.[2] stated that a ramp lesion repair can occur through anterior arthroscopic portals and all-inside sutures. However, creating a posteromedial accessory portal facilitates debridement for lesion access, allows better visualization of its complete repair, and helps the positioning of vertical sutures in the deep meniscal fibers, with a biomechanical advantage over sutures Sonnery-Cottet et al.[7] added that this additional portal aimed at better visualization of the posterior region of the medial meniscus, helping to discover a percentage of lesions that could go undiagnosed through a standard anterior exploration. Using this technique, arthroscopic repair of meniscal ramp injuries during ACL reconstruction provided a high healing rate, making it a reliable surgical procedure for treating this type of lesion

Using this technique, arthroscopic repair of meniscal ramp injuries during ACL reconstruction provided a high healing rate, making it a reliable surgical procedure for treating this type of lesion.[3,8] Underdiagnosis and failure to treat these injuries can directly influence rehabilitation after ACL reconstruction and culminate in anteroposterior and rotatory knee instability.[3,9]

Materials and methods

The ethics committee of our institution approved this study under number CAAE 46245121.5.0000.5479.

We studied 21 patients, all young athletes with suspected ACL injury after trauma at least 3 months previously and no evidence or history of other osteoarticular injuries in the knee. We excluded patients with current infection in the injured knee, chronic disease, severe conditions preventing surgical intervention, or previous knee injury. The study lasted for 2 years. Five radiologists assessed the selected patients, who underwent MRI, arthrotomography, and arthroscopy. Initially, an MRI of the affected knee occurred on a 1.5-T device. Immediately after, we performed an arthrotomography on a 64-channel device with an intra-articular injection of 15 mL of iopromide.

After imaging tests confirmed the ligament injury, the patients underwent an arthroscopic surgical procedure for ACL reconstruction. Knee-specialized surgeons performed the procedure, starting with anterolateral and anteromedial portals to assess the medial meniscus and the presence or absence of a ramp lesion. Next, they did an all-inside suturing in positive cases. If there was diagnostic doubt or non-diagnosis of the lesion through anterior portals, they created a posteromedial portal to confirm its existence and proceeded with the ACL reconstruction.

►**Table 1** compares the diagnostic methods per the association between the presence or absence of a meniscal ramp lesion. McNemar's agreement test compared arthrotomography and MRI. We calculated specificity and sensitivity using arthroscopy as the gold standard with a 95% confidence interval and $p < 0.05$.

Results

Twelve patients (57%) with a mean age of 26, nine men and three women, had a positive result for meniscal ramp lesion in MRI. Meanwhile, nine patients (43%) with a mean age of 23, four men and five women, had a negative result. In the arthrotomography study, 17 patients (81%) with a mean age of 26, 11 men and six women, had a positive result for the lesion, and four patients (19%) with a mean age of 19, two men and two women, had a negative result. However, in the arthroscopic study, 15 patients (71%) with a mean age of 26, 11 men and four women, had a positive result, and six patients (29%) with a mean age of 19, two men and four women, had a negative result (►**Table 1**). There was agreement for test positivity between the imaging methods and the arthroscopic study in 15 patients (71%). Furthermore, the lesion was positive in an arthroscopic procedure after a positive arthrotomography test and a negative MRI in four patients (19%). All patients underwent surgery within 3 months of the trauma (►**Table 1**).

Table 1 Comparison between arthrotomography, magnetic resonance imaging, and arthroscopy per the positivity of the diagnostic test

Diagnostic method	Number of patients
Arthrotomography	
Positive	17
Negative	4
Magnetic resonance imaging	
Positive	12
Negative	9
Arthroscopy	
Positive	15
Negative	6

The agreement between arthrotomography and arthroscopy was 90.5% ($p = 0.5$) using the McNemar test. Agreement between MRI and arthroscopy was 76.2% ($p = 0.375$). Arthrotomography had 100% sensitivity (lower limit = 90.4%, upper limit = 100.0%) and 66.7% specificity (lower limit = 5.8%, upper limit = 100.0%) with 95% CI. MRI showed 73.3% sensitivity (lower limit = 50.2%, upper limit = 100.0%) and 83.3% specificity (lower limit = 35.1%, upper limit =100.0%), also with 95% CI (►**Table 2**).

Discussion

Liu et al.[10] described the ramp lesion as a singular type of medial meniscal injury with a high association with ACL rupture. Its prevalence increases over time since the ACL injury. Therefore, this type of injury requires early diagnosis.

Regarding diagnostic methods, intraoperative detection of meniscal injury during arthroscopy for ACL is the gold standard for investigation.[4] Chahla et al.[11] also stated that arthroscopic evaluation is essential to detect meniscal ramp injuries. Sonnery-Cottet et al.[9] described that a systematic exploration of the posteromedial compartment of the knee is mandatory to identify ramp lesions.

Following diagnosis, treatment of these injuries can be conservative. Shelbourne and Rask[12] evaluated the need for suture repair versus treatment with follow-up and injury ablation based on the stability or instability of the meniscal tear (i.e., displaceable to the intercondylar notch upon stress), concluding that stable injuries even greater than 1 cm in length can undergo ablation and remain asymptomatic and with no destabilization. Arthroscopic repair, especially in unstable injuries, was the most widely used approach, with good clinical outcomes and a low failure rate[6] Arthroscopic repair of meniscal ramp injuries during ACL reconstruction provided a high healing rate and is a reliable surgical procedure to treat these injuries.[8] Hatayama et al.[3] studied 57 patients undergoing ACL reconstruction and presenting meniscal ramp injuries, opting for repair in 25 patients. They demonstrated that the meniscal healing rate was significantly higher in these patients and that this fact directly implies the anterior knee laxity and avoids increased forces on the graft.

According to recent research, MRI sensitivity ranges from 48% to 84.6%.[3,4,13] These values are consistent with our study, with a 73.3% sensitivity. Moreover, MRI had a lower

Table 2 Statistical analysis using the McNemar's method

Test type			Arthroscopy		Total
			Positive	Negative	
Arthrotomography	Positive	N	15	2	17
		%	71.4%	9.5%	81.0%
	Negative	N	0	4	4
		%	0.00%	19.0%	19.0%
Total		N	15	6	21
		%	71.40%	28.60%	100.00%
McNemar's test for agreement (p = 0.500)					
agreement	90.5%				
disagreement	9.5%				

			Arthroscopy		Total
			Positive	Positive	
Magnetic resonance imaging	Positive	N	11	1	12
		%	52.4%	4.8%	57.1%
	Negative	N	4	5	9
		%	19.0%	23.8%	42.9%
Total		N	15	6	21
		%	71.4%	28.6%	100.0%
McNemar's test for agreement (p = 0.375)					
agreement	76.2%				
disagreement	23.8%				

	Value	95% CI	
		Lower limit	Upper limit
Sensitivity	100.0%	90.4%	100.0%
Specificity	66.7%	5.8%	100.0%
PPV	88.2%	68.9%	100.0%
NPV	100.0%	70.5%	100.0%

	Value	95% CI	
		Lower limit	Upper limit
Sensitivity	73.3%	50.2%	100.0%
Specificity	83.3%	35.1%	100.0%
PPV	91.7%	71.0%	100.0%
NPV	55.6%	10.0%	100.0%

Abbreviations: CI, Confidence interval; NPV, negative predictive value; PPV, positive predictive value.

agreement (76.2%) than the gold standard diagnostic method, i.e., arthroscopy, compared with arthrotomography (90.5%).

Chahla et al.[11] found that intra-articular contrast infusion can help detect lesions between the meniscus and the capsule that may not be visible on MRI. These authors found a sensitivity ranging from 84% to 100% for arthrotomography detecting these lesions. In our study, arthrotomography had a higher sensitivity of 100%.

Similarly, Greif et al.[14] demonstrated high sensitivity and specificity for the contrast test, but their study warns about the lack of consistent data in the literature comparing its effectiveness with conventional MRI.

Our results indicate that arthrotomography is the test most resembling the gold standard, warranting its consideration in cases with suspected ramp injury associated with ACL injury. Nevertheless, unlike MRI, arthrotomography

involves the injection of intra-articular contrast. Therefore, it is an invasive examination with risks, and it is critical to select correctly patients benefiting from it. In addition, arthrotomography is not available in all services, making its access to certain patients difficult. As such, due to the small sample size, there was no statistical significance for sensitivity and specificity because of the wide range between lower and upper limits.

Our study reiterates the need for a larger sample to reliably evaluate the best diagnostic method for medial meniscal ramp lesions.

Conclusion

In our study, arthrotomography presented results closer to the gold standard, i.e., arthroscopy, with high sensitivity. MRI results were consistent with the literature, being less sensitive than arthrotomography. However, one must consider factors directly related to the performance of these imaging methods. More reliable results require further studies with a larger sample of patients.

Financial support
The authors declare that this research did not receive any grant from financial agencies from the public, commercial, or not-for-profit sources.

Conflicts of Interests
The authors declare no conflicts of interests.

References

1 Sonnery-Cottet B, Serra Cruz R, Vieira TD, Goes RA, Saithna A. Ramp Lesions: An Unrecognized Posteromedial Instability? Clin Sports Med 2020;39(01):69–81
2 Thaunat M, Fayard JM, Guimaraes TM, Jan N, Murphy CG, Sonnery-Cottet B. Classification and Surgical Repair of Ramp Lesions of the Medial Meniscus. Arthrosc Tech 2016;5(04):e871–e875
3 Hatayama K, Terauchi M, Saito K, Takase R, Higuchi H. Healing Status of Meniscal Ramp Lesion Affects Anterior Knee Stability After ACL Reconstruction. Orthop J Sports Med 2020;8(05): 2325967120917674
4 DePhillipo NN, Engebretsen L, LaPrade RF. Current Trends Among US Surgeons in the Identification, Treatment, and Time of Repair for Medial Meniscal Ramp Lesions at the Time of ACL Surgery. Orthop J Sports Med 2019;7(02):2325967119827267
5 Kumar NS, Spencer T, Cote MP, Arciero RA, Edgar C. Is Edema at the Posterior Medial Tibial Plateau Indicative of a Ramp Lesion? An Examination of 307 Patients With Anterior Cruciate Ligament Reconstruction and Medial Meniscal Tears. Orthop J Sports Med 2018;6(06):2325967118780089
6 Alessio-Mazzola M, Lovisolo S, Capello AG, et al. Management of ramp lesions of the knee: a systematic review of the literature. Musculoskelet Surg 2020;104(02):125–133
7 Sonnery-Cottet B, Conteduca J, Thaunat M, Gunepin FX, Seil R. Hidden lesions of the posterior horn of the medial meniscus: a systematic arthroscopic exploration of the concealed portion of the knee. Am J Sports Med 2014;42(04):921–926
8 Thaunat M, Jan N, Fayard JM, et al. Repair of Meniscal Ramp Lesions Through a Posteromedial Portal During Anterior Cruciate Ligament Reconstruction: Outcome Study With a Minimum 2-Year Follow-up. Arthroscopy 2016;32(11):2269–2277
9 Sonnery-Cottet B, Praz C, Rosenstiel N, et al. Epidemiological Evaluation of Meniscal Ramp Lesions in 3214 Anterior Cruciate Ligament-Injured Knees From the SANTI Study Group Database: A Risk Factor Analysis and Study of Secondary Meniscectomy Rates Following 769 Ramp Repairs. Am J Sports Med 2018;46(13): 3189–3197
10 Liu X, Feng H, Zhang H, Hong L, Wang XS, Zhang J. Arthroscopic prevalence of ramp lesion in 868 patients with anterior cruciate ligament injury. Am J Sports Med 2011;39(04):832–837
11 Chahla J, Kruckeberg BM, Moatshe G, LaPrade RF. Peripheral Meniscal Tears: How to Diagnose and Repair. In: LaPrade R, Arendt E, Getgood A, Faucett S, eds. The Menisci. Berlin: Springer-Verlag; 2017:88–83
12 Shelbourne KD, Rask BP. The sequelae of salvaged nondegenerative peripheral vertical medial meniscus tears with anterior cruciate ligament reconstruction. Arthroscopy 2001;17(03): 270–274
13 Arner JW, Herbst E, Burnham JM, et al. MRI can accurately detect meniscal ramp lesions of the knee. Knee Surg Sports Traumatol Arthrosc 2017;25(12):3955–3960
14 Greif DN, Baraga MG, Rizzo MG, et al. MRI appearance of the different meniscal ramp lesion types, with clinical and arthroscopic correlation. Skeletal Radiol 2020;49(05):677–689

Precision of Magnetic Resonance Imaging in Detection of Anterior Cruciate Ligament and Posterior Cruciate Ligament Ruptures and Subsequent Arthroscopic Correlations: An Investigation

Precisão da ressonância magnética na detecção de rupturas do ligamento cruzado anterior e do ligamento cruzado posterior e correlações artroscópicas subsequentes: Uma investigação

Vijendra Yadav[1] Chidanand Kaudki Janekunte Chandrashekhar[1] Rishi Pothuri Ram[1] Rafeeq Mohammed[1]

[1] Department of Orthopedics, Sanjay Gandhi Institute of Trauma and Orthopedics, Bangalore, Karnataka, India

Address for correspondence Rishi Ram, Department of Orthopedics, Sanjay Gandhi Institute of Trauma and Orthopaedics, Bangalore 560011, Karnataka, India (e-mail: rishiram.p@gmail.com).

Rev Bras Ortop 2024;59(5):e707–e711.

Abstract

Objective The present study endeavors to scrutinize the precision of magnetic resonance imaging as a diagnostic modality for detecting ligament disruption of the knee, with arthroscopy serving as the gold standard. The study delves into the sensitivity, specificity, positive predictive value, and negative predictive value of magnetic resonance imaging (MRI) results in a cohort of 200 patients against diagnostic arthroscopy.

Methods Our institution conducted a comprehensive clinical examination of all patients with knee injuries, and those with affirmative findings suggestive of ligament disruption were subjected to an MRI scan. The study comprised 200 patients with MRI-confirmed anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) tears, who subsequently underwent arthroscopy for both diagnostic and therapeutic purposes. The results were subjected to various statistical tests to compare and analyze the outcomes.

Results The study has demonstrated a remarkably high sensitivity and specificity, providing near-optimal accuracy for the diagnosis of ACL and PCL injuries via MRI compared with arthroscopy. Patients with affirmative MRI findings could proceed to undergo diagnostic/therapeutic arthroscopic procedures.

Conclusion The study emphasizes the significance of MRI as a noninvasive and highly precise method for assessing ligament injuries in the knee. Although MRI can be used as

Keywords
- anterior cruciate ligament
- arthroscopy
- knee
- magnetic resonance imaging
- meniscus

Work carried out at the Sanjay Gandhi Institute of Trauma and Orthopaedics, India.

received
March 3, 2023
accepted
July 21, 2023

DOI https://doi.org/10.1055/s-0044-1785508.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

a first-line investigation, it must be emphasized that arthroscopy remains the gold standard for diagnosing ACL and PCL tears. The current study recommends the use of MRI as a valuable screening tool in patients with suspected knee ligament disruption, with potential to reduce the number of diagnostic arthroscopies in patients with inconclusive clinical findings, thereby minimizing patient discomfort and healthcare costs.

Resumo

Objetivo Este estudo examinou a precisão da ressonância magnética (RM) como modalidade diagnóstica para detecção da ruptura de ligamentos do joelho, em que a artroscopia é o padrão-ouro. O estudo investigou a sensibilidade, especificidade, valor preditivo positivo e valor preditivo negativo dos resultados da RM em uma coorte de 200 pacientes em comparação à artroscopia diagnóstica.

Métodos Nossa instituição realizou um exame clínico abrangente de todos os pacientes com lesões no joelho e aqueles com achados afirmativos sugestivos de ruptura ligamentar foram submetidos à RM. O estudo incluiu 200 pacientes com rupturas do ligamento cruzado anterior (LCA) e do ligamento cruzado posterior (LCP) confirmadas por RM que, posteriormente, foram submetidos à artroscopia para fins diagnósticos e terapêuticos. Os resultados foram submetidos a vários testes estatísticos para comparação e análise dos desfechos.

Resultados O estudo demonstrou sensibilidade e especificidade notavelmente altas, com acurácia quase ideal para o diagnóstico de lesões do LCA e do LCP por meio de RM em comparação à artroscopia. Os pacientes com resultados afirmativos à RM poderiam ser submetidos a procedimentos artroscópicos diagnósticos ou terapêuticos.

Conclusão O estudo enfatiza a importância da RM como método não invasivo e altamente preciso para avaliação das lesões ligamentares do joelho. Embora a RM possa ser usada na investigação de primeira linha, deve-se enfatizar que a artroscopia continua a ser o padrão-ouro para o diagnóstico de rupturas do LCA e do LCP. Este estudo recomenda o uso da RM como uma valiosa ferramenta de triagem em pacientes com suspeita de ruptura de ligamentos do joelho, com potencial para reduzir o número de artroscopias diagnósticas em indivíduos com achados clínicos inconclusivos, o que minimiza o desconforto do paciente e os custos de saúde.

Palavras-chave
- artroscopia
- imagem de ressonância magnética
- joelho
- ligamento cruzado anterior
- menisco

Introduction

In contemporary times, injuries to the knee joint resulting from road traffic accidents and sports activities are ubiquitous.[1] These injuries typically involve the ligaments and meniscus of the knee, disrupting the stability and normal biomechanics of the joint and hindering routine daily activity. Hence, prompt and precise diagnosis and management of such injuries are imperative. Among the common knee injuries are anterior cruciate ligament (ACL) or combined ACL and posterior cruciate ligament (PCL) injuries. Initially, in the late 1960s and early 1970s, orthopedic surgeons solely relied on clinical examination until numerous reports suggested the efficacy of arthroscopy in diagnosing and treating various knee disorders.[2] The advent of magnetic resonance imaging (MRI) has revolutionized the diagnosis and management of ACL and meniscal tears of the knee, making arthroscopy less necessary. This study aims to evaluate the radiological and arthroscopic findings of the anterior and posterior cruciate ligaments, correlate the outcomes of both techniques, and determine which method is superior in accurately diagnosing ACL and PCL injuries.

Methods

The study was approved by the institutional ethics committee number ECR/1092/Inst/KA/2018.

A prospective study was undertaken on a cohort of 200 individuals who were admitted to a tertiary health care center with knee injuries arising from diverse etiologies and who satisfied the inclusion criteria. The study was conducted over a period spanning from November 2019 to November 2022.

Inclusion Criteria

1. Patients aged between 18 and 60 years.
2. Patients with positive MRI findings indicating ACL, PCL, or both injuries.
3. Patients who subsequently underwent arthroscopy for further evaluation and treatment.

4. Patients with confirmed ACL, PCL, or both injuries based on arthroscopic examination, utilizing the routine method described below.

Routine Arthroscopy Method

The routine arthroscopy method involved the use of anteromedial and lateral portals. Careful probing of the posterior cruciate ligament (PCL) was conducted to assess for laxity or lesions. In cases in which PCL issues were suspected based on clinical examination or preoperative MRI scans, the posteromedial portal was consistently employed during arthroscopic examination to confirm these findings and ensure a comprehensive evaluation of the PCL. The utilization of the posteromedial portal allowed for a more thorough assessment and characterization of PCL injuries identified through clinical examination or preoperative imaging.

By incorporating the routine arthroscopy method into the inclusion criteria, the paper provides clarity on the methodology used in the study, ensuring that patients with positive MRI findings underwent arthroscopy following a specific routine that includes the use of the anteromedial and lateral portals, as well as the potential use of the posteromedial portal for comprehensive evaluation of PCL injuries.

Exclusion Criteria

1. Patients with contraindications to MRI, such as having intracerebral aneurysmal clips, cardiac pacemakers, metallic foreign bodies in the eye, or implants in the middle ear.
2. Patients who have had a recent knee injury but, upon clinical examination, exhibit no instability.
3. Patients who are deemed unfit for anesthesia.

Methodology

Following the elicitation of medical history, a comprehensive clinical examination was conducted, wherein various tests were performed to assess the extent of knee injury. Specifically, the Lachman and anterior drawer tests were employed to evaluate the anterior cruciate ligament (ACL) injury, whereas the Godfrey sag sign and posterior drawer tests were employed to evaluate the posterior cruciate ligament (PCL) injuries.

Magnetic resonance imaging (MRI) was then performed using the 1.5 Tesla MR protocol on a General Electric Healthcare Company (GE Signa Voyager 1.5T,Waukesha, Wisconsin, USA) 1.5 T MRI machine. T1 and T2 weighted sequences were performed on axial, coronal, and sagittal planes. The MR films were meticulously assessed by a highly skilled radiologist, who carefully documented the status of the cruciate ligaments.

Subsequently, arthroscopic surgery was performed under spinal anesthesia, with the patient placed in a supine position, with lateral support to the proximal thigh. A proximal thigh tourniquet was utilized for each case. The operating surgeon was not apprised of the MRI findings.

The acquired data were analyzed using the sophisticated statistical tool SPSS software Statistics 28.0, IBM Corporation (Armonk, New York, USA). Continuous variables were analyzed by computing the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). A *P*-value lower than 0.05 was deemed statistically significant.

To ascertain the sensitivity, specificity, and accuracy of magnetic resonance imaging (MRI), the outcomes obtained through arthroscopic examination were considered to represent the true diagnosis. Sensitivity, which represents the ability of the MRI to identify individuals with the condition, was computed as the ratio of true positive results to the sum of true positive and false negative results.

Specificity, which reflects the MRI's capacity to accurately identify those without the condition, was determined as the ratio of true negative results to the sum of true negative and false positive results.

Accuracy, which represents the overall ability of the MRI to identify both positive and negative cases correctly, was calculated as the summation of true positive and true negative results divided by the total number of patients who underwent arthroscopy.

The combined data was meticulously compiled and categorized into four distinct groups, based on their correlation with the MRI findings. These categories included the following:

First, the true-positive result signified instances in which the MRI diagnosis was accurately confirmed by arthroscopy.

Second, the true-negative result, which pertained to cases in which the MRI yielded a negative finding for the lesion, and this was corroborated by the arthroscopic examination.

Third, the false-positive result, which represented situations in which the MRI indicated the presence of a lesion, but arthroscopy failed to confirm its existence.

Lastly, the false-negative result, which referred to cases in which arthroscopy detected the presence of the lesion, but the MRI failed to reveal any indication of it.

Results

A total of 200 patients who exhibited traumatic ACL and PCL injuries were carefully identified and examined through a retrospective and prospective approach, wherein MRI evaluation was followed by arthroscopic surgery. Specifically, patients who demonstrated suspected ACL and PCL injuries and fulfilled the predetermined inclusion criteria were carefully selected for inclusion in the study.

Notably, individuals who displayed degenerative changes or evidence of loose bodies in plain radiographs, those who were deemed unfit for anesthesia, and those who had undergone non-operative treatments were all carefully excluded from the study to ensure its validity.

The collected data was meticulously analyzed to determine the true positives, true negatives, false positives, and false negatives associated with the study. Using specificity and sensitivity measures, PPV and NPV were then calculated with the aid of arthroscopic examination, which served as the gold standard for comparison.

Age Distribution

This study was conducted on patients aged 18 to 60, with a mean age of 35.7 years at admission.

The highest frequency and percentage are observed in the 20-to-24 age group with 60 individuals, which accounts for 30% of the total sample. The remaining age groups range from 7 to 13% in frequency and 4 to 6% in percentage.

Mode of Injury

Road traffic accidents were our study's most common mode of injury, accounting for $\sim$ 60%.

Anterior Cruciate Ligament

Sensitivity: TP / (TP + FN) = 138 / (138 + 16) = 0.896 or 89.6%
Specificity: TN / (TN + FP) = 37 / (37 + 9) = 0.804 or 80.4%
PPV: TP / (TP + FP) = 138 / (138 + 9) = 0.939 or 93.9%
NPV: TN / (TN + FN) = 37 / (37 + 16) = 0.698 or 69.8%
Accuracy: (TP + TN) / (TP + TN + FP + FN) = (138 + 37) / 200 = 0.875 or 87.5%

Therefore, the MRI test has a high sensitivity (89.6%), indicating that it correctly identifies the majority of arthroscopically positive cases, but a lower specificity (80.4%), indicating that it also identifies some arthroscopically negative cases as positive. The PPV of the test is high (93.9%), meaning that if the MRI test is positive, there is a high probability that the patient is truly arthroscopically positive. However, the NPV is lower (69.8%), indicating that if the MRI test is negative, there is still a significant probability that the patient is arthroscopically positive. Overall, the MRI test has an accuracy of 87.5%, which is relatively good but not perfect.

Posterior Cruciate Ligament

Sensitivity: TP / (TP + FN) = 45 / (45 + 15) = 0.75 or 75%
Specificity: TN / (TN + FP) = 123 / (123 + 17) = 0.878 or 87.8%
PPV: TP / (TP + FP) = 45 / (45 + 17) = 0.726 or 72.6%
NPV: TN / (TN + FN) = 123 / (123 + 15) = 0.891 or 89.1%
Accuracy: (TP + TN) / (TP + TN + FP + FN) = (45 + 123) / 200 = 0.84 or 84%

Therefore, the MRI test has a sensitivity of 75%, indicating that it correctly identifies 75% of arthroscopically positive cases. The specificity is higher at 87.8%, indicating that it correctly identifies a higher proportion of arthroscopically negative cases. The PPV is 72.6%, meaning that if the MRI test is positive, there is a 72.6% probability that the patient is truly arthroscopically positive. The NPV is higher at 89.1%, indicating that if the MRI test is negative, there is a higher probability that the patient is truly arthroscopically negative. Overall, the MRI test has an accuracy of 84%, which is moderately good but not perfect.

Discussion

The knee joint's MRI scan is considered an efficacious non-invasive diagnostic tool and a preferred alternative to diagnostic arthroscopy. In current clinical practice, MRI scans are routinely performed to confirm the diagnosis of anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) injuries. Nonetheless, discerning partial tears may pose challenges and vary based on the observer and the scanner's sensitivity.

The current study aims to compare and correlate the MRI and arthroscopic findings in diagnosing ACL and PCL injuries. The study cohort encompassed individuals aged 18 to 60 years, with the youngest male patient being 18 years old, and the oldest female being 60 years old. Males were more prone to knee injuries and underwent surgery at a younger age, primarily due to their active involvement in sports. Furthermore, the right knee was more commonly injured than the left.[3]

Prior studies have reported high sensitivity and specificity in diagnosing ACL tears using MRI scans. Rubin et al.[4] reported 93% sensitivity for diagnosing isolated ACL tears. A sensitivity of 92 to 100% and specificity of 93–100% for the MR imaging diagnosis of ACL tears has been reported by similar studies in the past.[5] The current study attested to a sensitivity of 90.90% and a specificity of 78.26% for MRI in diagnosing ACL tears, displaying a fair correlation with arthroscopy. The accuracy of MRI in detecting ACL tears was 88%, categorizing it in the "very good" interpretation group (80–90%). The results were consistent with prior literature, suggesting an 80-to-94% accuracy range in detecting crucial ligament tears. The PPV of MRI was 93.33%, whereas the NPV was 72%.

The interpretation of MRI results is highly reliant on the experience and training of the radiologist.[6–8] Arthroscopy serves as the reference point in most knee MRI studies owing to its technical demands, and the results are subject to the surgeon's experience, primarily in challenging cases. Magnetic resonance imaging remains the quintessential diagnostic tool for ACL and PCL injuries, with reported accuracy ranging from 70 to 100%.[9] However, arthroscopy should be considered an adjunct to a comprehensive clinical examination, including a thorough history, physical examination, and appropriate radiographs. Surgical alternatives are thoroughly discussed with the patient before the procedure, and the definitive surgical procedure is performed during an arthroscopic examination.

Several studies have validated the utility of MRI scans in diagnosing ACL and PCL injuries. Despite the observer variability in interpreting MRI results, it remains an indispensable diagnostic tool in current clinical practice.[10] Arthroscopy, however, should be used in conjunction with a comprehensive clinical examination, providing a definitive diagnosis and treatment plan for patients.

Conclusion

Our research has conclusively demonstrated that MRI is an exceedingly reliable tool in the diagnosis of ACL and PCL injuries in the knee joint. The sensitivity, specificity, and overall accuracy of MRI are exceptionally high, thus affirming its indispensable role in identifying such injuries. As such, it is an ideal screening tool, rendering diagnostic arthroscopy unnecessary for diagnosis in the vast majority of patients.

Notably, MRI is both accurate and non-invasive, making it an optimal modality for assessing ligamentous injuries. In light of these findings, we conclude that MRI should be the

first-line investigation for patients presenting with a knee injury, in whom ligamentous injury is suspected.

Conflict of Interests

The authors have no conflict of interests to declare.

References

1 Kaplan PA, Walker CW, Kilcoyne RF, Brown DE, Tusek D, Dussault RG. Occult fracture patterns of the knee associated with anterior cruciate ligament tears: assessment with MR imaging. Radiology 1992;183(03):835–838

2 Levine WN, Bergfeld JA, Tessendorf W, Moorman CT. Intracapsular and extracapsular structure relationships at the knee: magnetic resonance imaging and arthroscopic correlation. Arthroscopy 1997;13(02):166–1707

3 Avcu S, Altun E, Akpinar I, Bulut MD, Eresov K, Biren T. Knee joint examinations by magnetic resonance imaging: The correlation of pathology, age, and sex. N Am J Med Sci 2010;2(04):202–204

4 Rubin DA, Kettering JM, Towers JD, Britton CA. MR imaging of knees having isolated and combined ligament injuries. AJR Am J Roentgenol 1998;170(05):1207–1213

5 Lee K, Seigel MJ, Lau DM, Hildebolt CF, Matava MJ. Anterior cruciate ligament tears: MR imaging-based diagnosis in a pediatric population. Radiology 1999;213(03):697–704

6 Oei EH, Nikken JJ, Verstijnen AC, Ginai AZ, Myriam Hunink MG. MR imaging of the menisci and cruciate ligaments: a systematic review. Radiology 2003;226(03):837–848

7 Esmaili Jah AA, Keyhani S, Zarei R, Moghaddam AK. Accuracy of MRI in comparison with clinical and arthroscopic findings in ligamentous and meniscal injuries of the knee. Acta Orthop Belg 2005;71(02):189–196

8 Navali AM, Bazavar M, Mohseni MA, Safari B, Tabrizi A. Arthroscopic evaluation of the accuracy of clinical examination versus MRI in diagnosing meniscus tears and cruciate ligament ruptures. Arch Iran Med 2013;16(04):229–232

9 Li K, Du J, Huang LX, Ni L, Liu T, Yang HL. The diagnostic accuracy of magnetic resonance imaging for anterior cruciate ligament injury in comparison to arthroscopy: a meta-analysis. Sci Rep 2017;7(01):7583

10 Shantanu K, Singh S, Srivastava S, Saroj AK. The Validation of Clinical Examination and MRI as a Diagnostic Tool for Cruciate Ligaments and Meniscus Injuries of the Knee Against Diagnostic Arthroscopy. Cureus 2021;13(06):e15727

Comparison between Atasoy-Kleinert V-Y Advancement Flap and Figueiredo Techniques for the Treatment of Transverse and Dorsal Oblique Fingertip Injuries

Comparação entre as técnicas de Figueiredo e de reconstrução volar V-Y de Atasoy-Kleinert no tratamento de lesões transversas e oblíquas dorsais de ponta de dedo

Leandro Azevedo de Figueiredo[1] Rafael de Souza Ribeiro[2] Pedro Hemerly Figueiredo[3]
André Luiz Machado Lima[1] Felipe Mantovani de Oliveira[1] Dalton Silva de Oliveira Júnior[2]

[1] Vitória Apart Hospital, Serra, ES, Brazil
[2] Hospital Jayme dos Santos Neves, ES, Brazil
[3] Santa Casa de Misericórdia de Vitória, Vitória, ES, Brazil

Address for correspondence Leandro Azevedo de Figueiredo, MD, Av. Adalberto Simão Nader, 117, apto. 1001A, Mata da Praia, Vitória, ES 29066-370, Brazil (e-mail: tecnicafigueiredo@gmail.com).

Rev Bras Ortop 2024;59(5):e712–e718.

Abstract

Objective Compare the results of the treatment of transverse and dorsal oblique fingertip lesions with Atasoy-Kleinert V-Y advancement flap or Figueiredo Technique (FT).

Method A total of 21 patients who suffered acute trauma in any finger with consequent transverse or oblique fingertip lesions were selected in a public referral hospital in high complexity trauma. Of these, 10 patients were treated with the Atasoy-Kleinert V-Y advancement flap technique and 11 with the FT. The aesthetic and functional results were compared based on four criteria: evolution of infectious process during treatment; capacity for static and dynamic discrimination between two points; neuroma formation; and aesthetic and functional evaluation of nail growth.

Results None of the studied groups developed neuroma or infectious process during treatment. In the general clinical evaluation, it was observed that no variable presented a statistically significant association, that is, both groups presented similar behaviors in the postoperative period with p value > 0.05 when comparing all the included variables.

Keywords
- finger injuries
- microsurgery
- surgical flaps

Work carried out at the Hospital Jayme dos Santos Neves, Serra, ES, Brazil.

received
October 7, 2021
accepted
March 28, 2022

DOI https://doi.org/10.1055/s-0042-1749202.
ISSN 0102-3616.

© 2022. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Conclusion The present study concluded that the FT is as efficient as the Atasoy-Kleinert V-Y advancement flap technique, both of which can be used for the treatment of transverse and dorsal oblique fingertip injuries, two techniques with excellent results for such lesions.

Resumo

Objetivo Comparar os resultados do tratamento de lesões transversais e oblíquas dorsais de ponta de dedo, tratadas pelas técnicas de reconstrução volar V-Y de Atasoy-Kleinert e a de Figueiredo.

Método Foram selecionados em um hospital público de referência em trauma de alta complexidade 21 pacientes que sofreram trauma agudo em qualquer dedo da mão com consequentes lesões transversas ou oblíquas dorsais de ponta de dedo. Destes, 10 pacientes foram tratados pela técnica de reconstrução volar V-Y de Atasoy-Kleinert e 11 pela Técnica de Figueiredo (TF) e os resultados estéticos e funcionais foram comparados com base em quatro critérios: evolução de processo infeccioso durante o tratamento; capacidade de discriminação estática e dinâmica entre dois pontos; formação de neuroma; e avaliação estética e funcional do crescimento da unha.

Resultados Nenhum dos grupos estudados desenvolveu neuroma ou processo infeccioso durante o tratamento. Na avaliação clínica geral observou-se que nenhuma variável apresentou associação estatisticamente significativa, ou seja, ambos grupos apresentaram comportamentos semelhantes no pós-operatório com um valor-p $> 0,05$ na comparação de todos os critérios estudados.

Conclusão O presente estudo concluiu que a Técnica de Figueiredo é tão eficiente quanto a técnica de reconstrução volar V-Y de Atasoy-Kleinert, ambas podem ser utilizadas para o tratamento de lesões transversas e oblíquas dorsais em ponta de dedos, sendo duas técnicas de excelentes resultados para tais lesões.

Palavras-chave
- lesões dos dedos
- microcirurgia
- retalhos cirúrgicos

Introduction

Fingertip injuries are defined as lesions in the distal portion of the fingers, where the flexor and extensor tendons are. They are often found by hand surgeons in the urgency and emergency setting and represent the most common type of upper limb amputation; furthermore, they are constantly associated with concomitant nail bed lesions.[1,2]

Despite its high prevalence, treatment is often not properly conducted in the patient's first care, thus causing chronic deformities and dysfunctions of the nail and fingertip over time. The lack of professionals prepared for the management of this type of injury in most emergency care in Brazil contributes significantly to these poor outcomes.[3,4]

To choose the surgical treatment method, it is important to consider individual variables of each patient and lesion, such as age, occupation, number of injured fingers, bone exposure, time of injury, and viability of digit reconstruction.[5] As well as variables inherent to the surgical method, such as: cost, complexity of the reproduction of the technique and possible secondary damage generated to the patient. Finally, given the range of treatment options, doctors should choose the one that promotes greater comfort, better recovery, and greater results.[3,6]

The aim of this study is to compare Figueiredo's surgical technique (FT)[3] with the Atasoy-Kleinert V-Y advancement flap technique,[7] evaluating the functional and aesthetic results for the treatment of transverse and dorsal oblique fingertip lesions.

Materials and Methods

The study protocol was approved by the Ethics Committee on Research Involving Human Beings of our institution. This is a prospective, randomized by lot, without masking of patients, convenience sample clinical trial.[8,9]

From July 2018 to December 2018, 21 patients, 17 males and 4 females, treated in the emergency room of a public hospital with reference in high complexity trauma, were selected for the study. The inclusion criterion was acute trauma to any finger with consequent transverse or dorsal oblique fingertip injury. Volar oblique lesions were excluded from the study, as it is not recommended to treat them with the Atasoy-Kleinert V-Y advancement flap technique.[7] Therefore, only lesions that can be treated by both methods will be under analysis.

The patients were numbered according to their order of care, the first being number 1, the second being number 2, and so on. Then, randomization was performed with the online mechanism Sealed Envelope (Sealed Envelope LTD. London, UK), and they were divided into two groups: A (patients 2, 4, 6, 8, 10, 11, 15, 16, 18, and 20) and B (patients

1, 3, 5, 7, 9, 12, 13, 14, 17, 19, and 21). We also used the Consolidated Standards Flowchart of Test Reports (CONSORT) represented in ►**Fig. 1**.

Group A was submitted to treatment with the Atasoy-Kleinert V-Y advancement flap technique, described in the literature as an option for the treatment of transverse or dorsal oblique injuries, already used for decades by surgeons around the world,[10–12] following the technical procedures described in their original work[7] (►**Fig. 2**).

Group B was submitted to treatment with the FT, which consists of promoting wound protection through a polypropylene prosthesis that is cut out of sterile vials of saline, in the wound's exact shape, sutured on its healthy edges through simple stitches, and accommodated without pressing the bloody area. In traumas in which there were concomitant lesions of the nail bed, this was previously sutured with nonabsorbable threads type prolene 7.0 or 8.0 and then protected by the prosthesis, which in this case was first fixed under the eponyquium with U-point and then sutured on the edges of the lesion[3] (►**Figs. 3** and **4**).

All procedures were performed by the same surgical team, composed of Orthopedists and Hand Surgeons and Microsurgeons, members of the Brazilian Society of Hand Surgery (SBCM). The surgery was timed from the confirmation of lidocaine block to the last suture point.

After completion of the surgery, a dressing was made with sterile gauze and micropore. The first change occurred after 7 days, in the first postoperative return consultation. All were followed weekly by the hand surgery and microsurgery team of the hospital where the study was conducted, until their full recovery. In patients treated by the V-Y technique, the stitches were removed after two weeks, while in patients undergoing treatment with FT, the prosthesis was removed six weeks after placement.

In the third postoperative month, the patients were evaluated by the same team based on 4 criteria. The first was considering the evolution of infectious process during

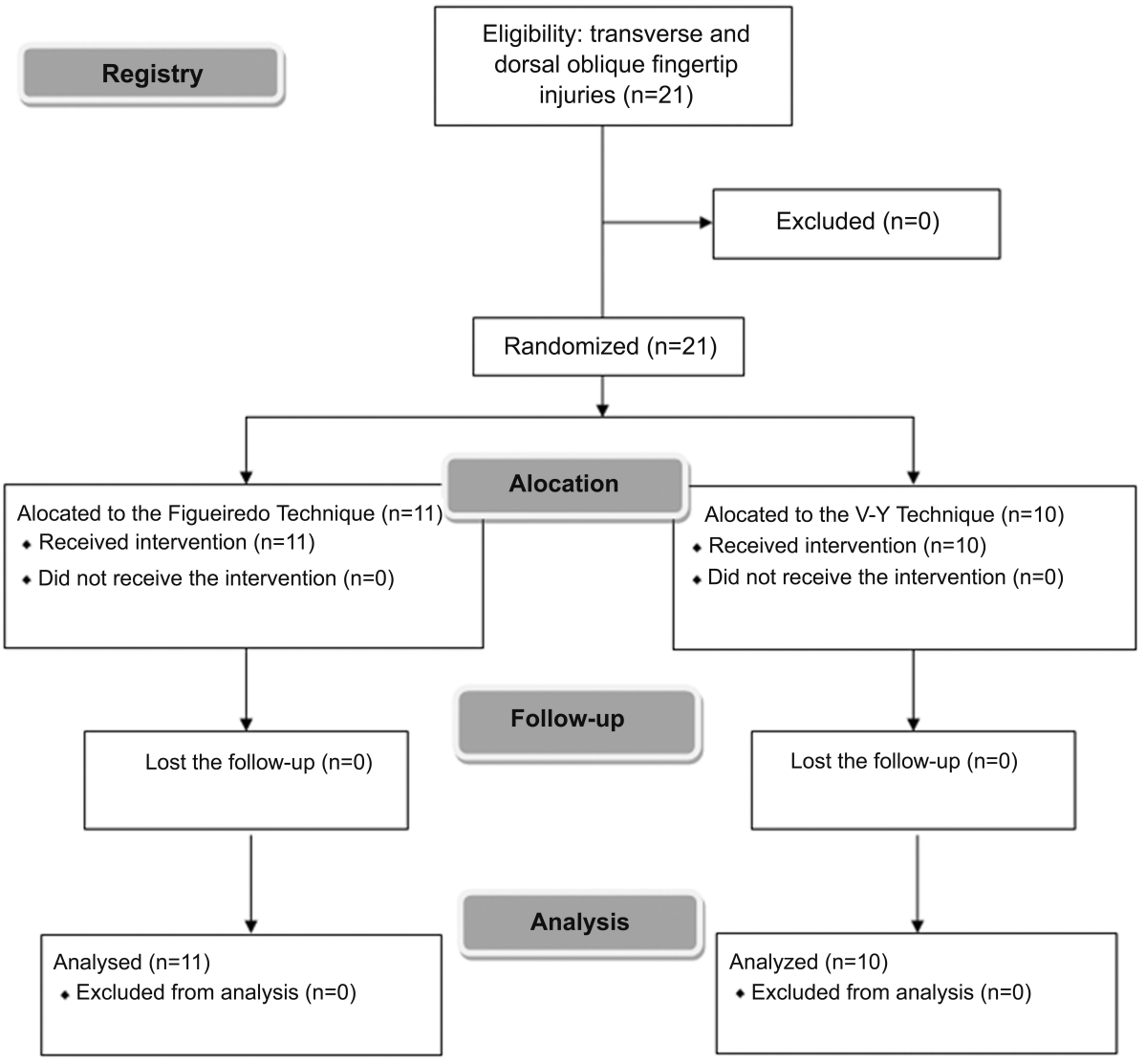


Fig. 1 Consolidated Standards Flowchart of Test Reports (CONSORT).



Fig. 2 Initial injury and surgical procedure – V-Y technique.

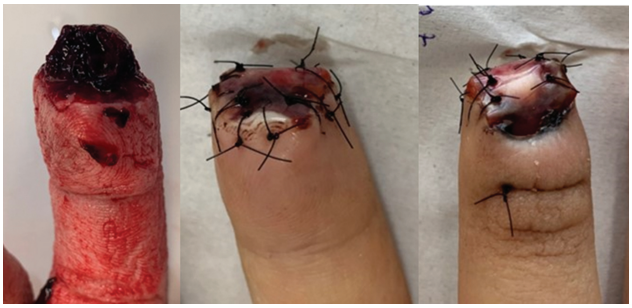


Fig. 3 Initial injury and surgical procedure – Figueiredo technique.

treatment, according to the records of medical records of outpatient consultations, being classified as "present" or "absent". If present, culture and antibiogram analysis would be carried out.

The second criterion evaluated the capacity of static and dynamic discrimination between two points, through the Weber test,[13] comparing with the non-traumatized contralateral side. In this item, the patient was classified as "normal" skilled case to discriminate two points with distance less than 6 mm; "satisfactory" between 6 and 10 mm; "poor" between 11 and 15 mm; "protective" when distinguishes only one point, and "anesthesia" if it can't distinguish any point.

The third criterion evaluated the formation of neuroma by the percussion test on the wound, classifying it as "present" or "absent".

The fourth criterion was the aesthetic and functional evaluation of nail growth, subdivided into three items, as described by Silva and Gerhardt,[14] also compared to the contralateral side. Item 1: Nail growth, rated 0 when there was no growth; 1, when there was partial growth with supports, and 2 with normal growth. Item 2: Nail size, classified with 0, if less than or equal to 50% on the opposite side, 1 when between 50 and 75%, and 2 if greater than or equal to 75%. Item 3: Nail shape, classified by 0 when there was a significant deformity in the vertical plane, 1 when a small deformity was observed, and 2 without deformities. These results were then added and classified as "bad" when the sum has a value less than three, "regular" when three or four, and "good" when five or six. Other variables are presented in ►**Table 1**.

Due to their qualitative nature, the data were analyzed by frequencies and percentages.

The association of categorical variables was performed by means of the Chi-square test, and for expected frequencies



Fig. 4 Respectively, result after 6 weeks and 3 months of the application of FT.

Table 1 Variables of characterization of the lesion and its mechanism of trauma and patient occupation

Variables		N	N%
Profession	Mechanic	6	26.6%
	Janitorial services	5	23.8%
	Stay-at-home person	2	9.5%
	Bricklayer	2	9.5%
	Carpenter	1	4.8%
	Electrician	1	4.8%
	Delivery person	1	4.8%
	Painter	1	4.8%
	Accountant	1	4.8%
	Salesperson	1	4.8%
Injured side	R	6	26.6%
	L	15	71.4%
Injured finger	1	5	23.8%
	2	8	38.1%
	3	5	23.8%
	4	1	4.8%
	5	2	9.5%
Mechanism	Explosive	1	4.8%
	Automatic door	1	4.8%
	Hydraulic press	1	4.8%
	Belt	2	9.5%
	Crushing	4	19.0%
	Bladed weapon	5	23.8%
	Toothed saw	7	33.3%

lower than 5, the Fisher exact test was performed in the case of crosstables that presented the matrix shape 2×2.

For the associations, a significance level of 5% was considered, so *p*-values lower than 0.05 indicated a significant result.

The data were organized in an Excel (Google LLC. Mountain View, CA, US) spreadsheet and analyzed in the Statistical Package for the Social Sciences (SPSS, IBM Corp. Armonk, NY, US) version 27 software.

Results

None of the groups of patients presented infectious or neuroma during the study and there was no significant difference in surgical time for the techniques employed.

In the general clinical evaluation, it was observed that no variable presented a statistically significant association, i.e., both groups presented similar behaviors in the postoperative period. The results are presented in ►**Table 2**.

Discussion

The V-Y advancement flap surgery described by Atasoy and Kleinert is already widely used by surgeons. The triangular flap is often used in fingertip amputation reconstructions with bone exposure and is indicated for transverse or oblique back lesions. This procedure was not recommended for volar oblique lesion. Additionally, it is necessary to use a donor area of cutaneous tissue, coming from a nontraumatized region from the injured finger.[5,15]

The FT, in turn, besides presenting a broader indication than the established Atasoy technique, because it also applies to the treatment of volar oblique lesions, makes it unnecessary to use a healthy donor area, avoiding secondary damage to the patient.[3]

Both techniques are easy to reproduce and can be carried out with low-cost materials.[3,15] The material used as a prosthesis in FT should be sufficiently resistant to protect the site of injury against painful stimuli and external forces, until proper healing occurs, but should not be so rigid as to cause tissue deformities. Thus, the material that proved most appropriate was the saline bag composed of polypropylene, because it was sterile, low cost and easily accessible in surgical centers throughout the country.[3]

In his initial description, Atasoy highlights the sensitivity at the fingertip as an advantage of performing the triangular

Table 2 Evaluation results three months after surgery

Variables		Figueiredo		V-Y		*P*-value
		N	N%	N	N%	
Infection	No	11	100,0%	10	100,0%	
Two static points	Normal	6	54,5%	4	40,0%	0,67
	Satisfactory	5	45,5%	6	60,0%	
Two dynamic points	Normal	8	72,7%	4	40,0%	0,198
	Satisfactory	3	27,3%	6	60,0%	
Neuroma	No	11	100,0%	10	100,0%	
Nail growth	1	1	9,1%	0	0,0%	0,999
	2	10	90,9%	10	100,0%	
Nail size	0	2	18,2%	0	0,0%	0,261
	1	5	45,5%	3	30,0%	
	2	4	36,4%	7	70,0%	
Nail shape	0	2	18,2%	0	0,0%	0,473
	1	6	54,5%	5	50,0%	
	2	3	27,3%	5	50,0%	
Nail complete	2	2	18,2%	0	0,0%	0,134
	4	3	27,3%	3	30,0%	
	5	5	45,5%	2	20,0%	
	6	1	9,1%	5	50,0%	

flap.[7,15] As presented in this study, coverage through FT presents results similar to the technique already established.

In the evaluation of the capacity of static discrimination between two points, 54.5% of the patients in the FT group were classified as normal and 45.5% as satisfactory. In the V-Y flap group, 40% of patients were classified as normal and 60% as satisfactory.

Regarding the capacity of dynamic discrimination between two points, the group submitted to reconstruction by V-Y maintained the results presented in the static evaluation. While in the TF group, there was an improvement in the results, with 72.7% classified as normal and 27.3% as satisfactory.

Considering the nail growth item in the FT group, 18.2% of the patients presented poor results, 27.3% regular, and 54.6% good results. In the V-Y group, no patient had poor results, 30% had regular, and 70% good.

A common concern in cases where there is bone exposure is the possibility of infection.[16] In none of the studied groups, this complication was present, evidencing that both techniques are safe in this item. Although it is a concern when flaps are performed, in this study there were no cases of digital skin necrosis in patients operated with the V-Y technique.

It is important to note that, in patients undergoing FT, there is the most exuberant formation of fibrin tissue between the second and third weeks, which has typical yellowish coloration and can lead the patient to imagine that it is purulent secretion. For this reason, patients should be alerted in advance about this important transitional stage of treatment. This yellowish tissue is precisely the ideal mold and will be gradually replaced by granulation tissue that will then undergo epithelialization process until complete healing. During this period, there is continuous improvement in the aspect of the entire area around the wound, with decreased edema and absence of phlogistic signs.[3]

The established V-Y technique is effective and presents excellent results when performed by a specialized professional. The FT showed the same efficacy and emerges as an alternative for the treatment of fingertip lesions, also standing out due to its easy execution—which can be performed by a larger number of surgeons—and for providing protection to the site of injury without requiring a healthy donor area, thus allowing wound healing to occur by a second intention.

As a limitation of the study, the non-correlation between the severity of the initial lesion and the outcome after treatment can be highlighted. More severe lesions with greater soft tissue involvement, associated with nail bed injury and fractures, generally present worse aesthetic and functional results and with greater sequelae, regardless of the surgical technique applied.

Another limitation of the study was the small sample, which occurred due to the demand for cases available in the proposed period for the study. These results can be used for future studies of hand surgery techniques.

Conclusion

The present study concluded that the FT is as efficient as the Atasoy-Kleinert V-Y advancement flap technique, both of which can be used for the treatment of transverse and dorsal

oblique fingertip lesions, presenting good aesthetic and functional results for such lesions.

Financial Support
The authors declare that this study received no financial support from public, commercial, or non-profit sources.

Conflicts of Interest
The authors have no conflicts of interest to declare.

References

1 Junqueira GDR, Lima ALM, Boni R, Almeida JC, Ribeiro RS, Figueiredo LA. Incidence of acute trauma on hand and wrist: a retrospective study. Acta Ortop Bras 2017;25(06):287–290
2 Martin C, González del Pino J. Controversies in the treatment of fingertip amputations. Conservative versus surgical reconstruction. Clin Orthop Relat Res 1998;(353):63–73
3 Figueiredo LA, Ribeiro RS, Melo ALB, Lima AL, Terra BB, Ventim FC. Uso da prótese de polipropileno para o tratamento das lesões em ponta de dedo. Descrição de técnica cirúrgica e resultados. Rev Bras Ortop 2017;52(06):685–692
4 Netscher D, Murphy DK, Fiore AN. Hand Surgery. In: Townsend CM Jr, Beauchamp RD, Evers B M, editors. Sabiston Textbook of Surgery: The Biological Basis of Modern Surgical Practice. 20th ed. Canadá: Elsevier; 2016:1975–2026
5 Matsumoto MK, Fernandes M, de Moraes VY, Raduan J, Okamura A, Belloti JC. Treatment of fingertip injuries by specialists in hand surgery in brazil. Acta Ortop Bras 2018;26(05):294–299
6 Panattoni JB, De Ona IR, Ahmed MM. Reconstruction of fingertip injuries: surgical tips and avoiding complications. J Hand Surg Am 2015;40(05):1016–1024
7 Atasoy E, Ioakimidis E, Kasdan ML, Kutz JE, Kleinert HE. Reconstruction of the amputated finger tip with a triangular volar flap. A new surgical procedure. J Bone Joint Surg Am 1970;52(05): 921–926
8 Souza RF. O que é um estudo clínico randomizado? Medicina (B Aires) 2009;42(01):3–8
9 Escosteguy CC. Methodological and statistical topics in randomized controlled clinical trials. Arq Bras Cardiol 1999;72(02): 139–148
10 Vaitsman GP, Bonadia CRF, Cardoso GF, Barona KEP, Esbérard F, Silva ML. Opções de retalhos para regularização de cotos de amputação e reconstrução de quirodáctilos. Rev Bras Cir Plást 2010;25(03):78
11 Silva JB, Martins P, Fridman M. Retalhos homodigitais nas perdas de substância distais. Rev Bras Ortop 1998;33(11):906–910
12 Germann G, Rudolf KD, Levin SL, Hrabowski M. Fingertip and Thumb Tip Wounds: Changing Algorithms for Sensation, Aesthetics, and Function. J Hand Surg Am 2017;42(04):274–284
13 Wilgis EF. Techniques for diagnosis of peripheral nerve loss. Clin Orthop Relat Res 1982;(163):8–14
14 Silva JB, Gerhardt S. Trauma to the nail complex. Rev Bras Ortop 2014;49(02):111–115
15 Cely AG, Díaz AM, Rueda JA, Forero PL. Colgajo de Atasoy: revisión de una técnica clásica para reconstrucción digital. Med UIS 2018; 31(01):57–64
16 Zalavras CG. Prevention of Infection in Open Fractures. Infect Dis Clin North Am 2017;31(02):339–352

Arthroscopy Treatment of Scaphoid Pseudarthrosis: Description of the Technique and Case Series

Tratamento da pseudoartrose do escafoide com uso de artroscopia: Descrição da técnica e série de casos

Ricardo Kaempf[1] João Brunelli[1] Leohnard Bayer[1] Márcio Aita[2] Santhiago Pereira Schneider[1] Pedro J. Delgado[3]

[1] Santa Casa de Misericórdia de Porto Alegre, Porto Alegre, RS, Brazil
[2] ABC Medical School, Santo André, SP, Brazil
[3] Madrid Monteprincipe University Hospital, San Pablo CEU University, Boadilla del Monte, Madrid, Spain

Address for correspondence Ricardo Kaempf, MD, Rua Leopoldo Bier, 825 Conjunto 301, Porto Alegre, RS, CEP: 90620-100, Brazil (e-mail: ricardokaempf@gmail.com).

Rev Bras Ortop 2024;59(5):e719–e729.

Abstract

Objective To describe the procedure and evaluate the results of a series of patients with stable and unstable pseudarthrosis of the scaphoids treated with the use of arthroscopy associated with cancellous bone graft and compression screw.

Methods Twenty-three patients were treated with this technique. The minimum postoperative follow-up was 12 months, and pre- and postoperative functional, clinical, and imaging analyses were performed.

Results Themean time from fracture to surgery was 26 months (12–60). Preoperative and postoperative clinical and radiological parameters were analyzed. The mean follow-up was 24.2 (12–60) months. Consolidation occurred in 22 patients (95.6%) in an average of 7.5 (4–12) weeks. Mean flexion range ofmotion improved from73.6° (60–80°) to 79.5° (60–90°); the range from 68.6° (50–80°) to 71.9° (45–85°); ulnar deviation from 20.6° (15–30°) to 26.9° (20–35°); and the radial deviation from 17.3° (15–25°) to 20.4° (10–25°). Pain (Visual Analog Scale [VAS] 0–10) improved from 7.3 (4–9) to 0.7 (0–6) and DASH functional scale improved from 49 (32–75) to 6 (2–12). The scapholunate angle improved from 69.1° (55–85°) to 48.4° (40–55°) and the radiolunar angle improved from 30° (10–40°) to 2.6° (0–8°).

Conclusion Treatment of stable and unstable pseudarthrosis of the scaphoid with spongy bone graft and percutaneous internal fixation, preferably with a headless compression screw, assisted by arthroscopy, showed good clinical and radiographic results in our series, with a short time for consolidation and functional recovery.

Keywords
- arthroscopy
- bone screws
- graft
- pseudarthrosis
- scaphoid bone
- wrist

Work carried out at the Santa Casa de Misericórdia de Porto Alegre, Porto Alegre, RS, Brazil.

received
March 9, 2022
accepted after revision
December 16, 2022

DOI https://doi.org/10.1055/s-0043-1770969.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Resumo

Objetivo Descrever o procedimento e avaliar os resultados de uma série de pacientes com pseudartroses estáveis e instáveis dos escafoides tratados com o uso de artroscopia associado a enxerto ósseo esponjoso e parafuso de compressão.

Método Foram tratados 23 pacientes com esta técnica. O acompanhamento mínimo no pós-operatório foi de 12 meses, e foram realizadas análises funcionais, clínicas e de imagem pré e pós-operatórias.

Resultados O tempo médio desde a fratura até a cirurgia foi de 26 meses (12-60). Parâmetros clínicos e radiológicos pré-operatório e pós-operatório foram analisados. O seguimento médio foi de 24,2 (12-60) meses. A consolidação ocorreu em 22 pacientes (95,6%) em uma média de 7,5 (4-12) semanas. A amplitude média de movimento de flexão melhorou de 73,6° (60-80°) a 79,5° (60-90°); a extensão de 68,6° (50-80°) a 71,9° (45-85°); o desvio ulnar de 20,6°(15-30°) a 26,9° (20-35°); e o desvio radial de 17,3° (15-25°) em 20,4° (10-25°). A dor (Escala Visual Analógica [EVA] 0-10) melhorou de 7,3 (4-9) para 0,7 (0-6) e a escala funcional DASH melhorou de 49 (32-75) para 6 (2-12). O ângulo escafolunar melhorou de 69,1°(55-85°) para 48,4° (40-55°) e o ângulo radiolunar melhorou de 30°(10-40°) a 2,6° (0-8°).

Conclusão O tratamento das pseudartrose estáveis e instáveis do escafoide com enxerto ósseo esponjoso e fixação interna percutânea, preferencialmente com parafuso de compressão sem cabeça, assistidos por artroscopia, mostrou bons resultados clínicos e radiográficos na nossa casuística, com curto tempo de consolidação e recuperação funcional.

Palavras-chave

- artroscopia
- enxertos
- osso escafoide
- parafusos ósseos
- pseudartrose
- punho

Introduction

Consolidation failure is one of the main complications in the treatment of scaphoid fractures, and it can progress to a degenerative pattern called SNAC (scaphoid nonunion advanced collapse) wrist, which generates pain, stiffness and loss of strength. To prevent this serious problem, scaphoid pseudarthrosis must be treated surgically, and the classic procedure is based on debridement of the lesion focus, placement of a bone graft and rigid internal fixation.[1–6]

The choice of the type of bone graft used in the treatment of scaphoid pseudarthrosis varies according to the vascularization and deformity of the scaphoid, which may be spongy for lesions with little deformity, cortico-spongy for unstable lesions and humpback deformity, and vascularized when the proximal pole of the scaphoid is necrotic.[2,3,6,7] These techniques make it possible to correct the deformity and restore the anatomy and alignment of the carpus, but most of them require a broad approach, producing damage to the capsule and ligaments, which may cause fibrosis, stiffness and loss of proprioception.[8]

Recently, some authors have shown the advantages of using arthroscopy and minimally invasive procedures in the treatment of fractures and scaphoid pseudarthrosis. It highlights the lower morbidity, generating rapid recovery, in addition to allowing the treatment of associated injuries during the same procedure. In addition, wrist proprioception is preserved by minimizing damage to the capsule and ligaments and does not cause further damage to the already fragile vascularization of the scaphoid.[9–15]

Arthroscopy was initially indicated for stable scaphoid pseudarthrosis, taking into account the difficulty of correcting the scaphoid flexion deformity without the use of a structured cortico-spongy graft.[14] However, Cohen et al.[3], using only cancellous bone graft (unstructured) in scaphoid pseudarthrosis with collapse, had 100% consolidation and excellent clinical results with two years of evolution. As a result, some authors began to use arthroscopy in the treatment of all patterns of scaphoid pseudarthrosis, including those that were unstable and collapsed in flexion.[14,16,17] Recent articles even show good results in the treatment of scaphoid pseudarthrosis without the use of bone graft, betting on the biological regenerative potential of the wrist and bone stability.[18]

We will describe here the technique and results of a series of 23 patients with scaphoid pseudarthrosis, including unstable lesions and carpal collapse, treated using arthroscopy, cancellous graft and percutaneous internal fixation, preferably with headless compression screw.

Material and method

This work was submitted and accepted by the ethics committee of our hospital, and the term of Free, Prior and Informed Consent used was approved.

Twenty-three patients (18 men and 5 women) were operated on using this technique. The mean age was 33.4 (16-55) years and the mean time between fracture and surgery was 26 months (12-60). As for the type of initial fracture, 1 was A2, 7 were B1, 9 were B2 and 6 were B3,

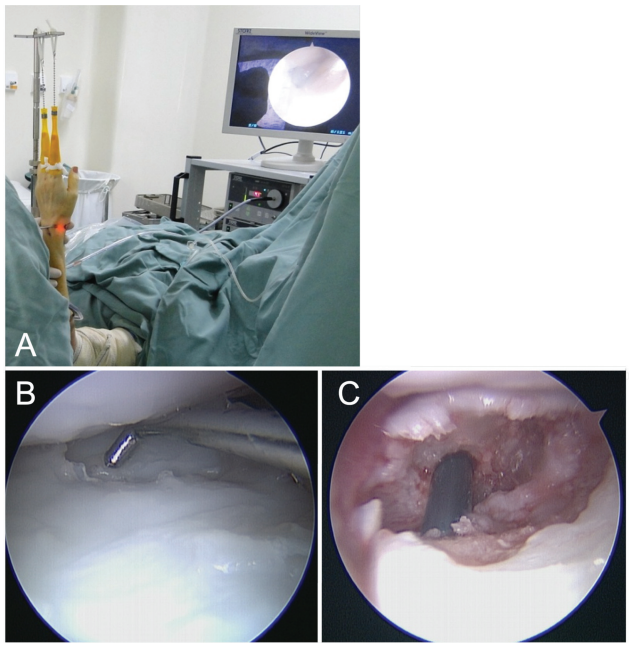


Fig. 1 Patient with scaphoid pseudarthrosis treated using arthroscopy, cancellous bone graft and percutaneous internal fixation, using a specific traction tower and Chinese mesh placed on the second and fourth fingers (A). We used the ulnar radiocarpal portals for visualization and the radial one for instrumentation (probe) (B). After fixation, the correct position of the headless compression screw (C) can be seen.

according to the Herbert and Fisher classification.[19,20] Among the included cases, 5 (21.7%) had fibrous union and 11 (47.8%) had humpback deformity. In three patients, a partial lesion of the scapholunate ligament was observed during arthroscopy, and two had a TFCC lesion, having been treated in the same procedure.

We present a retrospective study of a series of patients diagnosed with scaphoid pseudarthrosis treated with arthroscopy-assisted reconstruction, operated between January 2016 and October 2020. The inclusion criteria were absence of consolidation after fracture of the scaphoid at least six months ago of evolution after the initial trauma. Patients with severe degenerative changes in the radiocarpal and midcarpal joints (RC) (SNAC types II and III) were excluded. The evaluation of the vascularization of the proximal pole was performed using magnetic resonance imaging (MRI). However, vascular alteration of the scaphoid was not an exclusion criterion, nor was previous surgery at the site.

After anamnesis and physical examination suggestive of the lesion, all patients had the diagnosis confirmed with bilateral radiographs of the wrist, showing classic characteristics of scaphoid pseudarthrosis, with consolidation failure associated with sclerosis at the bone edges and cystic alterations. Before surgery, all patients underwent bilateral radiography of the wrists and computed tomography (CT) and MRI of the affected wrist.

We used the Herbert and Fischer classification preoperatively to define the type of scaphoid fracture.[19,20] (►**Table 1**). The degree of displacement and instability of the lesion, defined through the scapholunate (SL) and radiolunar (RL) angles, were obtained using PACS® system measurement tools (Terch Heim, Seoul, Republic of Korea).[4]

Following these criteria, 27 patients who underwent treatment of scaphoid pseudarthrosis with arthroscopy were found. Due to lack of adequate follow-up, four patients were excluded, and 23 patients were analyzed, who had a complete evaluation and a minimum postoperative follow-up of 12 months. The results analyzed the clinical aspect, consolidation time and time to return to physical and work activities, as well as possible complications resulting from the surgery. All surgeries were performed according to the technique described here.

Postoperatively, a radiological study of the wrist was carried out in projections specific to the scaphoid every two weeks until consolidation, including lateral, posteroanterior and oblique projections with 45° of pronation of the

Table 1 Classification of scaphoid fractures by Herbert and Fisher

Classification of scaphoid fractures by Herbert and Fisher				
	Type	**Column 1**	**Sub-type**	**Location and/or injury**
A	Acute stable fracture		A1	Tubercle
			A2	Nondisplaced crack in the waist
B	Acute unstable fracture		B1	Oblique
			B2	Displaced or mobile, waist
			B3	Proximal pole
			B4	Fracture-dislocation
			B5	Comminuted
C	Delayed union		C	
D	Established nonunion		D1	Fibrous
			D2	Sclerotic
	Taken from Herbert and Fisher (17)			

forearm. In case of doubt about the healing of the scaphoid, CT scans were performed every 30 days.

Range of motion was assessed with a standard goniometer and a functional assessment was performed with the DASH questionnaire.[21] These assessments were performed preoperatively and at the end of follow-up. Bone consolidation was clinically determined by the absence of pain on palpation of the scaphoid in the anatomical snuffbox and through examinations with the presence of a bone bridge between the two ends of the scaphoid pseudarthrosis in all radiographic projections or in at least two CT slices.[17,22]

Surgical technique

To access the site of the scaphoid pseudarthrosis, the ulnar midcarpal (MC) portal is used for vision (optical) and the radial MC portal as the working portal (probe, shaver, curettes, osteotomes). The site of the scaphoid pseudarthrosis is initially explored and opened using a periosteum reamer (3mm Freer), after which it is debrided with a soft tissue and bone shaver. Finally, the devitalized fibrous and bone tissue is removed with the aid of curved curettes and delicate osteotomes. We used the dry arthroscopic technique for most of the procedure, with the serum used only for joint cleaning and removal of resected tissue fragments.

After cleaning the site of the scaphoid pseudarthrosis, the next step is to correct the DISI deformity of the proximal row of the carpus, obtained with the fixation of the reduced lunate with a 1.5mm K-wire.

Afterwards, the spongy bone graft must be placed in the site of the scaphoid pseudarthrosis. We use an insulin syringe with its tip cut obliquely to facilitate the entry and positioning of the graft. The radial MC portal must be widened by a few millimeters to allow syringe entry. After placing the graft in the pseudarthrosis site, it must be impacted with the back of a curette or with a periosteum reamer. In scaphoid pseudarthrosis of the middle or distal third, when radius styloidectomy is performed through the RC 1/2 portal, this portal can also be used for cleaning the pseudarthrosis focus and placing the graft, providing direct access to the radial and volar portion of the scaphoid.

The last step of the procedure is the reduction of the distal pole and fixation of the scaphoid, preferably with the headless compression screw. Depending on the type and location of the lesion, fixation can be performed with Kirschner wires, mini-fragment screws or associated methods. For this, the handle is removed from the traction tower and placed with the palm upwards on the support table. For the reduction of the distal pole, the wrist must be positioned at maximum extension, a maneuver that also generates better alignment and gain in length of the scaphoid. We routinely use the retrograde percutaneous fixation technique for scaphoid pseudarthrosis of the middle and distal thirds. In it, a guide wire is initially used, which must enter right into the trapezium, and after checking that the wire is fixing the two fragments of the scaphoid and is central in its longitudinal axis, it must serve as a guide for the placement of the compression screw without head (cannulated Herbert or similar) (►**Fig. 1**). For scaphoid pseudarthrosis of the proximal third, we used anterograde fixation, which should be performed with the wrist in flexion and with the entry of the guide wire through the dorsum of the CR joint, so that the screw is centrally located in the longitudinal axis of the scaphoid. The correct entry point for the guide wire and subsequently for the screw can be found with the aid of arthroscopy. Under direct visualization, an abocath is placed in the proximal and ulnar part of the scaphoid, next to the insertion of the scapholunate ligament (►**Figs. 2**, **3**, **4**, **5** and **6**).

We usually perform this procedure on an outpatient basis. After the surgery, the patient is immobilized with a plaster

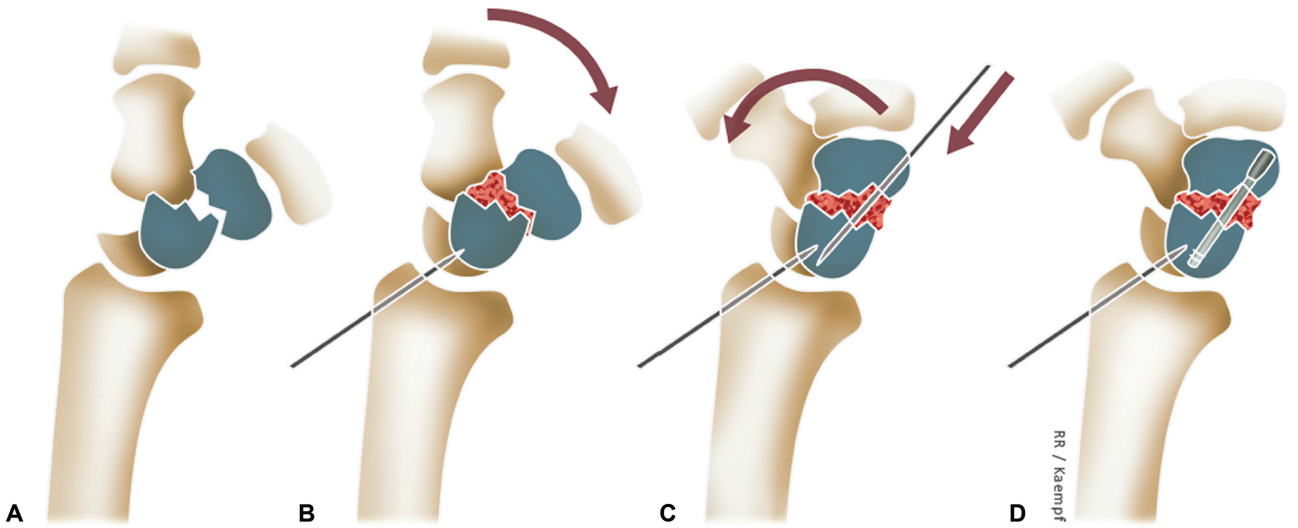


Fig. 2 Technique for the arthroscopic treatment of scaphoid pseudarthrosis. After cleaning the edges of the pseudarthrosis, the proximal pole of the scaphoid is reduced by fixing the lunate to the radius in a neutral position (A). The bone graft is placed in the space created (B) and the wrist is reduced to the maximum extent (C) so that the distal pole of the scaphoid is reduced (1) and the scaphoid gains length. The scaphoid is then fixed with a 1.2mm Kirschener wire (2) and both scaphoid fragments are fixed with a cannulated headless screw. (D).

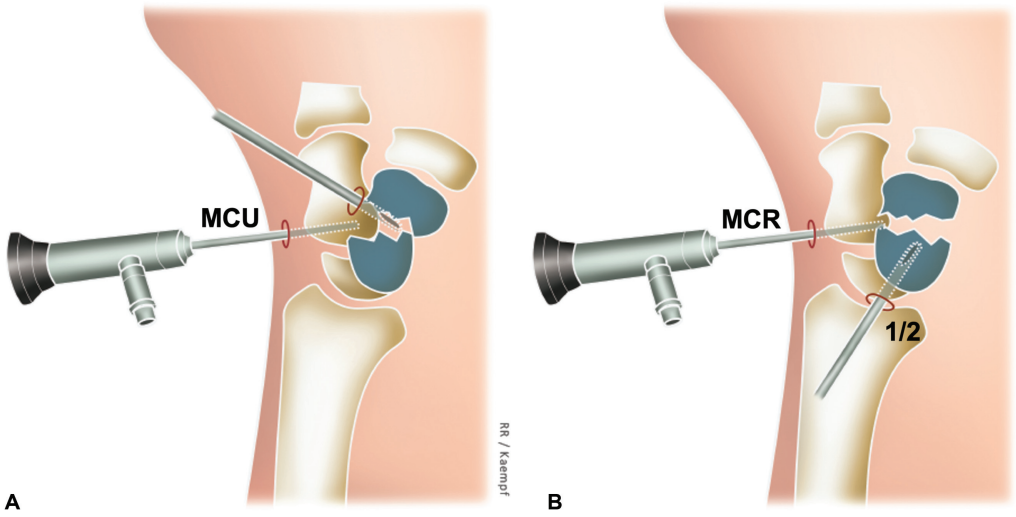


Fig. 3 Initially, the ulnar MC portal is used for vision (optical) and the radial MC portal as the workplace (probe, shaver, curettes, osteotomes) (A). Afterwards, in pseudarthrosis of the middle third or distal scaphoid, when the radius styloidectomy is performed through the RC 1/2 portal, this portal can also be used to clean the focus of the pseudarthrosis and place the graft, providing direct access to the radial portion and scaphoid volar (B).

splint on the wrist (antebrachio-palmar), leaving the fingers and thumb completely free, for two weeks. We maintained the FK by fixing the radius to the lunate for four weeks, after which the splint was removed and the patient was referred to therapy. Lesions heal over an average period of seven weeks (►**Fig. 7**), and until consolidation, the patient is advised to use a removable orthosis on the wrist in activities that require strength.

Results

Consolidation was achieved in 22 patients (95.6%) in an average of 7.5 weeks (4 to 12). As for complications, one patient did not heal and another had skin burns due to overheating of the shaver motor, which was resolved with serial dressings. None of the patients had neurotendinous

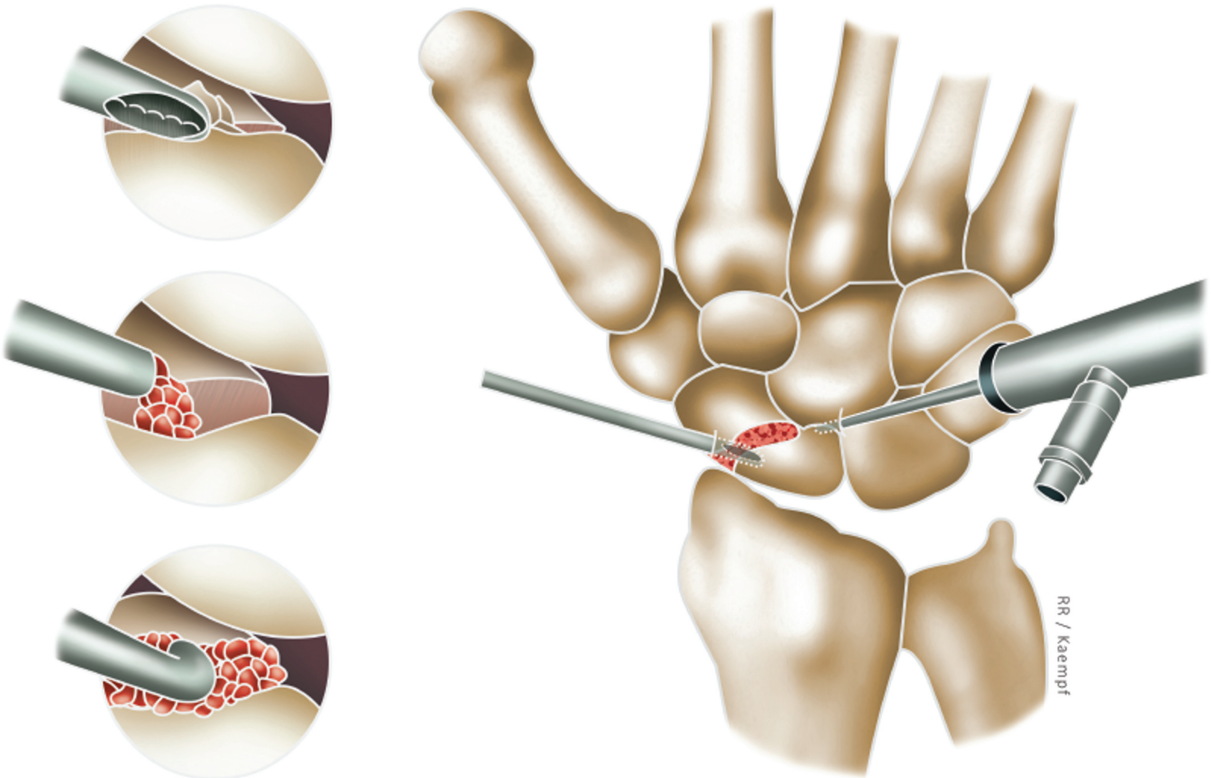


Fig. 4 Main steps in the treatment of scaphoid pseudarthrosis using arthroscopy. Initially, the focus of the lesion is cleaned using a shaver (top detail). After that, the bone graft is placed and its impaction is performed (middle and lower detail).

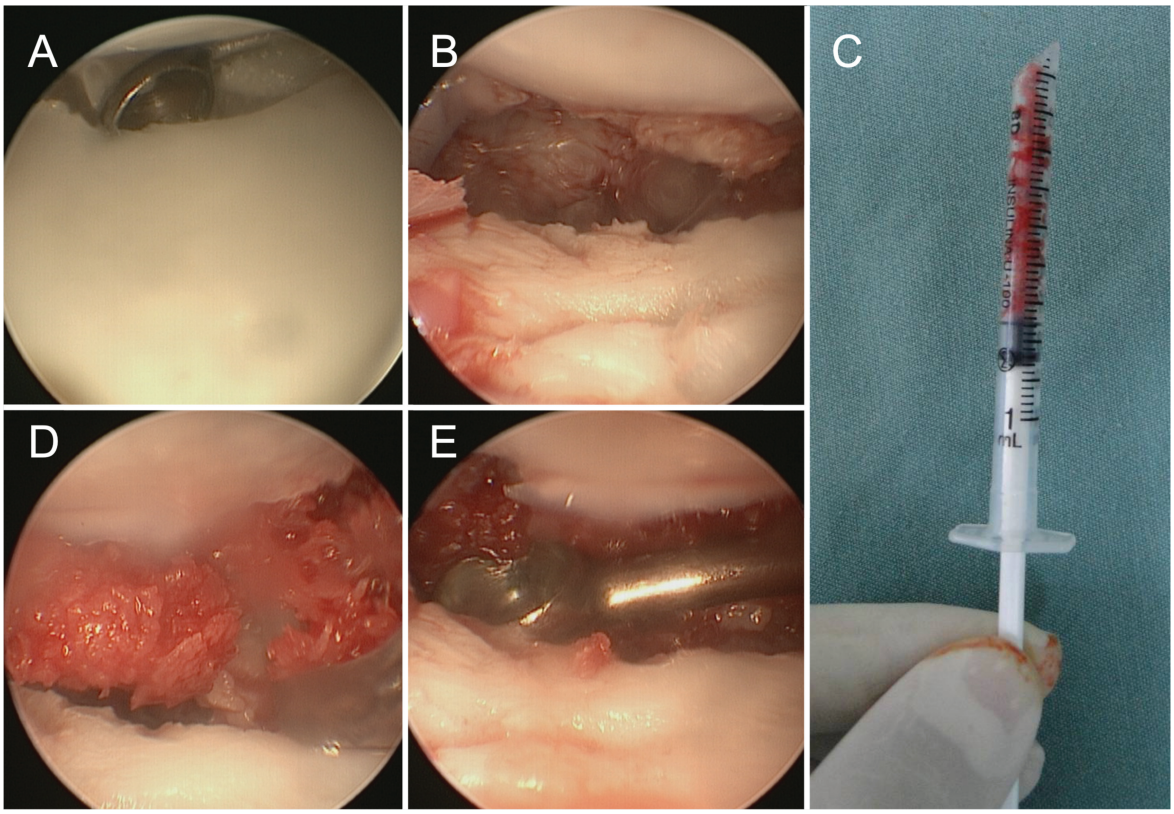


Fig. 5 Cleaning of the scaphoid bone defect with the aid of a curette (A and B), bone graft placed in an insulin syringe (C and D) and the final appearance after impaction of the graft inside the bone defect (E).

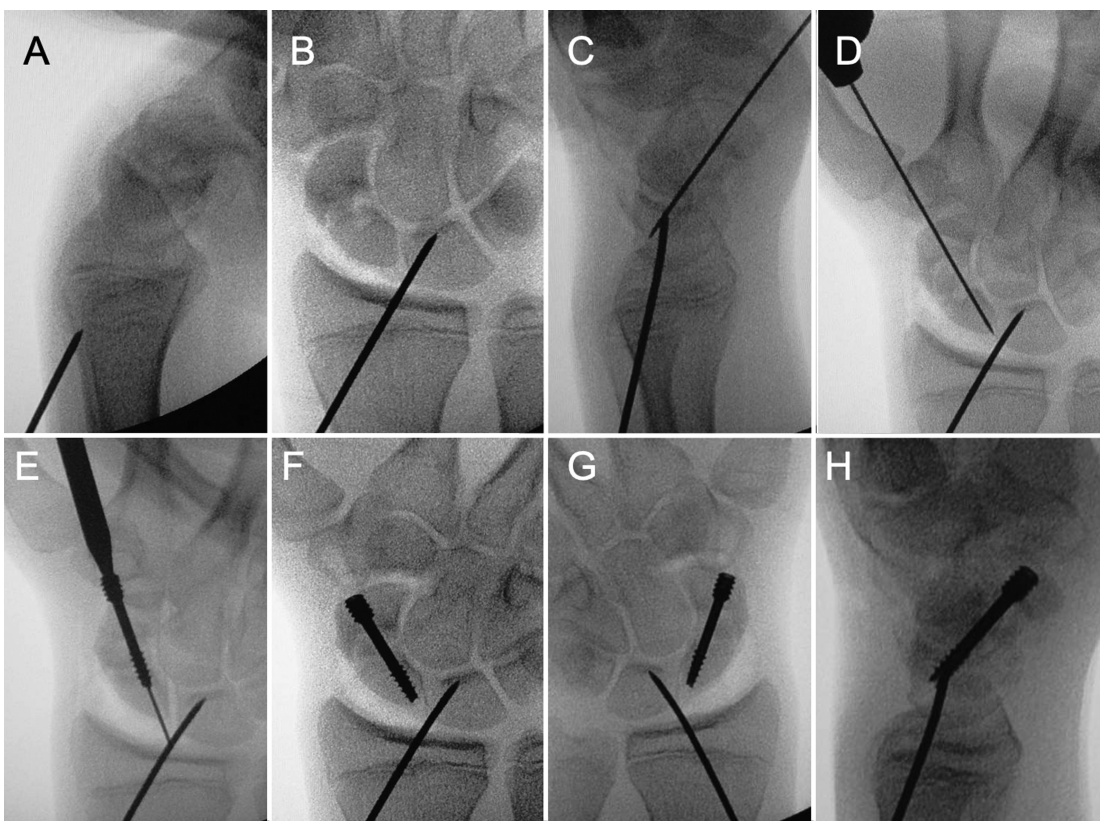


Fig. 6 Steps of reduction of the scaphoid and restoration of carpal alignment with a Kirschner wire through the radius, fixing the lunate in a neutral position (A and B). Afterwards, placement of the guide Kirschner wire (C and D) and percutaneous fixation with the headless compression screw in a retrograde manner (E, F, G and H).

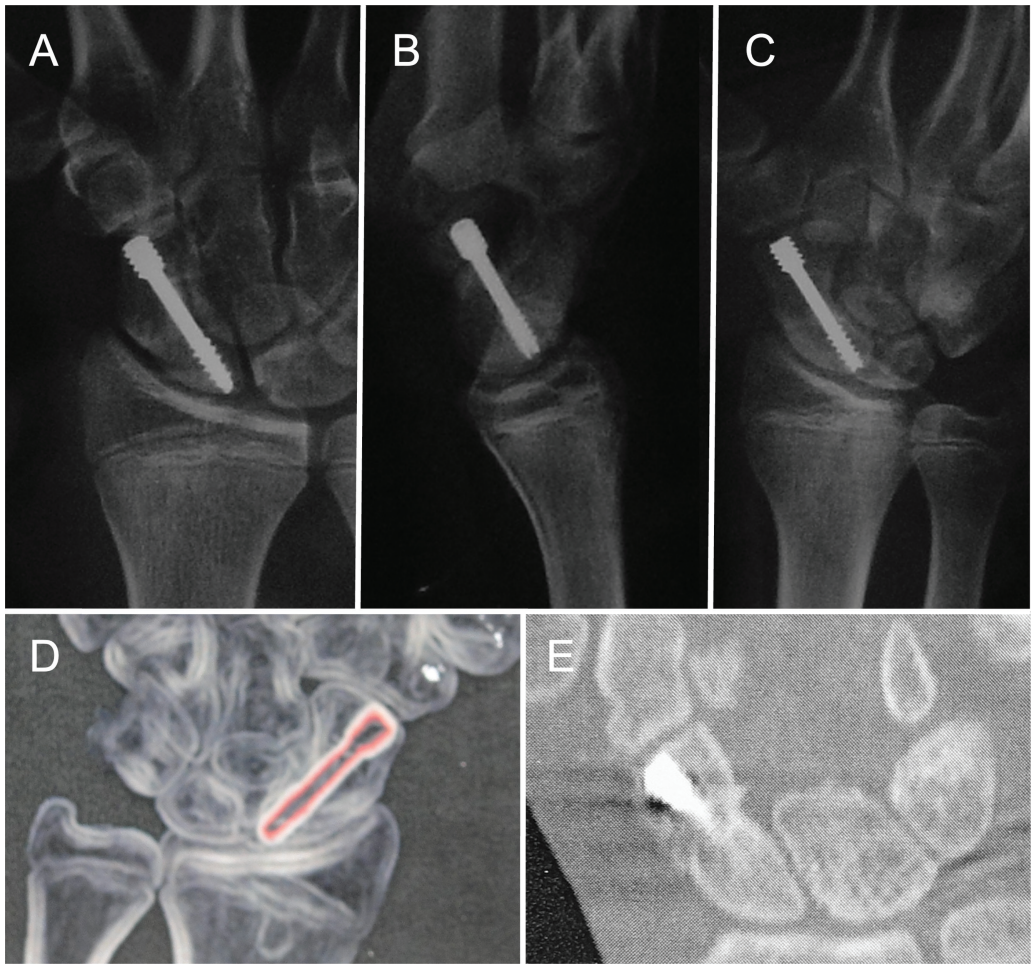


Fig. 7 Consolidation of pseudarthrosis after five weeks of evolution. Observed by radiographs (A, B and C) and computed tomography (D and E).

injuries or there was a need to reverse the procedure using an open technique.

The mean follow-up was 24.2 months (12-60) months. The degree of mobility, pain, functional assessment (DASH questionnaire) and radiographic measurements improved in relation to the preoperative period, being shown in ►**Tables 2** and **3**. Mean flexion range of motion improved from 73.6° (60-80°) to 79.5° (60-90°), extension from 68.6° (50-80°) to 71.9° (45°). -85°), ulnar deviation 20.6° (15-30°) to 26.9° (20-35°) and radial deviation 17.3° (15-25°) to 20.4° (10-25°) . Pain (VAS 0-10) improved from 7.3 (4-9) to 0.7 (0-6), and the DASH functional scale improved from 49 (32-75) to 6 (2-12). The scapholunate angle improved from 69.1° (55-85°) to 48.4° (40-55°) and the radiolunar angle improved from 30° (10-40°) to 2.6° (0- 8°) (►**Fig. 8**).

Discussions

Other studies have already shown good results using minimally invasive methods in the treatment of fractures and scaphoid pseudarthrosis. They are associated with lower morbidity, fast recovery and allow the treatment of associated injuries during the same procedure.[6,9,14,17,23]

When untreated, scaphoid pseudarthrosis generates instability that progresses to an early degenerative process, with carpal collapse, a pattern known as SNAC wrist.[1,5] Thus, the objective of the surgical treatment of scaphoid pseudarthrosis is to achieve bone consolidation associated with restoration of bone anatomy and carpal alignment. For this, techniques with different concepts have been described, some that prioritize mechanical bone stability, including the use of plates and screws, and others that aim to maintain and stimulate vascular biology, stimulating early healing.[7,14,16,18,24]

Arthroscopy was initially indicated for stable and fibrous scaphoid pseudarthrosis, however, with the evolution of the technique and the confirmation that there is no need for a structural graft to correct the deformity in scaphoid flexion, its use was expanded to unstable scaphoid pseudarthrosis and with flexion collapse. In chronic and unstable scaphoid pseudarthrosis, techniques using cortico-spongy bone grafts (vascularized or not) offer the greatest guarantee of obtaining bone consolidation and restoring the alignment and anatomy of the carpus. However, as they are open techniques, they generate aggression to local tissues and neurovascular structures, and may also damage the extrinsic stabilizing ligaments of the carpus, in addition to the risk of stiffness, infection, graft protrusion and delay in achieving complete consolidation, a time that varies in the literature between 12 to 19 weeks.[2,3,6]

Rev Bras Ortop Vol. 59 No. 5/2024 © 2024. The Author(s).

Table 2 Preoperative findings of the casuistry of the article

Patient	Gender	Age	Side	Dominance	Pseudarthrosis time (months)	Class. by Herbert	Sla	Rla	Pain	Flex.	Ext.	Rd	Ud	Dash
1	M	28	R	R	12	B1	60	20	8	75	70	20	30	60
2	M	16	R	R	12	A2	65	25	4	80	75	25	25	32
3	F	55	R	R	36	B1	60	20	7	65	70	15	20	46
4	M	51	L	R	48	B2	80	40	8	65	60	15	15	50
5	M	20	R	L	18	B3	55	10	9	70	65	20	15	38
6	M	34	L	L	24	B2	80	20	8	70	60	20	20	72
7	M	29	R	R	16	B1	70	20	7	80	70	20	25	63
8	M	37	R	R	36	B2	75	30	9	75	75	15	20	57
9	F	42	R	R	20	B2	75	25	9	60	65	15	20	75
10	F	24	R	R	24	B2	85	15	8	75	70	20	15	46
11	M	25	L	R	12	B3	70	25	7	70	60	15	20	52
12	M	28	R	R	20	B3	60	10	6	80	70	20	30	36
13	M	45	L	R	36	B2	70	20	7	80	75	15	20	39
14	M	32	R	R	12	B1	75	30	8	70	75	15	20	52
15	M	17	R	R	18	B1	60	15	6	80	70	20	20	41
16	M	47	R	R	48	B2	70	20	9	75	70	15	20	64
17	M	49	L	L	42	B3	60	15	8	70	65	15	20	48
18	M	38	R	R	18	B1	65	25	7	80	70	20	25	37
19	M	37	R	R	24	B3	70	20	7	70	60	15	20	61
20	M	31	R	L	20	B3	60	10	5	80	75	15	20	42
21	F	21	R	R	60	B1	80	20	8	70	70	15	20	50
22	M	36	R	L	18	B2	75	10	8	75	75	20	15	42
23	F	28	R	R	24	B2	70	15	7	80	80	15	20	46

Abbreviations: class., classification; ext., extension; flex., flexion; RD, radial deviation; RLA, radioulnar angle; SLA, scapholunate angle; UD, ulnar deviation.

Table 3 Trans- and postoperative findings of the casuistry of the article

Patient	Gender	Age	Pain	SLA	RLA	Flex.	Ext.	RD	UD	Graft	Screw	Consol. (weeks)	DASH	Return to work (weeks)
1	M	28	1	50	0	80	70	20	35	IL	Her.	8	8	6
2	M	16	0	45	5	80	75	25	25	IL	Her.	6	5	4
3	F	55	1	50	5	70	70	15	20	IL	Her.	8	6	8
4	M	51	2	50	0	75	70	15	15	IL	Her.	10	7	12
5	M	20	1	45	5	80	65	20	25	IL	Her.	8	3	10
6	M	34	0	50	0	70	60	25	30	IL	Her.	10	12	8
7	M	29	0	45	5	85	75	20	30	IL	Her.	7	11	12
8	M	37	0	50	0	80	80	25	30	Rad.	ACCU	10	2	12
9	F	42	2	50	3	70	65	20	25	IL	Her.	8	9	10
10	F	24	1	55	5	80	75	25	20	IL	Her.	12	6	4
11	M	25	0	45	0	85	80	20	35	IL	Her.	10	4	4
12	M	28	0	45	0	90	80	25	30	Rad.	Normal	12	2	6
13	M	45	0	50	5	90	85	20	30	IL	Her.	8	8	8
14	M	32	1	55	0	75	75	20	35	IL	Her.	10	6	4
15	M	17	0	40	0	90	80	25	30	IL	Her.	8	2	10
16	M	47	2	55	5	75	65	10	20	Rad.	Her. + K-Wire	16	7	12
17	M	49	1	50	0	65	70	15	25	IL	Her.	12	10	16
18	M	38	0	45	5	80	80	20	30	IL	Her.	8	4	12
19	M	37	1	50	5	75	60	20	25	IL	Her.	10	11	4
20	M	31	0	45	0	90	75	20	30	Rad.	Mini	12	8	10
21	F	21	2	50	5	80	70	20	25	IL	Her.	10	6	12
22	M	36	2	50	0	80	70	25	25	Rad.	Her.	12	3	8
23	F	28	1	45	0	90	85	20	30	Rad.	ACCU	8	2	6

Abbreviations: ACCU, Accutrak; consol., time until consolidation; ext., extension; flex., flexion; Her., Herbert; IL, iliac crest; mini, mini-fragment screw; rad., radio; RD, radial deviation; RLA, radioulnar angle; SLA, scapholunate angle; UD, ulnar deviation.

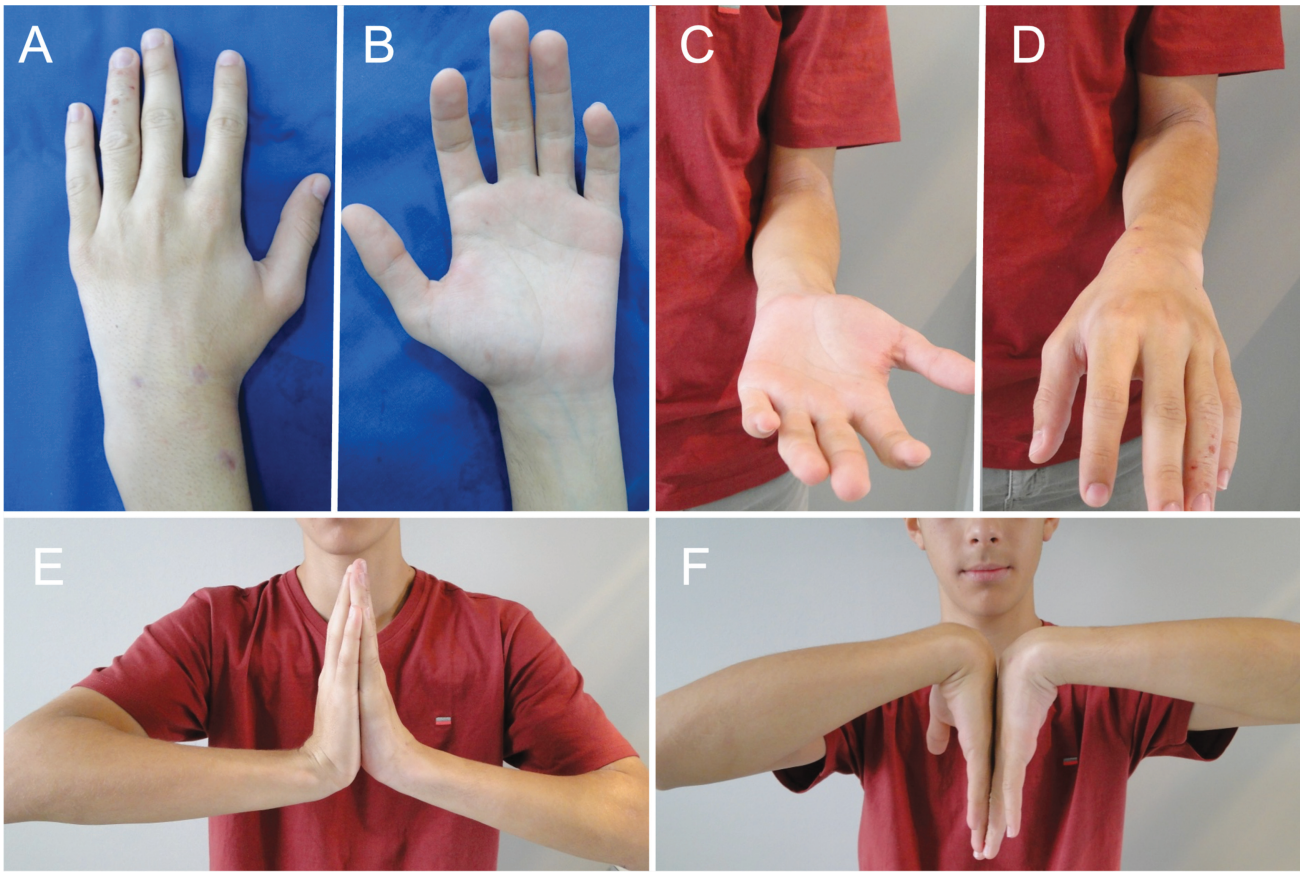


Fig. 8 Patient eight weeks after the operation, view of the dorsal and volar face of the wrist with the incisions in the arthroscopy portals and percutaneous fixation of the scaphoid (A and B). Complete recovery of mobility, both in pronation-supination (C and D) and in extension and flexion (E and F).

Trying to reduce the trauma to local tissues and improve the consolidation potential, some articles describe good results with the use of cancellous bone graft in unstable scaphoid pseudarthrosis. Park et al.[22] treated 61 patients with scaphoid pseudarthrosis, 52% stable and 48% unstable, using cancellous bone graft and fixation with Kirschner wires. They achieved consolidation in 88.2% of stable and 83.9% of unstable lesions, with no statistically significant differences between groups.

There is no rule as to the type of bone graft to be used. We prefer the use of an iliac graft in patients with severe deformity and bone resorption. In cases of stable scaphoid pseudarthrosis with little deformity, we used a spongy bone graft taken from the distal metaphysis of the radius. The short time to achieve consolidation, mean of 7.5 weeks, is lower than those presented in series using the open technique, both in vascularized and non-vascularized grafts, allowing for a short time of immobilization and early return to activities.

Some series show results similar to ours with the use of arthroscopy and percutaneous screw fixation, without using bone graft.[9,13,14,23,25] Slade et al.[13] published a series of 15 patients with stable scaphoid pseudarthrosis achieving consolidation in all, in a mean time of 14 weeks. Chu e Shih,[26] on the other hand, treated 15 stable scaphoid pseudarthrosis patients with arthroscopy associated with combined percutaneous screw fixation and use of demineralized bone matrix. They showed 93% consolidation over 15 weeks on average. In the series by Wong and Ho with 68 patients with scaphoid pseudarthrosis treated with the arthroscopic technique and screws, there was 91.2% of union, in an average period of 12 weeks, without presenting any complications resulting from the method.[10] Kim et al.[17] evaluated 36 patients with arthroscopy and cancellous bone graft for unstable scaphoid pseudarthrosis achieving healing in 86% of patients at an average of 11 weeks.

With the arthroscopic technique using cancellous bone graft, it is more difficult to restore the anatomy of the scaphoid and the normal alignment of the carpus. However, other techniques also show similar difficulty. Jiranek et al.[27]in a series of patients treated for scaphoid pseudarthrosis with trapezoidal corticocancellous bone graft, obtained a deformity of 45° or more at the intrascaphoid angle in more than half of the cases and did not find any relationship between the alignment and the final clinical result. Also from Kim et al.[17] series, radiological parameters of the scaphoid and carpal alignment did not correlate with the patient's final clinical function. Like these authors, we think that the positive effects of the arthroscopic technique and percutaneous fixation outweigh a possible difficulty in completely correcting the deformity, given that this does not change the final function of the wrist.[28]

Wrist arthroscopy is a valid alternative in the treatment of carpal scaphoid injuries. It presents good clinical and consolidation results, even in lesions with deformity and carpal instability, with a shorter recovery period. It is likely limited to restoring normal carpal alignment, but it is beneficial and improves recovery time for these injuries.

Conclusion

The presented results demonstrate low morbidity and fast recovery with this technique. However, to confirm these results, we need larger series, with longer follow-up and with patients randomized into groups, comparing different techniques.

Financial Support
The authors declare that they received no financial support from public, commercial or non-profit sources.

Conflict of interests
The authors declare no conflict of interest.

References

1 Krakauer JD, Bishop AT, Cooney WP. Surgical treatment of scapholunate advanced collapse. J Hand Surg Am 1994;19(05): 751–759
2 Fernandez DL. A technique for anterior wedge-shaped grafts for scaphoid nonunions with carpal instability. J Hand Surg Am 1984; 9(05):733–737
3 Cohen MS, Jupiter JB, Fallahi K, Shukla SK. Scaphoid waist nonunion with humpback deformity treated without structural bone graft. J Hand Surg Am 2013;38(04):701–705
4 Watanabe K. Analysis of carpal malalignment caused by scaphoid nonunion and evaluation of corrective bone graft on carpal alignment. J Hand Surg Am 2011;36(01):10–16
5 Moritomo H, Tada K, Yoshida T, Masatomi T. The relationship between the site of nonunion of the scaphoid and scaphoid nonunion advanced collapse (SNAC). J Bone Joint Surg Br 1999; 81(05):871–876
6 Waitayawinyu T, McCallister WV, Nemechek NM, Trumble TE. Scaphoid nonunion. J Am Acad Orthop Surg 2007;15(05): 308–320
7 Zaidemberg C, Siebert JW, Angrigiani C. A new vascularized bone graft for scaphoid nonunion. J Hand Surg Am 1991;16(03): 474–478
8 Hagert E, Forsgren S, Ljung BO. Differences in the presence of mechanoreceptors and nerve structures between wrist ligaments may imply differential roles in wrist stabilization. J Orthop Res 2005;23(04):757–763
9 Slutsky DJ, Trevare J. Use of arthroscopy for the treatment of scaphoid fractures. Hand Clin 2014;30(01):91–103
10 Wong WY, Ho PC. Minimal invasive management of scaphoid fractures: from fresh to nonunion. Hand Clin 2011;27(03): 291–307
11 Wong WC, Ho PC. Arthroscopic Management of Scaphoid Nonunion. Hand Clin 2019;35(03):295–313
12 Jegal M, Kim JS, Kim JP. Arthroscopic Management of Scaphoid Nonunions. Hand Surg 2015;20(02):215–221
13 Slade JF III, Gillon T. Retrospective review of 234 scaphoid fractures and nonunions treated with arthroscopy for union and complications. Scand J Surg 2008;97(04):280–289
14 Delgado-Serrano PJ, Jiménez-Jiménez I, Nikolaev M, Figueredo-Ojeda FA, Rozas-López MG. Arthroscopic reconstruction for unstable scaphoid non-union. Rev Esp Cir Ortop Traumatol 2017;61 (04):216–223
15 Belloti JC, Vasconcelos KBL, Raduan Neto J, Okamura A, Fernandes M, Moraes VY. Fixação percutânea sem enxerto ósseo para pseudartrose do escafóide. Rev Bras Ortop 2020;55(06): 759–763
16 Zemirline A, Lebailly F, Taleb C, Naito K. Arthroscopic treatment of scaphoid nonunion with humpback deformity and DISI with corticocancellous bone grafting: Technical note. Hand Surg Rehabil 2019;38(05):280–285
17 Kim JP, Seo JB, Yoo JY, Lee JY. Arthroscopic management of chronic unstable scaphoid nonunions: effects on restoration of carpal alignment and recovery of wrist function. Arthroscopy 2015;31 (03):460–469
18 Liu B, Wu F, Ng CY. Wrist arthroscopy for the treatment of scaphoid delayed or nonunions and judging the need for bone grafting. J Hand Surg Eur Vol 2019;44(06):594–599
19 Herbert TJ, Fisher WE. Management of the fractured scaphoid using a new bone screw. J Bone Joint Surg Br 1984;66(01): 114–123
20 Herbert TJ. A rational approach to treatment of acute scaphoid-fractures. In: Herbert TJ, ed. The fractured scaphoid. St. Louis: Quality Medical Publishing; 1990:51–67
21 Rosales RS, Delgado EB, Díez de la Lastra-Bosch I. Evaluation of the Spanish version of the DASH and carpal tunnel syndrome health-related quality-of-life instruments: cross-cultural adaptation process and reliability. J Hand Surg Am 2002;27(02):334–343
22 Park HY, Yoon JO, Jeon IH, Chung HW, Kim JS. A comparison of the rates of union after cancellous iliac crest bone graft and Kirschner-wire fixation in the treatment of stable and unstable scaphoid nonunion. Bone Joint J 2013;95-B(06):809–814
23 Oh WT, Kang HJ, Chun YM, Koh IH, Lee YJ, Choi YR. Retrospective Comparative Outcomes Analysis of Arthroscopic Versus Open Bone Graft and Fixation for Unstable Scaphoid Nonunions. Arthroscopy 2018;34(10):2810–2818
24 Cagnolati AF, Andrade FR, Rezende LGR, Mazzer N, Sugano RMM, Garcia LM. Fixação interna de pseudoartrose de escafoide com deformidade angular associada utilizando enxerto de ilíaco e placa volar: Série de oito casos. Rev Bras Ortop 2021;56(05): 588–593
25 Cognet JM, Louis P, Martinache X, Schernberg F. Arthroscopic grafting of scaphoid nonunion - surgical technique and preliminary findings from 23 cases. Hand Surg Rehabil 2017;36(01):17–23
26 Chu PJ, Shih JT. Arthroscopically assisted use of injectable bone graft substitutes for management of scaphoid nonunions. Arthroscopy 2011;27(01):31–37
27 Jiranek WA, Ruby LK, Millender LB, Bankoff MS, Newberg AH. Long-term results after Russe bone-grafting: the effect of malunion of the scaphoid. J Bone Joint Surg Am 1992;74(08): 1217–1228
28 Megerle K, Harenberg PS, Germann G, Hellmich S. Scaphoid morphology and clinical outcomes in scaphoid reconstructions. Injury 2012;43(03):306–310

Percutaneous Surgery for Tailor's Bunion: A Comparative Study

Tratamento cirúrgico do joanete do alfaiate por técnica percutânea: Um estudo comparativo

Luiz Carlos Ribeiro Lara[1] Lara Furtado Lancia[1] Diego Vitor Braga Santos[1]
Matheus Maciel Dornelles de Carvalho[1] Frederico Pinheiro de Lima[1] João Lucas Gonçalves Arruda[1]

[1] Orthopedics and Traumatology Service, Municipal University Hospital of Taubaté, Taubaté, SP, Brazil

Rev Bras Ortop 2024;59(5):e730–e736.

Address for correspondence Luiz Carlos Ribeiro Lara, MD, Member of the Ankle and Foot group, Medical Residency in Orthopedics and Traumatology, Municipal University Hospital of Taubaté, Avenida Itália, n° 1551, complement R2 Rua 1, n°666, Bairro Jardim das Nações, 12030-212, Taubaté, SP, Brazil (e-mail: luizrlara@hotmail.com).

Abstract

Objective To analyze and compare the clinical and radiographic outcomes of bunionette correction using two percutaneous surgical techniques: the Sponsel technique and the medial wedge osteotomy of the distal metaphysis. The results were evaluated individually and comparatively using the American Orthopaedic Foot and Ankle Society's Lesser Metatarsophalangeal-Interphalangeal Scale (AOFAS), Visual Analog Scale (VAS) for pain assessment, and radiographic measurements of the intermetatarsal angle IV-V (AIM4–5) and metatarsophalangeal angle of the fifth ray (AMF-5).

Methods This was a retrospective study conducted from May 2011 to February 2022. A total of 32 feet were operated on, with 12 feet undergoing the Sponsel technique and 20 feet undergoing the medial wedge osteotomy of the distal metaphysis of the fifth metatarsal.

Results Both surgical techniques showed significant improvement in the correction of AIM4–5 and AMF-5 angles ($p < 0.001$). However, there was no statistical significance when comparing the two techniques. In terms of AOFAS and VAS scores, both techniques yielded satisfactory results. Nevertheless, the medial wedge osteotomy demonstrated significantly better outcomes compared with the Sponsel technique ($p < 0.001$).

Conclusions Both percutaneous techniques employed for bunionette correction resulted in significant improvement in radiographic angles and evaluated scores, with a low complication rate, making them viable options for treating this condition. When compared, the medial wedge osteotomy appeared to yield better clinical outcomes.

Keywords
- bunion
- metatarsal bones
- bunion, tailor's/diagnostic imaging
- bunion, tailor's/surgery
- treatment outcome

Work carried out at the Orthopedics and Traumatology Service of the Municipal University Hospital of Taubaté, Taubaté, SP, Brazil.

received
January 9, 2023
accepted
July 28, 2023

DOI https://doi.org/10.1055/s-0043-1776292.
ISSN 0102-3616.

© 2023. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Resumo

Objetivos Analisar e comparar os resultados clínicos e radiográficos da correção do joanete do alfaiate, utilizando-se duas técnicas cirúrgicas percutâneas, técnica de osteotomia oblíqua de Sponsel e osteotomia em cunha medial da metáfise distal. Os resultados foram avaliados individualmente e comparativamente através do *Lesser Metatarsophalangeal-Interphalangeal Scale* da *American Orthopaedic Foot and Ankle Society* (AOFAS), Escala Visual Analógica de Dor (VAS) e radiograficamente, analisando-se os ângulos: ângulo intermetatársico IV-V (AIM4–5) e ângulo metatarsofalangico do 5° raio (AMF-5).

Métodos Trata-se de um estudo retrospectivo no período de maio de 2011 a fevereiro de 2022. Foram operados 32 pés, destes, em 12 pés foram utilizadas a técnica de Sponsel e em 20 pés a osteotomia em cunha medial da metáfise distal do 5° metatársico.

Resultados Ambas as técnicas cirúrgicas empregadas mostraram melhora significativa na correção dos ângulos AIM4–5 e AMF-5 ($p < 0{,}001$), todavia, não observamos significância estatística comparando-se as técnicas. Já em relação ao AOFAS e VAS, ambas as técnicas apresentaram resultados satisfatórios. Porém, a osteotomia em cunha apresentou resultados significativamente melhores quando comparados a técnica de *Sponsel* ($p < 0{,}001$).

Conclusões Ambas as técnicas percutâneas utilizadas para correção do joanete do alfaiate conferiram melhora significativa das angulações radiográficas e dos scores avaliados, com baixo índice de complicações, mostrando-se boas opções para tratamento desta patologia. Quando comparadas, a osteotomia em cunha medial parece conferir melhores resultados dos parâmetros clínicos analisados.

Palavra-chave

- joanete do alfaiate/diagnóstico por imagem
- joanete do alfaiate/cirurgia
- ossos do metatarso
- resultado do tratamento

Introduction

Tailor's bunion is characterized by a deformity in the region of the head of the fifth metatarsal with painful lateral, dorsolateral or plantar prominence. Its etiology is multifactorial,[1] being associated with both anatomical and structural factors.[2–4]

The initial treatment involves implementing conservative measures,[5] while surgical treatment is indicated when conservative treatment fails. Several surgical techniques have been described for the treatment of this deformity, which basically consist of exostectomies, bone resections and metatarsal osteotomies (distal, diaphyseal and proximal). These techniques are indicated after a clinical and radiographic evaluation, based on the classification of the type of deformity.[1,2,4,6,7]

Initially described by Isham[8] and De Prado et al.,[9] percutaneous surgery has been gaining space and popularity in recent years, proving to be a useful procedure for treating tailor's bunion in a minimally invasive way.[7]

The objective of the present study is to compare the clinical and radiographic aspects of patients undergoing surgical treatment for tailor's bunion using two different percutaneous techniques: Sponsel's oblique osteotomy[1] and medial wedge osteotomy of the distal metaphysis of the 5th metatarsal bone (MWO).[5]

Methods

During the period between May 2011 and February 2022, 29 patients with Tailor's Bunion were operated on, 3 of which were bilateral, thus totaling 32 feet. The procedures were performed at a Municipal University Hospital of Taubaté and in a private clinic owned by one of the authors.

This study included symptomatic cases refractory to conservative treatment, with a minimum follow-up time of 6 months postoperatively. Furthermore, patients with the following characteristics were excluded: history of previous surgery on the 5th ray, those with vascular and/or rheumatoid diseases and those with calluses on the 5th metatarsal bone that did not generate radiographic angular changes, these being submitted only to exostectomy.

In this context, among the 32 feet with tailor's bunion evaluated in the study, other associated pathologies were observed: 15 cases of hallux valgus (46%), seven with central metatarsalgia (21%) and one with Morton's neuroma (3%). For all these cases, surgical treatments for the pathologies were performed concomitantly with the correction of the tailor's bunion.

The data used to evaluate the subjective and radiographic results studied were collected preoperatively and 6 months after surgery.

Statistical Methodology

Initially, the data were descriptively analyzed using summary measures such as mean and standard deviation. To assess the effect of the intervention at a single evaluation timepoint on the following parameters: fifth metatarsophalangeal angle (AMF-5), fourth and fifth intermetatarsal angle (AIM4-5), the Lesser Metatarsophalangeal-Interphalangeal Scale of the American Orthopaedic Foot and Ankle Society

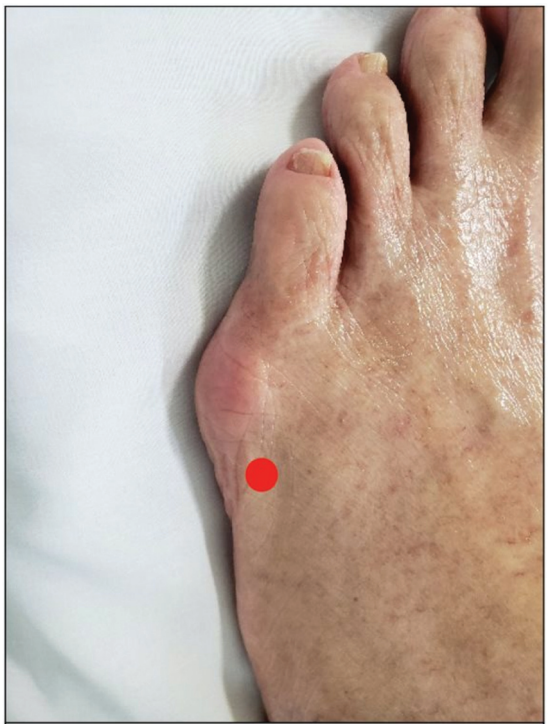


Fig. 1 Entry point using the Sponsel technique.

(AOFAS), and the visual analog pain scale (VAS), we employed multilevel linear regression models. In this model, we considered feet and patients as levels 1 and 2, respectively, taking into account the potential dependence between foot observations within the same patient and the two measurements resulting from the initial and final evaluations.

The multilevel linear regression model presents normality in data distribution as one of its assumptions, which was verified using the Kolmogorov-Smirnov test.

For all statistical tests, a significance level of 5% was used. The analyzes were carried out using the statistical package SPSS 20.0 and STATA 17.

Radiographic Measurements

Radiographs of the feet were taken in anteroposterior (AP) and lateral (L) weight-bearing views, following the standard used in our service.[10] In the study, the AMF-5 and AIM4–5 angles were analyzed, with values lower than 14° and 10°, respectively, being considered normal.[7]

Surgical technique

Patients were placed in a supine position, with the foot to be operated on slightly off the table, while the contralateral foot was supported on a support at the side.

Surgeries were performed under locoregional anesthesia (penta foot block) or spinal anesthesia. The procedures were carried out under radioscopy with the aid of a motor, rasps and cutting and grinding mills.

In total, 12 Sponsel oblique osteotomies (three associated with exostectomy) and 20 MWO osteotomies (10 associated with exostectomy) were performed.

Sponsel Technique

The technique begins with a small incision (2mm) in the infero-lateral region proximal to the head of the 5th metatarsal bone (►**Fig. 1**), heading towards the lateral bone cortex. Next, the joint capsule is detached from the metatarsal head and, with the help of a rasp, a safe working area is created.

The osteotomy occurs in the metaphyseal region, from distal to proximal, with an angle of 30° in relation to the metatarsal axis and from dorsal to plantar, which allows for proximal, dorsal and medial sliding of the head. Internal fixation is not necessary (►**Fig. 2**).

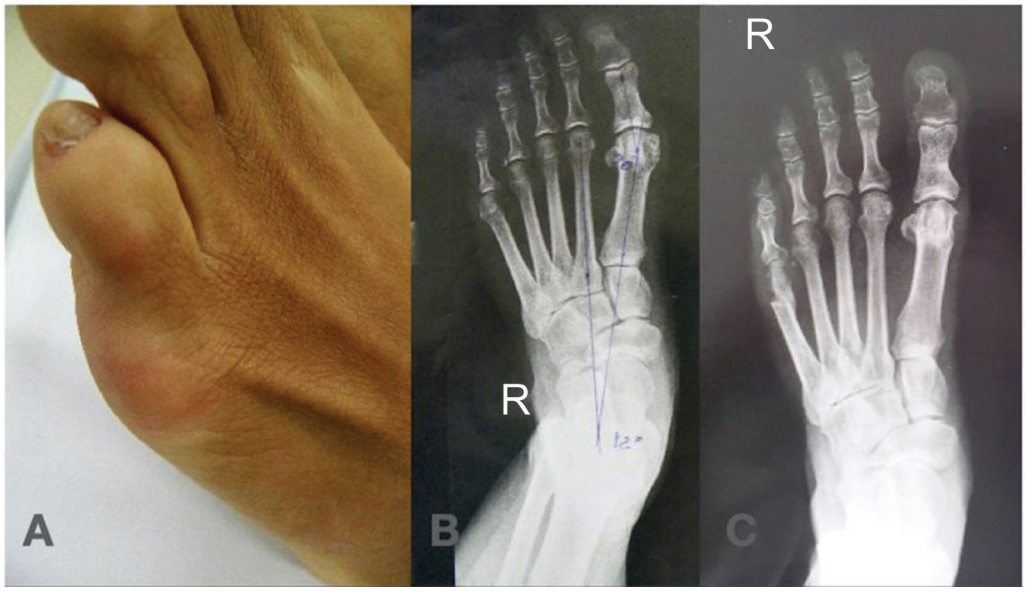


Fig. 2 Clinical image (**A**). Preoperative x-ray (**B**). Postoperative x-ray (**C**).



Fig. 3 Wedge osteotomy entry point.

Wedge osteotomy (MWO)

This process begins with a small incision (2 mm) in the dorsomedial region proximal to the head of the 5th metatarsal, going to the medial cortical bone (►**Fig. 3**). The osteotomy is performed under a medial to lateral orientation seeking to preserve the lateral cortex in order to create a medial closing wedge to correct the deformity (►**Fig. 4**).

After the osteotomy is completed, the percutaneous accesses are sutured and the dressing begins. Proper dressing is essential for post-surgical success, as it positions the foot in such a way as to correct the deformity, seeking medial displacement of the head of the 5th metatarsal.

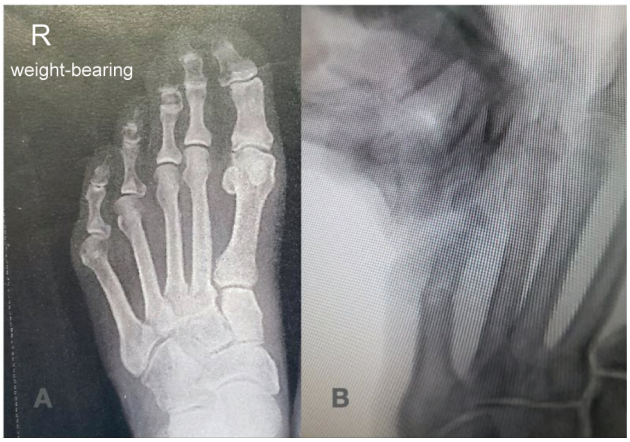


Fig. 4 Preoperative x-ray (**A**). Intraoperative wedge osteotomy closure (**B**).

Postoperative

Patients are discharged from hospital on the same day as the surgical procedure and are instructed to walk using rigid-soled sandals. Outpatient visits are carried out every seven days to change dressings, until four weeks have passed. After this period, patients are advised to continue changing dressing at home until the eighth week, when they will be able to wear comfortable shoes.

Subjective Results

In addition to radiographic evaluations, all patients were interviewed pre- and postoperatively using the Visual Analogue Pain Scale (VAS),[11] which consists of grading pain intensity on a scale from 0 to 10, with 0 being painless and 10 being more intense pain, and submitted to the AOFAS Lesser Metatarsophalangeal-Interphalangeal Scale questionnaire,[12] translated and adapted to Portuguese, which consists of a subjective and functional analysis, which totals 100 points, considering pain (40 points), function (45 points) and alignment (15 points). All participating patients were informed about the objectives of the work and asked to sign informed consent. This work was previously submitted and approved for analysis by the Ethics and Research Committee of the University of Taubaté (UNITAU), under opinion number 5,761,205.

Results

Information from 29 patients was considered, whose average age was 50.7 years (SD = 14.9 years), with a minimum age of 14 years and a maximum of 84 years.

It was noted that the majority of patients (89.7%) were female. For three patients, the deformity was bilateral, thus totaling 32 feet, and average follow-up time was 36.4 months (SD= 36.9 months) (►**Table 1**).

According to ►**Tables 2** and **3**, no interaction effect was observed for the AIM4–5 correction ($p = 0.189$), indicating that the mean variations were similar for both groups. Furthermore, no differences were found in the means between the intervention groups in the two assessments ($p = 0.374$). Likewise, there were no differences in the mean variation of the AMF-5 in relation to the type of intervention ($p = 0.062$). However, an average reduction in the angles evaluated in both surgical techniques was observed ($p < 0.001$). The mean AIM4–5 correction in the Sponsel technique was 13.4° preoperatively to 9.25° postoperatively, while in the MWO it was 12.6° to 7.15° at the final evaluation. The average reduction in AMF-5 was 10.5° using the Sponsel technique and 14.8° using the MWO.

For both surgical techniques, the increase in the AOFAS score and the decrease in pain on the VAS scale stand out. However, MWO obtained statistically superior results ($p < 0.001$) compared to Sponsel osteotomy, both in increasing the AOFAS score and decreasing pain on the VAS scale. The mean AOFAS score increase for MWO was 55.3, while for Sponsel osteotomy it was 36.9. Furthermore, MWO showed an average pain reduction on the VAS scale of 8.2, in contrast to the Sponsel technique, which recorded an average reduction of 7.1.

Table 1 Patient characteristics and foot follow-up time by type of intervention

	Wedge osteotomy	SPONSEL	Total	*p*
Patients	N = 17 (58,6%)	N = 12 (41,4%)	N = 29	
Gender, n(%)				0,246
Masculine	3 (17,6)	0 (0,0)	3 (10,3)	
Feminine	14 (82,4)	12 (100,0)	26 (89,7)	
Age (years)				0,185[a]
Mean ± SD	47,9 ± 18,1	54,6 ± 7,6	50,7 ± 14,9	
Median (Min - Max)	45,0 (14,0 to 84,0)	56,0 (42,0 to 64,0)	51,0 (14,0 to 84,0)	
Feet	N = 20 (62,5%)	N = 12 (37,5%)	N = 32	
Follow-up time (months)				0,076[a]
Mean ± SD	25,2 ± 17,0	55,2 ± 52,1	36,4 ± 36,9	
Median (Min - Max)	20,0 (6,0 to 54,0)	30,5 (6,0 to 128,0)	22,0 (6,0 to 128,0)	

p - descriptive level of Fisher's Exact test and Student's t([a]).

Table 2 Summary measurements of intermetatarsal angles 4–5 (°) by assessment timepoint, according to type of intervention

	Pre	Post	Post - Pre	*p*		
	Mean ± SD	Mean ± SD	Mean ± SD	Treatment	Time	Interaction between Treatment and Time
Intermetatarsal angles 4–5 (°)				0,374	<0,001	0,189
Wedge osteotomy	12,60 ± 2,14	7,15 ± 1,50	−5,45 ± 2,98			
SPONSEL	13,42 ± 4,08	9,25 ± 2,90	−4,17 ± 2,33			

p - descriptive level of treatment effects, time and interaction between treatment and time.

Table 3 Summary measurements of metatarsophalangeal angle, AOFAS and Pain score by assessment timepoint, according to type of intervention

	Pre	Post	Post - Pre	*p*		
	Mean ± SD	Mean ± SD	Mean ± SD	Treatment	Time	Interaction between Treatment and Time
Metatarsophalangeal Angle (°)				0,174	<0,001	0,062
Wedge osteotomy	16,20 ± 7,27	1,40 ± 6,18	−14,80 ± 7,05			
SPONSEL	15,50 ± 8,33	5,00 ± 8,00	−10,50 ± 5,45			
AOFAS				<0,001	<0,001	<0,001
Wedge osteotomy	36,80 ± 8,24	93,75 ± 4,25	56,95 ± 9,58			
SPONSEL	52,83 ± 10,75	90,58 ± 7,70	37,75 ± 13,05			
Pain				0,002	<0,001	<0,001
Wedge osteotomy	9,0 ± 0,6	0,8 ± 0,7	−8,2 ± 0,8			
SPONSEL	8,0 ± 1,3	0,9 ± 0,7	−7,1 ± 1,2			

p - descriptive level of treatment effects, time and interaction between treatment and time.
Wedge osteotomy versus SPONSEL: AOFAS - pre: $p < 0.001$ and post: 0.245; Pain - pre: $p = 0.002$; post: 0.539.
Pre versus Post - Wedge osteotomy: AOFAS - $p < 0.001$ and SPONSEL: $p < 0.001$; Pain - $p < 0.001$ and SPONSEL: $p < 0,001$.

Only two cases showed delayed consolidation, with spontaneous resolution within 6 months. We consider a delay if radiographic signs of bone consolidation are not seen within 3 months postoperatively. Additionally, a case of symptomatic bone spike formation was observed (►**Fig. 5**), which presented good resolution of symptoms after bone consolidation. In this study, no other complications were observed, such as pseudarthrosis, superficial or deep infection, recurrence, neuropraxia or hypertrophic callus.



Fig. 5 Complication of bone spike in a patient operated using the Sponsel technique.

Discussion

Many surgical techniques have been described for the treatment of tailor's bunion over the years.[13–19] Recently, percutaneous techniques have gained prominence due to their less invasive approach to soft tissues,[1,2,4,20,21] with effective corrections and less postoperative pain. In this context, it is extremely important to make comparisons between different surgical techniques.

Both MWO and Sponsel osteotomy have already proven to be effective for the minimally invasive treatment of tailor's bunion, as shown by several authors.[7,22–25] By comparing two specific approaches, we seek to identify possible differences and advantages of one over the other.

When analyzing the radiographic results, we observed significant improvements in the parameters evaluated in both groups submitted to different surgical techniques. These findings are in agreement with individual studies of each technique,[7,22–25] in which similar radiographic improvements were observed.

In relation to AIM4–5, we observed an average reduction of 4.2° using the Sponsel technique, while MWO showed an average correction of 5.5°, being slightly greater. This trend was also observed in the correction of the AMF-5, in which the MWO guaranteed a greater angular correction, 14.8° versus 10.5° using the Sponsel osteotomy. We believe that this difference can be attributed to the greater capacity to medialize the head of the fifth metatarsal using the MWO technique.

However, when we directly compared the two techniques in our study, we did not find statistically significant differences in relation to the improvement in radiographic parameters. These results are consistent with the lack of comparative studies in the literature.

Regarding subjective results, both surgical techniques demonstrated a statistically significant improvement in increasing the AOFAS score and reducing pain assessed by the VAS scale, indicating the effectiveness of both approaches in relieving pain and functional improvement of the foot affected by tailor's bunion. Results similar to those obtained in other studies are available in the literature.[3,22,24,25]

When comparing the techniques, we observed a significant difference in the improvement of the AOFAS score in favor of MWO in relation to Sponsel osteotomy, with an average improvement of 55.3 points versus 36.9, respectively. Furthermore, the analysis of pain reduction using the VAS scale followed the same trend, with the MWO technique presenting statistically significant better results (average reduction of 8.2 points in the OCM group versus 7.1 points in the oblique osteotomy group; $p < 0.001$). These results provide additional evidence that MWO may be a more effective surgical approach for treating tailor's bunion, resulting in improved function and reduced postoperative pain.

Both techniques used presented satisfactory results with few complications. Using the Sponsel technique, two cases of delayed consolidation were observed, which progressed well after the formation of bone callus around the sixth month, and one case of symptomatic bone spike formation, which also progressed with resolution of symptoms without the need for new surgical intervention (►**Fig. 5**). Using the wedge osteotomy technique, no complications were observed. Such findings, when compared with the literature, confirm the low complication rates of percutaneous techniques, especially for distal osteotomies.[3,21,23,25]

Some limitations of our study should be mentioned. Both preoperative and postoperative assessments were carried out by the same team, which could generate performance bias in data analysis. The number of cases operated using both techniques could be greater, allowing a more statistically significant comparison of results.

Another limitation is that the AOFAS Lesser Metatarsophalangeal-Interphalangeal Scale questionnaire was translated and adapted into Portuguese by the researchers, as at the time of this study we have not found work with a validated translation for the lesser toes scale. Therefore, it is important to consider that the results obtained may not have been completely reliable due to the lack of validation of the translated scale. Furthermore, although the questionnaire for smaller toes was used, which has a more specific approach to tailor's bunion, it is important to highlight that other pathologies were associated and may have influenced the subjective results obtained. For a future study, we suggest including only those with tailor's bunion as a single deformity, thus analyzing the results can be more objective.

Our study was considered pertinent, presenting the comparison of the results of two percutaneous surgical techniques for the correction of tailor's bunion, both with low rates

of complications and promoting a good improvement in the deformity in the operated feet.

Conclusions

Both the wedge osteotomy (MWO) technique and Sponsel's oblique osteotomy proved to be effective in correcting and improving radiographic and clinical parameters in the treatment of tailor's bunion. However, MWO showed statistically superior results in the AOFAS scoring criteria and pain scale (VAS). Based on these findings, we started to adopt MWO as the preferred technique for the surgical approach to tailor's bunion in our service. However, it is important to highlight that each case must be evaluated individually, taking into account the patient's characteristics, the degree of deformity and the surgeon's experience, in order to define the most appropriate technique to be used.

Financial Support
The authors declare that this study received no financial support from public, commercial or non-profit sources.

Conflict of Interests
The authors declare no conflict of interest.

References

1 Sponsel KH. Bunionette correction by metatarsal osteotomy: preliminary report. Orthop Clin North Am 1976;7(04):809–819
2 Roukis TS. The tailor's bunionette deformity: a field guide to surgical correction. Clin Podiatr Med Surg 2005;22(02):223–245
3 Martijn HA, Sierevelt IN, Wassink S, Nolte PA. Fifth metatarsal osteotomies for treatment of bunionette deformity: a meta-analysis of angle correction and clinical condition. J Foot Ankle Surg 2018;57(01):140–148
4 Coughlin MJ. Treatment of bunionette deformity with longitudinal diaphyseal osteotomy with distal soft tissue repair. Foot Ankle 1991;11(04):195–203
5 Ajis A, Koti M, Maffulli N. Tailor's bunion: a review. J Foot Ankle Surg 2005;44(03):236–245
6 Bertrand T, Parekh SG. Bunionette deformity: etiology, nonsurgical management, and lateral exostectomy. Foot Ankle Clin 2011;16(04):679–688
7 Michels F, Van Der Bauwhede J, Guillo S, Oosterlinck D, de Lavigne C. Percutaneous bunionette correction. Foot Ankle Surg 2013;19(01):9–14
8 Isham SA. The Reverdin-Isham procedure for the correction of hallux abducto valgus. A distal metatarsal osteotomy procedure. Clin Podiatr Med Surg 1991;8(01):81–94
9 De Prado M, Ripoll PL, Golano P. Cirugia percutanea del pie. Tecnicas quirurgicas, indicaciones, bases anatomicas Barcelona (Spain): Masson, Elsevier; 2003:129–148
10 Lara LCR, Ribeiro GA, Leite MS, Szulman S. Estudo radiográfico e morfológico de pés assintomáticos numa amostra populacional. J Foot Ankle 2011;5(01):8–14
11 Delgado DA, Lambert BS, Boutris N, et al. Validation of digital visual analog scale pain scoring with a traditional paper-based visual analog scale in adults. J Am Acad Orthop Surg Glob Res Rev 2018;2(03):e088
12 Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. Foot Ankle Int 1994;15(07):349–353
13 Bishop J, Kahn A 3rd, Turba JE. Surgical correction of the splayfoot: the Giannestras procedure. Clin Orthop Relat Res 1980;(146):234–238
14 Boyer ML, Deorio JK. Bunionette deformity correction with distal chevron osteotomy and single absorbable pin fixation. Foot Ankle Int 2003;24(11):834–837
15 Castle JE, Cohen AH, Docks G. Fifth metatarsal distal oblique wedge osteotomy utilizing cortical screw fixation. J Foot Surg 1992;31(05):478–485
16 Catanzariti AR, Friedman C, DiStazio J. Oblique osteotomy of the fifth metatarsal: a five year review. J Foot Surg 1988;27(04):316–320
17 Friend G, Grace K, Stone HA. L-osteotomy with absorbable fixation for correction of tailor's bunion. J Foot Ankle Surg 1993;32(01):14–19
18 Kaplan EG, Kaplan G, Jacobs AM. Management of fifth metatarsal head lesions by biplane osteotomy. J Foot Surg 1976;15(01):1–8
19 Vienne P, Oesselmann M, Espinosa N, Aschwanden R, Zingg P. Modified Coughlin procedure for surgical treatment of symptomatic tailor's bunion: a prospective followup study of 33 consecutive operations. Foot Ankle Int 2006;27(08):573–580
20 Redfern D, Vernois J, Legré BP. Percutaneous surgery of the forefoot. Clin Podiatr Med Surg 2015;32(03):291–332
21 Del Vecchio J, Ghioldi M, Dalmau-Pastor M, Uzair A, Chemes L. Sliding Distal Metatarsal Minimally Invasive Osteotomy (S-DMMO) for the Treatment of Tailor's Bunion. Tech Foot Ankle 2018;19(01):1. Available from: https://www.researchgate.net/publication/323900819
22 Ferreira GF, Dos Santos TF, Oksman D, Pereira Filho MV. Percutaneous Oblique Distal Osteotomy of the Fifth Metatarsal for Bunionette Correction. Foot Ankle Int 2020;41(07):811–817
23 Lui TH. Percutaneous osteotomy of the fifth metatarsal for symptomatic bunionette. J Foot Ankle Surg 2014;53(06):747–752
24 Laffenêtre O, Millet-Barbé B, Darcel V, Lucas Y Hernandez J, Chauveaux D. Percutaneous bunionette correction: results of a 49-case retrospective study at a mean 34 months' follow-up. Orthop Traumatol Surg Res 2015;101(02):179–184
25 Lima AFV, Baumfeld TS, Braga BM, Baumfeld DS, Cordier G, Nunes GA. Minimally invasive bunionette treatment: clinical and radiographic results. J Foot Ankle 2020;14(02):148–152

Three-dimensional Evaluation of Gait: Kinetics, Kinematics, and Electromyographic in Patients with Mucopolysacharidosis Types IV and VI

Avaliação tridimensional da marcha: Cinética, cinemática e eletromiográfica em pacientes com mucopolissacaridose tipos IV e VI

Francisco Robson Queiroz Rego[1] Herison Franklin Viana de Oliveira[1] Epitácio Leite Rolim Filho[1]

[1] Universidade Federal de Pernambuco, Recife, PE, Brazil

Rev Bras Ortop 2024;59(5):e737–e744.

Address for correspondence Francisco Robson Queiroz Rego, MD, Rua Morais Navarro, n. 55, Lagoa Nova, Natal, RN, CEP 59.075-770, Brazil (e-mail: francisco.robson@ufpe.br).

Abstract

Objective This study evaluated and determined, through instrumented three-dimensional (3D) gait analysis, the kinetic, kinematic, and electromyographic profile of patients with mucopolysaccharidosis (MPS) IV and VI.

Methods This crossectional study included 11 patients treated at a rare diseases reference service and evaluated in a movement analysis laboratory. We collected clinical, physical examination, and kinetic, kinematic, and electromyographic data using a 3D movement system, from June 2020 to January 2021.

Results There were 5 (45.5%) female patients, and 6 (54.5%) males. Furthermore, 9 (81.8%) subjects had MPS VI, and 2 (18.2%) had MPS IV. Their average age was 14.6 years. The average speed was 0.68 m/s (±0.21), and the stride length was 0.66 (±0.15). The most altered static angles were the hips' abduction-adduction, knees' range of movement, and foot's progression angle. Most cases presented a gait pattern of hip flexion-adduction and knee flexion. The gait profile scale (GPS) was 14.58 (±6.72) on the right side and 11.71 (±3.39) on the left. The gait deviation index (GDI) was 73.23 (±14.50) on the right side and 80.45 (±17.05) on the left. Muscle activity approximately followed the current model.

Conclusion The patients showed a decreased average speed and stride length. Most cases presented a gait pattern of hip flexion-adduction and knee flexion. Both GPS and GDI showed a significant deviation from normality.

Keywords

- electromyography
- kinematics
- kinetics
- mucopolysaccharidoses
- three-dimensional gait evaluation

Resumo

Objetivo Avaliar e determinar, através de análise tridimensional (3D) instrumentada da marcha, o perfil cinético, cinemático e eletromiográfico de pacientes com mucopolissacaridose (MPS) IV e VI.

Work carried out at the Universidade Federal de Pernambuco, Hospital Maria Lucinda, and Movement Analysis Laboratory, Instituto Rolim, Recife, PE, Brazil.

received
April 19, 2023
accepted
July 21, 2023

DOI https://doi.org/10.1055/s-0044-1786200.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Métodos Foi realizado um estudo transversal com 11 pacientes atendidos em um serviço de referência em doenças raras, avaliados em laboratório de análise do movimento. Foram coletados dados clínicos, do exame físico e dados cinéticos, cinemáticos e eletromiográficos através de sistema 3D de movimento, entre junho de 2020 e janeiro de 2021.

Resultados Havia 5 pacientes (45,5%) do gênero feminino e 6 (54,5%) do masculino. Adicionalmente, 9(81,8%) tinham MPS VI e 2 (18,2%) IV. A idade média foi de 14,6 anos. A velocidade média (m/s) foi de 0,68 (±0,21) e o comprimento da passada de 0,66 (±0,15). Os ângulos estáticos mais alterados foram a abdução-adução dos quadris, o arco de movimento dos joelhos e o ângulo de progressão do pé. Um padrão de marcha em flexão e adução dos quadris e flexão dos joelhos foi identificado na maioria dos casos. O *Gait Profile Score* (GPS) foi de 14,58 (±6,72) à direita e 11,71(±3,39) à esquerda. O *Gait Deviation Index* (GDI) foi de 73,23 (±14,50) à direita e de 80,45 (±17,05) à esquerda. A atividade muscular seguiu aproximadamente o modelo corrente.

Conclusão Os pacientes apresentaram uma velocidade média e comprimento da passada diminuídos. Um padrão de marcha em flexão e adução dos quadris e flexão dos joelhos foi identificado na maioria dos casos. Tanto GPS quanto GDI mostraram desvio importante da normalidade.

Palavras-chave
- avaliação tridimensional da marcha
- cinemática
- cinética
- eletromiografia
- mucopolissacaridoses

Introduction

Mucopolysaccharidoses (MPS) are rare genetic syndromes constituting the largest group of lysosomal storage diseases. Affected subjects present abnormal intracellular micromolecule degradation by lysosomal enzymes, leading to the intracellular accumulation of semi-degraded compounds called glycosaminoglycans (GAG).[1]

Its general incidence is estimated as 1 in every 25,000 live births, varying according to country and ethnic origin. The most common MPS are the Morquio (MPS IV) and Hurler (MPS I) syndromes.[2,3] In Brazil, the most common subtypes are MPS II (Hunter syndrome) and VI (Maroteaux-Lami syndrome).[4]

There are specific mutations in each type of MPS[2,5] resulting in a characteristic accumulation of GAGs and allowing MPS classification into seven types.

The clinical picture is quite diverse, involving multiple organs and systems, presenting different phenotypes and a range of functionality and severity; it can be fatal in some cases.[6,7] Limited ambulation and reduced resistance due to cardiopulmonary disease, joint stiffness, contractures, pain, and skeletal deformities are significant and progressive issues for many of these patients.

The diagnosis of MPS relies on GAG level, enzymatic activity, and genotype determination.[8] Chorionic villi and amniotic fluid cell samples establish prenatal diagnosis in fetuses.[2]

Enzyme replacement therapy (ERT) and hematopoietic stem cell transplantation (HSCT) are the most common treatment options. Furthermore, several surgical techniques are used to treat musculoskeletal changes.

Few studies obtained appropriate functional measurements to monitor the MPS course and evaluate the impact of current therapeutic options. These studies highlight the difficulty in carrying out traditional performance tests in this population, including resistance and strength tests using treadmills, exercise bikes, and dynamometry. This partly occurs because MPS patients present reduced limb size and stature, joint diseases, limited strength, and a broad clinical spectrum. Assessing these patients is more effective using tests incorporating daily activities such as walking.[9] In these cases, an alternative is computerized gait analysis.[10]

The importance of this tool motivated the development of indices to synthesize gait analysis data, facilitating its understanding.[11] Two of these data, the gait profile scale (GPS) and the gait deviation index (GDI) are global measures of gait variability and are sensitive to detect relevant changes in the deambulation of patients with orthopedic and neurological disorders.[12,13]

The objective of the present study was to evaluate and determine, through instrumented three-dimensional (3D) gait analysis, the kinetic, kinematic, and electromyographic (EMG) profile of patients with MPS IV and VI in a reference service for rare diseases.

Material and Methods

The Research Ethics Committee of the proposing Institution approved this cross-sectional, descriptive, and analytical study under number CAAE 40847720.5.0000.5208. The 3D gait analysis examination used the BTS-Gaitlab Hardware (BTS Bioengineering, Milan, Italy), and data analysis employed Excel (Microsoft Corp. Redmond, WA, USA) version 2301 and the Statistical Package Social Sciences (SPSS IBM Corp. Armonk, NY, USA) version 22. The study included 11 patients with MPS IV and VI evaluated from June 2020 to

January 2021. The choice for both types of MPS occurred because affected subjects typically have better cognitive capacity, facilitating the test. Additionally, these are the most frequent MPS types monitored at the partner service.

The inclusion criteria were patients aged 4 years and older, diagnosed with MPS IV or VI, deambulatory, and treated at the partner service who agreed to participate in the study after invitation, with the patient or legal guardian having signed the informed consent form (ICF). Those with confirmation of other potential conditions, severe heart diseases, and cognitive, visual, or auditory deficits that compromised test application were excluded from the study.

We evaluated the following epidemiological variables: age, gender, disease classification, other conditions, and use of orthoses. The instrumented 3D gait analysis occurred per the following standardization. First, we collected anthropometric data, including weight, height, distance between the anterior superior iliac spines, pelvic depth, length of the lower limbs, and width of the knees and ankles. Next, we defined the BTS-Gaitlab protocol to carry out the test. For convenience and suitability for patients, especially concerning knee valgus deviations, we adopted the Helen Hayes or Modified Helen Hayes protocol for some subjects and the Davis protocol for others (►**Fig. 1**). Both protocols provide the same variables of interest.

Reflective markers for movement capturing were placed in anatomical locations defined by the chosen protocol. The same occurred for the EMG sensors, using the rectus femoris, semitendinosus, gastrocnemius, and anterior tibialis muscles as anatomical references.

After placing the markers and sensors, we asked the patients to perform two different tasks, for example, static and dynamic acquisition. For the static acquisition, patients remained in an orthostatic position for approximately 5 seconds on the force platforms. This protocol calculates joint angles and performs a 3D reconstruction of the patient to provide static data. For the dynamic acquisition, the patients walked naturally on the laboratory's track with six digital 3D force platforms to capture their ground reaction forces. Ten high-resolution,

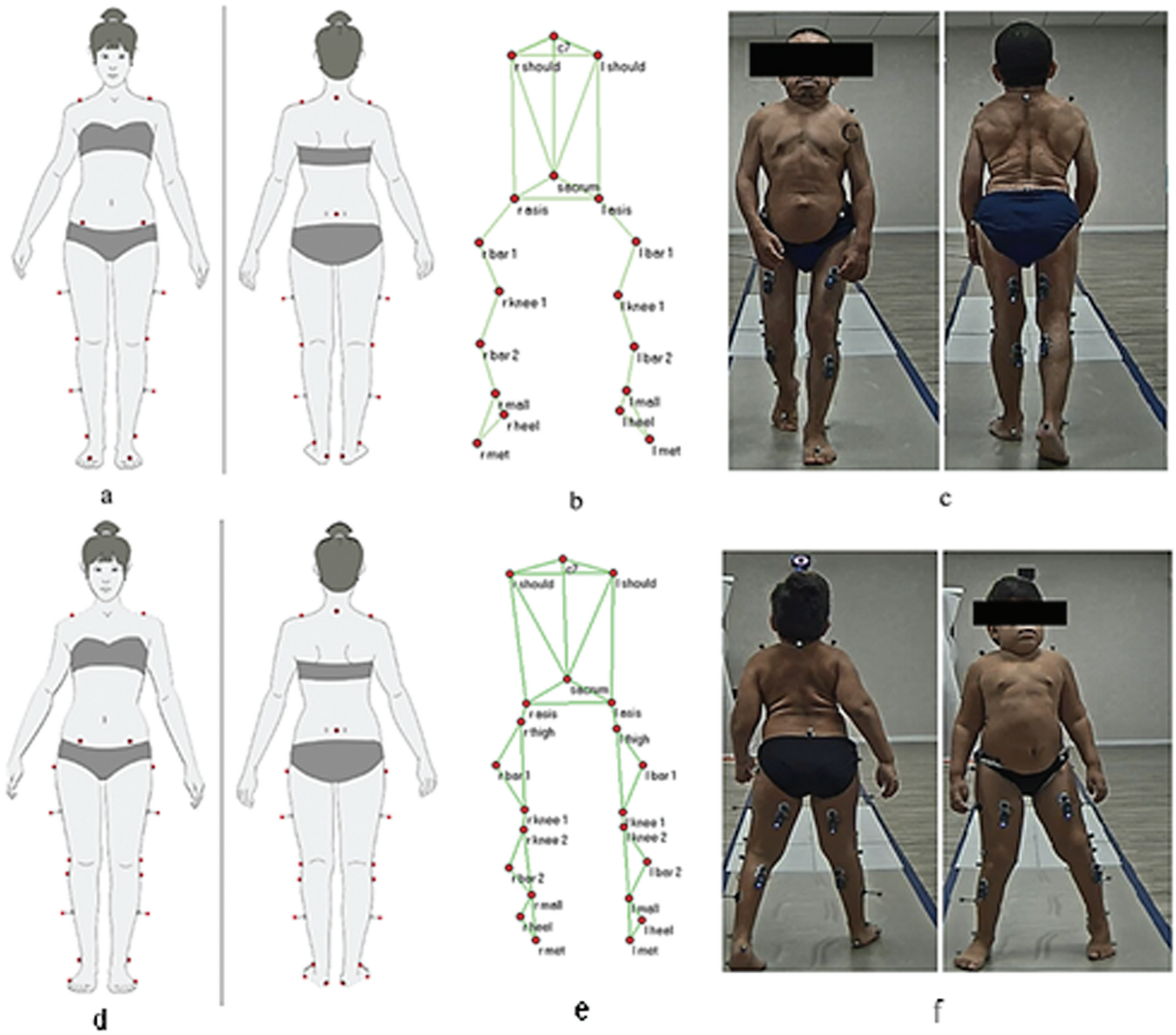


Fig. 1 (**a**) Front and back view of the modified Helen Hayes protocol. (**b**) Helen Hayes protocol markers placed on the model. (**c**) Patient performing gait analysis using the Helen Hayes protocol. (**d**) Front and back view of the Davis Protocol. (**e**) Davis protocol markers placed on the model. (**f**) Patient performing gait analysis using the Davis protocol.

high-frequency infrared cameras captured information from the reflective markers to determine joint position and movement during gait. The EMG sensors captured the activity of the chosen muscles. Each patient performed approximately 18 repetitions. The data was recorded and transmitted to a computer via Bluetooth for processing and generation of a final report. On average, each complete exam lasted one hour.

The spatiotemporal variables of interest were cadence, speed (m/s), average speed (percentage of height/s), step length, stride length (m), stride length (percentage of height), width step, stance phase, swing phase, double stance, single stance, stride time, stance time and swing time. The hip assessment included inclination (pelvic tilt), obliquity, rotation, hip flexion-extension, and abduction-adduction angles. The range of motion evaluated knee (flexion-extension angle) and ankle (ankle dorsal plantar flexion) deviations. The progression angle determined foot deviations. Both GPS and GDI analyzed the general condition and gait quality.

We compared some analyzed variables with normative data to better understand potential movement compensation activities in different anatomical planes.

Regarding EMG data, we use its activation as a reference, i.e., whether the muscles were active or not (on-off) and during which phases of the gait cycle, as proposed by Sutherland.[13]

The initial data analysis consisted of descriptive statistics, mean, standard deviation, absolute, and percentage frequency, as well as the validated gait analysis protocols integrated into BTS-Gaitlab. Statistical tests identified significant differences between the observed variables and the system's normality parameters. Non-parametric, Wilcoxon, and Mann-Whitney tests were used as an exact method for small samples. The 5% significance value indicated statistically significant correlation coefficients.

Results

The present study included 11 patients with MPS (►**Table 1**), of which 5 (45.5%) were female and 6 (54.5%) were male. None of the patients used orthoses. Furthermore, 9 (81.8%) have MPS VI, and 2 (18.2%) IV. The patients' ages ranged from 4 to 43 years, with an average of 14.6.

Regarding temporal parameters, the average speed (m/s) and average speed (percentage of height/s) were below the normality parameter. The average values of the other temporal parameters evaluated had little change or values within normal limits. As for spatial parameters, a mean stride length lower than the reference value is worth mentioning. ►**Fig. 2** and ►**Table 2** show this data.

In the evaluation of static angles (►**Table 2**), the hips showed an average flexion above the normal value (►**Fig. 3**). The range of motion of the knees also demonstrated important changes, reaching a maximum individual flexion value of 56.8° in the right knee and 48.9° in the left one. Most patients (54.5%) presented a gait pattern with increased hip flexion-adduction and knee flexion.

Table 1 Sample characterization

Variable	N (%)
Gender	
Female	6 (54.5)
Male	5 (45.5)
MPS	
IV	2 (18.2)
VI	9 (81.8)
Protocol type	
Helen Hayes	6 (54.5)
Davis Heel	5 (45.5)
Variable	**Mean (SD)**
Weight (kg)	31.5 (13.1)
Height (cm)	113.6 (12.5)
Age (years)	14.6 (11.7)

Abbreviation: SD, standard deviation; MPS, mucopolysaccharidosis.

The mean GPS showed a significant deviation from the normality parameter. Regarding the gait variable score (GVS), hip flexion-extension and rotation, the range of movement of the knees and ankles, and the foot progression angle were the highest average values and were the major contributors to the elevation of the GPS value. All patients had a GDI below 100, and the lowest individual value was 59.67 (►**Table 2** and ►**Fig. 4**).

The EMG data consisted of the activities of the rectus femoris, anterior tibiae, gastrocnemius (medial head), and semitendinosus muscles of 10 patients. One subject decided to undergo the examination without EMG.

Our results demonstrated intervals of muscular activity similar to the usual pattern. However, there was high variability between patients. Different activation modalities were captured and observed even in consecutive strides of a same subject. There were variations in the number of activations, onset time, and signal displacement. The muscles most activated during the gait cycle were the tibialis anterior (more active in 60% of patients) and the gastrocnemius. Muscle activation was asymmetric when comparing limbs from the same patient in 10% of cases.

Discussion

Skeletal deformities are striking features present in different types of MPS. Angular defects, such as knee and ankle valgus, progressive hip dysplasia, and joint laxity/hypermobility are examples of changes resulting in gait dysfunction in these patients,[14] making walking and balance difficult and causing greater functional dependence in daily activities.[15]

Matos et al.[16] studied 19 patients with MPS and showed that gait dysfunctions are the main complaints reported by this group and one of the major causes of functional disability in this population.

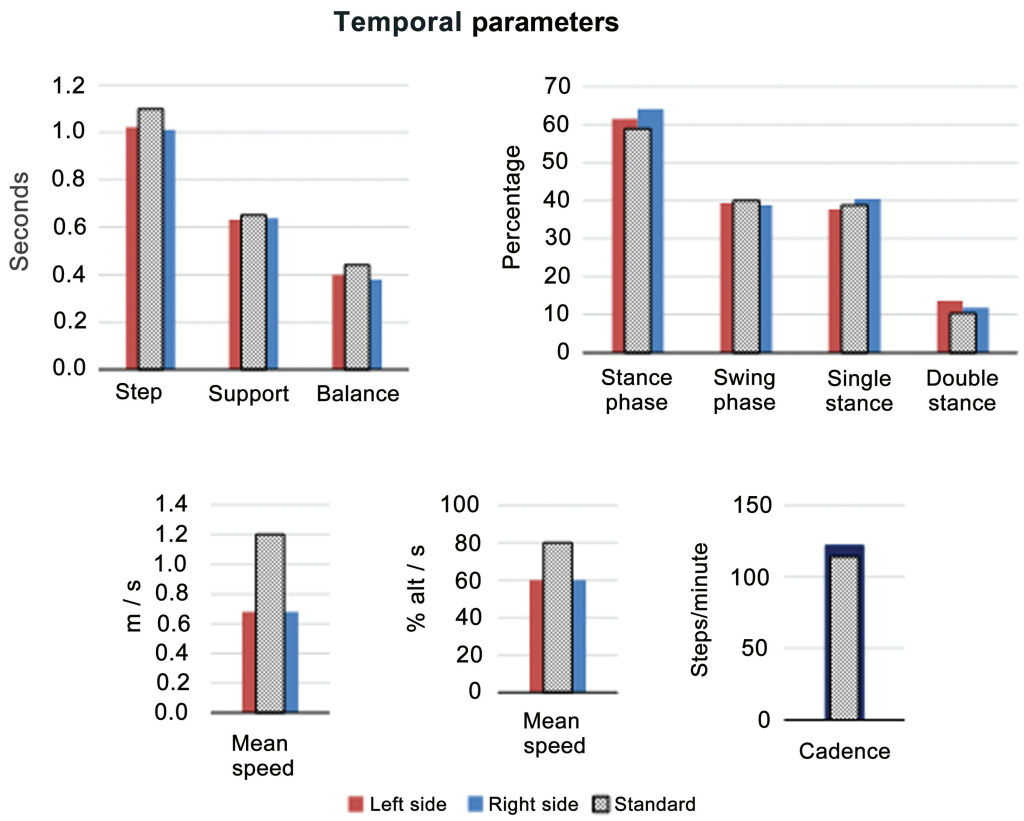


Fig. 2 Mean values from each temporal parameter variable.

Human mobility represents a fundamental requirement for an adequate quality of life. The ability to walk is a general health indicator as it denotes autonomy.[17] Since walking is a basic requirement for many daily activities, gait analysis provides critical information about people's functional capacity.

The gait pattern of subjects has become an area of great interest. Gait analysis is widely used to diagnose diseases and evaluate therapeutic plans and the prognosis of several conditions.[18] Deviations from the typical gait pattern are frequent in neurological, muscular, and skeletal diseases.[19]

Each MPS type has a wide range of clinical manifestations.[4,20] Furthermore, the same subtype can present several abnormal osteoarticular patterns and, therefore, gait patterns. The 3D assessment of these patients allows for a better understanding of the natural history of the disease in its different phenotypes.

The average speed and, mainly, stride length were below normal in our study, consistent with Salazar-Torres.[21] This finding indicates a higher metabolic demand for gait, as demonstrated by Kimoto et al.[22]

Support time shows a fundamental correlation with stability and balance. High stance times represent a decrease in patients' ability to balance.[23] The average stance time in our study was normal, demonstrating that these patients have good stability during walking.

Another key aspect observed was the asymmetry between the values obtained for each member. The parameters with the most differences between limbs during walking were the knees' range of movement and the foot's progression angle. Asymmetry was also noted in temporal values and, to a lesser extent, in EMG data. It is known that the greater the asymmetry of the lower limbs during walking, the greater the energy consumption.[24]

Most of our patients presented a pattern of flexion and adduction of the hips and flexion of the knees. Changes in these joints are well described in both the Maroteaux-Lamy and Morquio syndromes. It is known that, especially in the hips and knees of these patients, there may be impairment from the first years of life.[25]

The GPS and GDI indices represent a summary of the general gait quality, facilitating the comparison between pathological and normal deambulation. Massad et al.[26] described GDI as a reliable measure for gait assessment even in a single session. In our study, both these score values showed an important deviation from normality.

The EMG data demonstrated intervals of muscular activity approximately following the current model. However, it is worth highlighting the high variability of this tests' patterns between patients, consistent with Agostini et al.[27] A limiting factor in the evaluation of these data in our study was that 54.5% of the patients were children, of which 45.5% ranged from 4 to 8-years-old. Although subjects from this age group have mature deambulation, Granata et al.[28] demonstrated that intrasession EMG variability in children aged 6 to 8 years is twice as high as in adults. Agostini et al.[27] stated that this exam's activity can vary drastically between children, with less than 50% showing a similar pattern. The large variability

Table 2 Mean (SD) of the variables observed at the three-dimensional gait analysis of the patients

	Standard value	Right limb	Left limb
Temporal parameters			
Stride time (s)	1.10 (0.09)	1.01* (0.17)	1.02* (0.16)
Stance time (s)	0.65 (0.07)	0.64 (0.11)	0.63 (0.13)
Swing time (s)	0.44 (0.05)	0.38* (0.06)	0.40* (0.04)
Stance phase (%)	58.98 (1.97)	64.11* (5.48)	61.62* (3.41)
Swing phase (%)	40.03 (3.56)	38.75 (6.49)	39.38 (3.11)
Single stance (%)	38.87 (2.57)	40.41 (5.72)	37.72 (4.02)
Double stance (%)	10.27 (3.09)	11.83 (2.35)	13.60* (4.40)
Mean speed (m/s)	1.20 (0.20)	0.68* (0.21)	
Mean speed (height %/s)	80.00 (5.00)	60.05* (19.98)	
Cadence (steps/min):	114.00 (4.20)	121.85* (18.02)	
Spatial parameters ciais			
Stride length (m)	1.36 (0.11)	0.66* (0.15)	0.67* (0.17)
Stride length (height %)	80.00 (10.00)	58.29* (14.20)	59.27* (15.32)
Step length (m)	0.62 (0.05)	0.35* (0.09)	0.33* (0.09)
Step width (m)	0.08 (0.05)	0.14* (0.07)	
Static angles			
Pelvic obliquity (°)	0.00 (1.00)	4.74* (12.60)	−0.46* (4.00)
Pelvic tilt (°)	10.00 (4.00)	13.85* (7.60)	13.85* (7.60)
Pelvic rotation (°)	0.00 (5.00)	1.23 (5.13)	−1.23 (5.13)
Hip abduction-adduction (°)	0.00 (3.00)	−6.51* (8.46)	−8.74* (7.64)
Hip flexion-extension (°)	10.00 (4.00)	17.25* (13.65)	20.32* (14.72)
Hip rotation (°)	0.00 (5.00)	3.45 (12.02)	3.05 (9.71)
Knee flexion-extension (°)	5.00 (5.00)	13.25 (17.17)	17.28* (14.31)
Ankle dorsal-plantar flexion (°)	0.00 (5.00)	−2.46* (38.64)	−6.61* (41.77)
Foot progression (°)	−10.00 (5.00)	−26.59* (15.40)	−16.55* (13.51)
GPS			
GPS (°)	< 7	14.85* (6.72)	11.71* (3.39)
GVS			
Pelvic obliquity (°)		4.50 (1.87)	4.94 (1.86)
Pelvic tilt (°)		7.86 (6.57)	7.85 (6.58)
Pelvic rotation (°)		6.06 (4.33)	6.34 (4.03)
Hip abduction-adduction (°)		8.22 (4.41)	9.57 (5.86)
Hip flexion-extension (°)		13.18 (5.87)	13.65 (6.89)
Hip rotation (°)		9.75 (5.36)	9.90 (4.74)
Knee flexion-extension (°)		15.38 (7.73)	12.99 (7.02)
Ankle dorsal-plantar flexion (°)		13.19 (13.65)	13.33 (11.87)
Foot progression (°)		14.04 (8.80)	10.64 (5.68)
GDI	> 100	73.23* (14.50)	80.45* (17.05)

Abbreviation: GDI, gait deviation index; GPS, gait profile scale; GVS, gait variable scores; SD, standard deviation. **Notes:** * $p < 0.05$ comparing with the standard value.

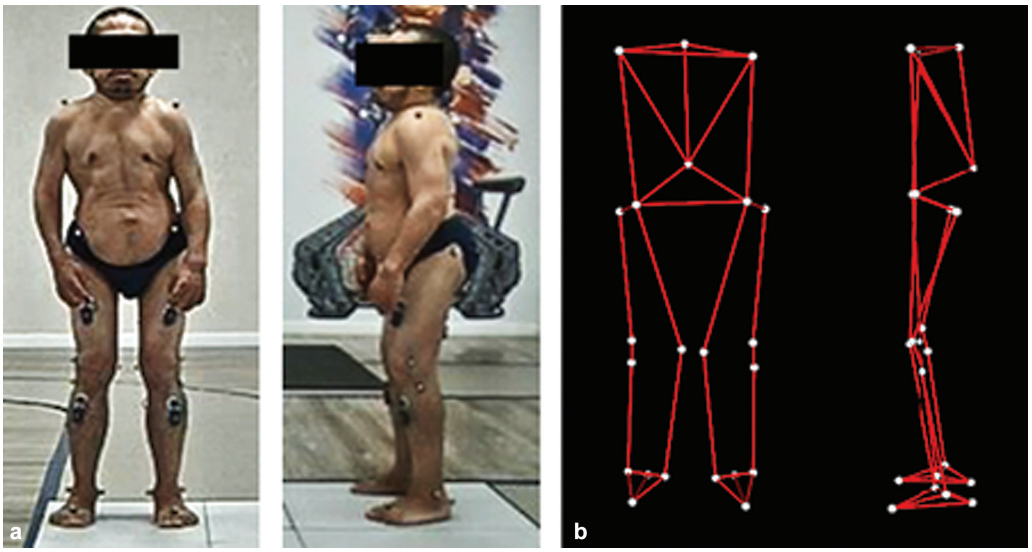


Fig. 3 (**a**) Patient during the static examination (standing) with Helen Hayes MM protocol in the gait laboratory; (**b**) The 3D reconstruction at BTS SMART-Clinic. Note the pattern of hip flexion.

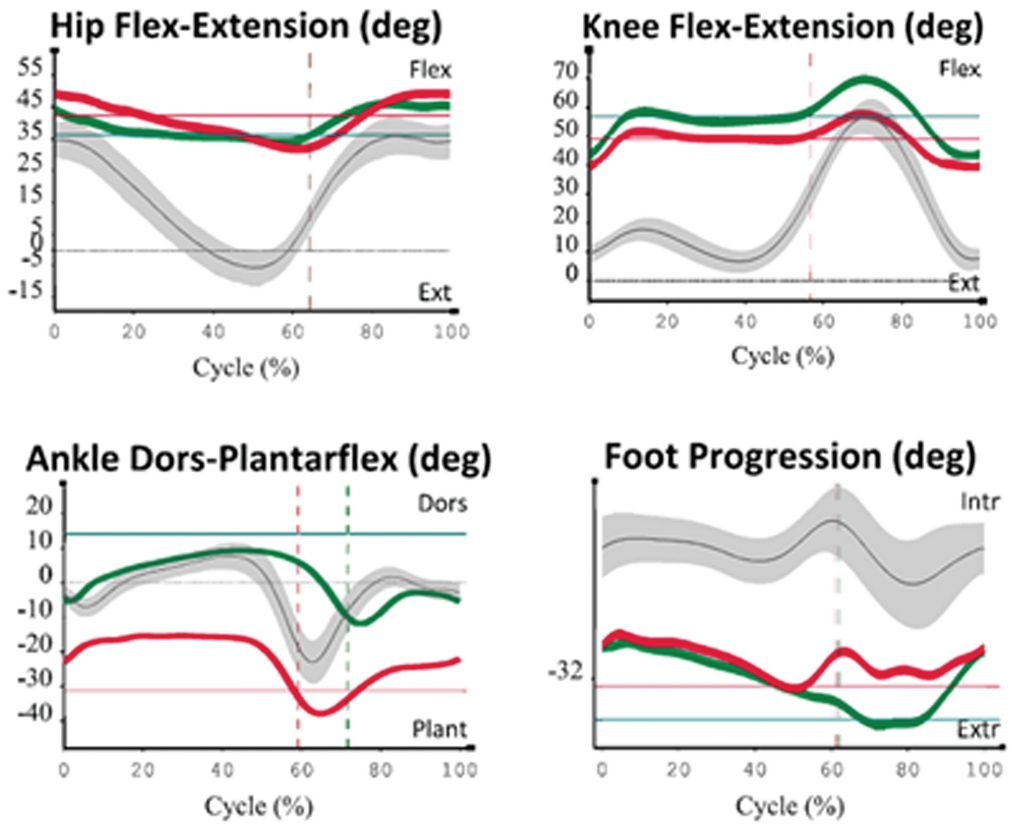


Fig. 4 The BTS motion analysis graphs of different patients from the study. Note the deviation of the lower limb curves concerning the normality parameter in all images.

in children may indicate more responsive stabilization control than in adults.[27]

A study by Fleming et al.[29] evaluated the level of functionality in 15 children with MPS using the International Classification of Functioning, Disability, and Health. These authors reported mild impairment of bodily functions and severe impairment of joint mobility and gait, which is in line with our study.

The limitation of this study was the small number of subjects. In genetic storage syndromes, involving different systems, research must deal with the high variability between patients. As such, these studies must include a large

number of subjects. Therefore, further studies are required with a larger sample of patients.

Conclusion

Patients presented a decreased average speed and stride length. Most cases presented a gait pattern of flexion and adduction of the hips and flexion of the knees. Both GPS and GDI showed an important deviation from normality. The analysis of EMG data revealed intervals of muscular activity approximately following the current model, highlighting the high variability of muscle activation patterns between patients.

Financial Support
The authors declare that there was no financial support from public, commercial, or not-for-profit sources.

Conflict of Interests
The authors have no conflict of interests to declare.

References

1 Gaffke L, Pierzynowska K, Podlacha M, Brokowska J, Węgrzyn G. Changes in cellular processes occurring in mucopolysaccharidoses as underestimated pathomechanisms of these diseases. Cell Biol Int 2021;45(03):498–506
2 Herring JA, Tachdjian MO. Texas Scottish Rite Hospital for Children. 5th ed. Philadelphia: Saunders; 2013:455
3 Çelik B, Tomatsu SC, Tomatsu S, Khan SA. Epidemiology of Mucopolysaccharidoses Update. Diagnostics (Basel) 2021;11(02):273
4 Federhen A, Pasqualim G, de Freitas TF, et al. Estimated birth prevalence of mucopolysaccharidoses in Brazil. Am J Med Genet A 2020;182(03):469–483
5 Pinto LL, Schwartz IV, Puga AC, Vieira TA, Munoz MV, Giugliani R. Prospective study of 11 Brazilian patients with mucopolysaccharidosis II. J Pediatr (Rio J) 2006;82(04):273–278
6 Del Longo A, Piozzi E, Schweizer F. Ocular features in mucopolysaccharidosis: diagnosis and treatment. Ital J Pediatr 2018;44 (Suppl 2):125
7 Barone R, Pellico A, Pittalà A, Gasperini S. Neurobehavioral phenotypes of neuronopathic mucopolysaccharidoses. Ital J Pediatr 2018;44(Suppl 2):121
8 Kubaski F, de Oliveira Poswar F, Michelin-Tirelli K, et al. Diagnosis of Mucopolysaccharidoses. Diagnostics (Basel) 2020;10(03):172
9 Cardoso-Santos A, Azevedo AC, Fagondes S, Burin MG, Giugliani R, Schwartz IV. Mucopolysaccharidosis type VI (Maroteaux-Lamy syndrome): assessment of joint mobility and grip and pinch strength. J Pediatr (Rio J) 2008;84(02):130–135
10 Davis RB, Ounpuu S, Tyburski D, Gage JR. A gait analysis data collection and reduction technique. Hum Mov Sci 1991;10(05):575–587
11 Souza MA, Cezarani A, Lizzi EADS, et al. The use of the gait profile score and gait variable score in individuals with Duchenne Muscular Dystrophy. J Biomech 2020;98:109485
12 Schwartz IV, Ribeiro MG, Mota JG, et al. A clinical study of 77 patients with mucopolysaccharidosis type II. Acta Paediatr 2007; 96(455):63–70
13 Sutherland DH. The evolution of clinical gait analysis part l: kinesiological EMG. Gait Posture 2001;14(01):61–70
14 Dhawale AA, Church C, Henley J, et al. Gait pattern and lower extremity alignment in children with Morquio syndrome. J Pediatr Orthop B 2013;22(01):59–62
15 Akyol MU, Alden TD, Amartino H, et al; MPS Consensus Programme Steering Committee MPS Consensus Programme Co-Chairs. Recommendations for the management of MPS VI: systematic evidence- and consensus-based guidance. Orphanet J Rare Dis 2019;14(01):118
16 Matos MA, Prado A, Schenkel G, Barreto R, Acosta AX. Energy expenditure during gait in patients with mucopolysaccharidosis. Acta Ortop Bras 2013;21(02):116–119
17 Schmid S, Schweizer K, Romkes J, Lorenzetti S, Brunner R. Secondary gait deviations in patients with and without neurological involvement: a systematic review. Gait Posture 2013;37(04): 480–493
18 Patterson KK, Nadkarni NK, Black SE, McIlroy WE. Gait symmetry and velocity differ in their relationship to age. Gait Posture 2012; 35(04):590–594
19 Baker R, Esquenazi A, Benedetti MG, Desloovere K. Gait analysis: clinical facts. Eur J Phys Rehabil Med 2016;52(04):560–574
20 Lin HY, Lee CL, Lo YT, et al. The relationships between urinary glycosaminoglycan levels and phenotypes of mucopolysaccharidoses. Mol Genet Genomic Med 2018;6(06):982–992
21 Salazar-Torres JJ, Church C, Shields T, et al. Evaluation of Gait Pattern and Lower Extremity Kinematics of Children with Morquio Syndrome (MPS IV). Diagnostics (Basel) 2021;11 (08):1350
22 Kimoto M, Okada K, Sakamoto H, Kondou T, Kawanobe U. Relationship between walking efficiency and muscular strength of the lower limbs in children with cerebral palsy. J Phys Ther Sci 2019; 31(03):232–235
23 Hahn ME, Chou LS. Can motion of individual body segments identify dynamic instability in the elderly? Clin Biomech (Bristol, Avon) 2003;18(08):737–744
24 Ellis RG, Howard KC, Kram R. The metabolic and mechanical costs of step time asymmetry in walking. Proc Biol Sci 2013;280(1756): 20122784
25 Neufeld EF, Muenzer J. The mucoplysaccharidoses. In: Scriver CR, et al. The metabolic and molecular bases of inherited disease. 8 th ed. New York: McGraw-Hill; 2001:3421–3452
26 Massaad A, Assi A, Skalli W, Ghanem I. Repeatability and validation of gait deviation index in children: typically developing and cerebral palsy. Gait Posture 2014;39(01):354–358
27 Agostini V, Nascimbeni A, Gaffuri A, Imazio P, Benedetti MG, Knaflitz M. Normative EMG activation patterns of school-age children during gait. Gait Posture 2010;32(03):285–289
28 Granata KP, Padua DA, Abel MF. Repeatability of surface EMG during gait in children. Gait Posture 2005;22(04):346–350
29 Fleming AM, Ribeiro CT, Horovitz DG, Ribeiro LC, Correa AP. Description of functioning in children and adolescents with mucopolysaccharidosis-case series. J Inborn Errors Metab Screen 2020;8:e20190010

Periprosthetic Fractures of the Femur during the Operation of Primary Total Hip Arthroplasties

Fraturas periprotéticas do fêmur no peroperatório das artroplastias totais primárias do quadril

Conrado Auer Trentini[1,2] Marcela de Andrade Balsano[1] Mark Deeke[2] Francisco José Zaniolo[2]

[1] Orthopedics and Traumatology Service, Hospital Universitário Regional dos Campos Gerais, Ponta Grossa, PR, Brazil
[2] Orthopedics and Traumatology Service, Hospital Universitário Cajuru, Curitiba, PR, Brazil

Address for correspondence Marcela de Andrade Balsano, MD, Rua Venezuela, 74, apto.704, Ponta Grossa, Paraná, Brazil (e-mail: marcela.balsano@gmail.com).

Rev Bras Ortop 2024;59(5):e745–e751.

Abstract

Objective To determine the incidence of periprosthetic femoral fractures during the operation in primary hip arthroplasties and correlate them with the inherent risk factors associated with patients, implants, and the diagnosis of coxarthrosis and/or femoral neck fractures.

Methods Cross-sectional study, with retrospective analysis of medical records and image exams of patients operated between 2014 and 2019. The variables analyzed followed those proposed by the world literature, namely: age, sex, Dorr index, surgical indication, Vancouver classification, location, type of fixation (cemented or non-cemented), implant model used, intraoperative diagnosis, and corresponding treatment approach. All surgeries used the same posterolateral access route and were performed by the same group of surgeons.

Results Within the sample of 2,217 arthroplasties (2,154 patients), 12 fractures (0.56%) were identified in 12 patients. The sample consisted of 8 females and 4 males, with an average age of 62.53 years. In all diagnosed cases, protective cerclages were added at the level of the lesser trochanter and/or the greater trochanter, and, in 3 cases, there was a change from uncemented to cemented femoral stems and only 1 required revision.

Conclusion Data Analysis Allows Us To State That The Risk Of Intraoperative Periprosthetic Fracture Is Greater In Women And With The Use Of Cementless Stems. The Occurrence Of These In This Study Had A Rate Of Less Than 1%.

Keywords
- arthroplasty
- hip fractures
- intraoperative complications
- periprosthetic fractures

Work developed at Hospital Universitário Cajuru, Curitiba, PR, Brazil.

received
October 24, 2022
accepted
August 10, 2023

DOI https://doi.org/10.1055/s-0044-1779320.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Resumo

Objetivo Determinar a incidência de fraturas periprotéticas do fêmur no peroperatório em artroplastias primárias do quadril e correlacioná-las com os fatores de risco inerentes aos pacientes, implantes e ao diagnóstico de coxoartrose e/ou fratura do colo do fêmur.

Métodos Estudo transversal, com análise retrospectiva de prontuários e exames de imagem de arquivos do pacientes operados entre 2014 e 2019. As variáveis analisadas seguiram o proposto pela literatura mundial, sendo elas: idade, sexo, índice de Dorr, indicação cirúrgica, classificação de Vancouver, local, tipo de fixação (cimentada ou não cimentada), modelo do implante utilizado, diagnóstico intraoperatório e tratamento instituído. Todas as cirurgias utilizaram a mesma via de acesso póstero-lateral e foram realizadas pelo mesmo grupo de cirurgiões.

Resultados Dentro da amostra de 2.217 artroplastias (2.154 pacientes) foram identificadas 12 fraturas (0,56%) em 12 pacientes. A amostra foi composta por 8 pacientes do gênero feminino e 4 do gênero masculino, com média de idade de 62,53 anos. Em todos os casos diagnosticados foram adicionadas cerclagens de proteção ao nível do pequeno trocanter e ou do grande trocanter e em 3 casos houve mudança de hastes femorais não cimentadas para cimentadas e apenas 1 evoluiu com necessidade de revisão.

Conclusão A análise dos dados permite afirmar que o risco de fratura periprotética intraoperatória é maior em mulheres e com o uso de hastes não cimentadas. A ocorrência destas neste estudo teve taxa inferior a 1%.

Palavras-chave

- artroplastia
- complicações intraoperatórias
- fraturas do quadril
- fraturas periprotéticas

Introduction

Total hip arthroplasty (THA) is a common and successful surgical procedure in the treatment of patients with osteoarthritis or hip fractures, whose main objective is to provide pain relief and restore joint biomechanics, substantially improving the quality of life of the patient.[1]

Among the complications resulting from THA, periprosthetic fracture is mentioned. It is considered a rare complication that, when not diagnosed during surgery, requires complex, clinically relevant treatment and is generally associated with an unfavorable outcome, such as the need for early revision arthroplasty and poor functional recovery.[2] For these reasons, it is important to identify which predisposing factors are present in the cases to be operated on so that we can reduce the risks of this complication.[3]

Intraoperative fractures in primary arthroplasties can be observed during surgery and are related to the type of implant, uncemented prostheses, incompatibility between the rasp and the implant, joint interface, gender and/or defects created during the osteotomy or milling of the femoral canal.[4] The fracture diagnosis can be made through direct visualization of the line, a change in sound during the impaction of reamers, a sudden alteration in resistance during the implantation of the definitive femoral component, or through the immediate postoperative x-ray.[5]

After diagnosis, it is important to classify the fractures as this will guide the treatment strategy. To this end, we used the Vancouver classification for intraoperative femoral fractures, which takes into account the stability of the implant. Type A occurs in the proximal metaphysis, type B occurs in the diaphysis, and type C occurs distal to the shaft. They can further be subdivided into type I (perforation), type II (non-displaced fracture line), and type III (unstable or displaced).[4]

Dorr et al.[6] classified the conformation of the proximal femur into types A, B, and C based on the thickness of the cortices and the shape of the spinal canal. Patients with type C femoral pain had a 6.5 times higher risk of postoperative periprosthetic fracture compared to those with type A, while female patients had a 1.3 times higher risk of experiencing this complication.[7] Considering intraoperative fractures, 86% occur during the use of cementless stems in patients with good bone quality, Dorr A or B.[8]

The consequences of intraoperative periprosthetic fractures are varied resulting in higher readmission rates, financial burden, inferior functional outcome, increased revision rates, and increased mortality. Given this scenario, the importance of diagnosing these fractures intraoperatively is highlighted, since the treatment is highly effective and low complexity.[9]

In this scenario, the present study aims to determine the incidence of periprosthetic femur fractures during the operative period in primary hip arthroplasties and correlate it with the risk factors inherent to patients, implants, and the diagnosis of coxoarthrosis and/or fracture of the femoral neck.

Materials and Methods

This is a retrospective cross-sectional study, based on medical records and imaging exams from the archives of 2 tertiary

hospitals from 01/01/2014 to 12/31/2019. All patients undergoing primary total hip arthroplasty via posterolateral access during the study period and with a period of at least 1 year of postoperative follow-up were included. This research was submitted for analysis by the Research Ethics Committee of Hospital Universitário Cajuru- Curitiba/PR and Hospital Marcelino Champagnat- Curitiba/PR.

Patients undergoing revision arthroplasty, those with previous surgeries on the affected hip, resection arthroplasty, patients who missed follow-ups, and cases related to pathological fracture were excluded.

The variables analyzed followed those suggested in the literature and were age, sex, Dorr index, surgical indication, Vancouver fracture classification, location, type of femoral fixation (cemented or uncemented), implant model used, intra or postoperative diagnosis and corresponding treatment approach (►**Table 1**). All cases were performed by a surgical team comprising 5 members, 4 of whom were experienced senior surgeons with over 6 years of expertise, and 1 junior surgeon with 2 years of experience at the beginning of the study.

The sample consisted of 2,217 arthroplasties performed on 2,154 patients, with 12 fractures (0.56%) identified. All radiographs from the immediate postoperative period, as well as subsequent follow-up imaging examinations (15th day, 4 and 6 weeks, 3 months, 6 months, and yearly), were analyzed.

The data obtained were analyzed quantitatively using the Microsoft Excel Office 2010 software (Microsoft Corporation, Redmond WA, USA) for absolute and relative frequency measurements. Comparisons between variables were carried out using the Student t test, after checking the normality and variance of the data. Statistical significance was $p < 0.05$.

Results

12 femoral fractures that occurred intraoperatively (0.56%) were detected in a total of 2,117 hip arthroplasties in 2,054 patients over 6 years (►**Table 2**).

The femoral component was cemented in 1,208 cases (57.06%) and uncemented in 909 cases (42.93%), with an increase in the frequency of use of uncemented implants over the years (►**Table 3**).

Eleven fractures were detected intraoperatively. In a case in which there was no diagnosis during surgery, nor was it possible to show the fracture on the immediate control x-ray, the patient developed disproportionate postoperative discomfort and pain, and, on the 13th day, he presented to the emergency room reporting severe pain associated with functional impotence without history of trauma, with the fracture being identified, which occurred intraoperatively.

Regarding cementation of the femoral component, there was 1 case (0.11%) involving the use of a cemented implant ($n = 909$, $p = 0.004$), and 11 cases (0.91%) involving the use of

Table 1 Cases

Age	Sex	Door	Indication	Vancouver	Location	Cemented stem	Model used	Diagnosis	Treatment
74	F	C	Fracture	A2	GT	No	Stryker- Accolade II (Portage, MI, USA)	Yes	Conversion + cerclage
56	M	B	Osteoarthritis	A2	GT	No	Zimmer-ML (Warsaw, IN, USA)	Yes	Cerclage
73	F	A	Osteoarthritis	A2	Calcar	No	Stryker- Accolade II (Portage, MI, USA)	Yes	Cerclage
74	F	B	Fracture	A2	Calcar	No	Jhonson- Corall (São Paulo, SP, BR)	Yes	Cerclage
65	F	B	Osteoarthritis	A2	Calcar	No	Jhonson- Corall (São Paulo, SP, BR)	Yes	Conversion + cerclage
78	F	A	Osteoarthritis	A2	GT	No	Aesculap- Bicontact (Tullingen, GER)	No	RATQ
67	F	B	Osteoarthritis	A2	Calcar	No	Jhonson- Corall (São Paulo, SP, BR)	Yes	Conversion + cerclage
47	M	A	Osteoarthritis	A2	Calcar	No	Aesculap- Bicontact (Tullingen, GER)	Yes	Cerclage
83	M	A	Osteoarthritis	A2	Calcar	No	Jhonson- Corall (São Paulo, SP, BR)	Yes	Conversion + cerclage
62	M	B	Osteoarthritis	B2	Diaphysis	Yes	Baumer-Alpha (Mogi Mirim, SP, BR)	Yes	Cerclage
32	F	A	Osteoarthritis	A2	Calcar	No	Aesculap- Bicontact (Tullingen, GER)	Yes	Cerclage
40	F	B	Osteoarthritis	A2	Calcar	No	Aesculap- Bicontact (Tullingen, GER)	Yes	Cerclage

Abbreviations: GT, great trochanter; Conversion, replacement with cemented femoral stem, RATQ, arthroplasty revision.

Table 2 Arthroplasties performed over a 6-year period by the group of surgeons, total number and percentage of intraoperative periprosthetic fractures

Year	Total number of surgeries	Total number of periprosthetic fractures	Percentage of periprosthetic fractures
2014	272	0	0%
2015	280	1	0.35%
2016	335	1	0.29%
2017	382	0	0%
2018	440	6	1.36%
2019	408	4	0.98%

Table 3 Total quantity of cemented and uncemented femoral components

Year	Cemented	Uncemented
2014	156	116
2015	161	119
2016	176	159
2017	117	265
2018	179	261
2019	120	288

uncemented implants (n =1,208, $p = 0.005$). Of the 12 reported cases, 8 occurred in women (66.6%), and the age of the patients ranged between 32 and 83 years, with an average of 62.5 years.

Out of the 10 elective arthroplasties performed, 8 were due to arthrosis, while only 2 were prompted by femoral neck fractures. Despite being carried out by different surgeons, all procedures employed the same posterolateral access approach. The surgical technique for all femoral stems involved a sequential milling of the canal until achieving implant stability, and there were no fractures during test reductions. In 4 instances, the decision was made to replace the femoral stem with a cemented one and secure the fracture with cerclage, utilizing a 1.5-mm steel wire positioned above the lesser trochanter or, if necessary, involving the greater trochanter. In the remaining cases, the stem was retained, and treatment was administered using cerclage with a 1.5-mm steel wire, as shown in ►**Fig. 1**.

In the case in which the fracture was not identified intraoperatively but upon the patient's postoperative return, the radiography detected a fracture starting in the greater trochanter and extending to the metaphyseal region (Vancouver B2) in addition to signs compatible with implant loosening. In this case, a revision arthroplasty was performed with a distal fixation femoral stem (►**Fig. 2**).

Visual and tactile stability was achieved in all cases, and weight bearing was permitted by the patient as tolerated.

Discussion

Intraoperative periprosthetic fracture of the femur is a complication frequently described in the literature and lacks studies with a broad sample. When not detected immediately, it leads to early implant failure, increased hospital stay, increased morbidity, and costs inherent to the procedure.[10] This has a variable incidence in the literature, being approximately 0.62% for cemented implants and 0.87% for non-cemented implants in a sample of 793,823 THAs.[11] There is currently an increase in the incidence of this event, which is related to the aging of the population and the increased use of uncemented stems.[12,13]

Over the course of 6 years, we obtained an incidence of 0.11% using cemented stems and 0.91% using uncemented stems, which is compatible with the global literature. The risk approximately doubles in women.[14] Our data point to an increase in the prevalence of fractures with increasing age in women, which does not occur in men. This difference may exist because women are more affected by postmenopausal osteoporosis, which leads to a decrease in bone resistance.[15]

Increasing age has already been associated with an increase in intraoperative fractures,[14] but young patients may have a greater risk of suffering calcar fractures due to the proximal femoral canal being narrower and requiring longer

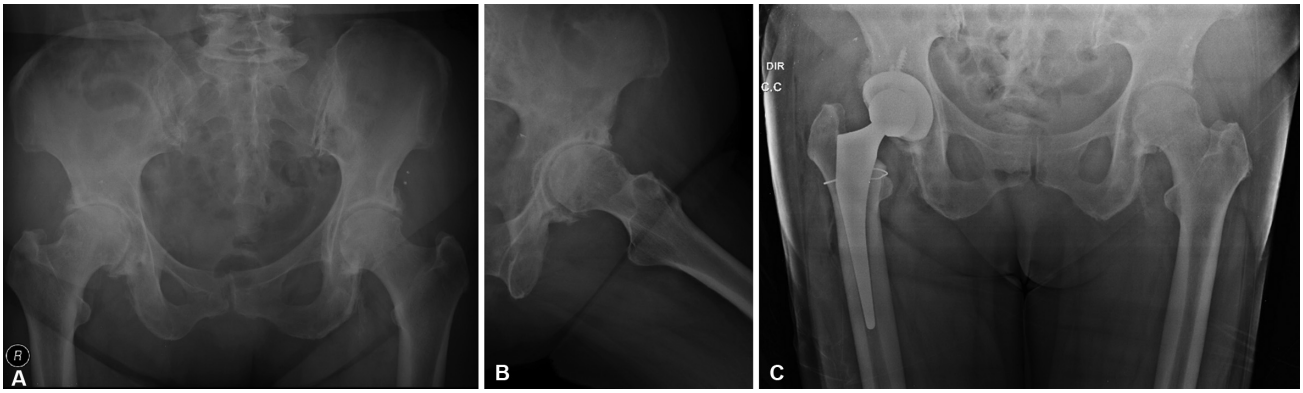


Fig. 1 (**A-B**) Preoperative radiograph, (**C**) Immediate control radiograph, maintenance of the nail and cerclage above the lesser trochanter. Source: researcher's collection.

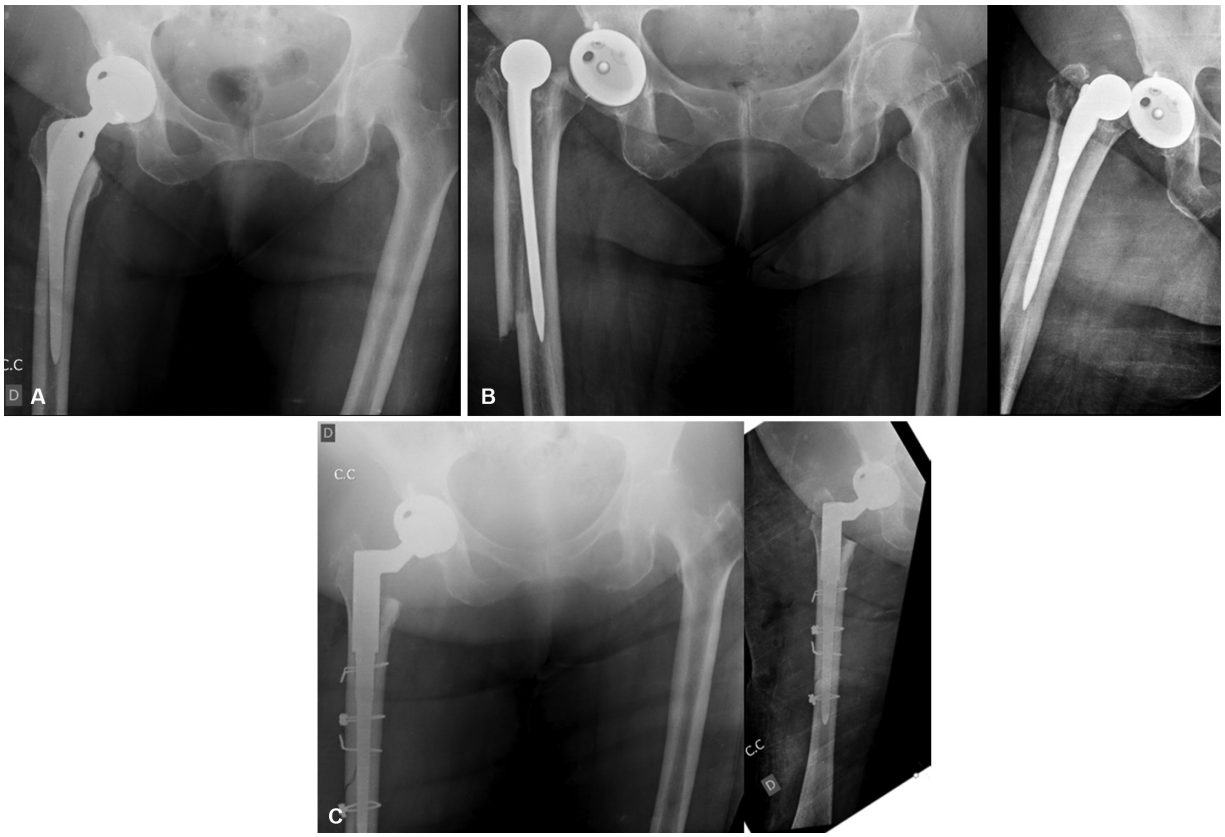


Fig. 2 (A) Immediate postoperative X-ray, (B) X-ray on the 13th day of evolution, (C) Control X-ray after review. Source: researcher's collection.

reaming with greater force transmitted between the bone and the instrument.

The analysis in ►**Table 2** shows the progressive increase in the use of uncemented femoral stems instead of cemented ones, a change that has occurred over the years due to a global trend in changing the technique. Uncemented stems, when properly indicated and executed, can reduce surgical time and also the chances of pulmonary embolism resulting from the cementation process.[16] Another possible explanation for this migration is lower revision rates due to aseptic loosening.[17]

The cementless stem model is the most common in THAs performed in the United States, although studies have demonstrated excellent results over the years using different femoral fixation options, a scenario that points to an increased risk of intraoperative fracture when using uncemented stems,[14] as evidenced in our data. Correct planning of the prosthesis with radiographs and transparencies is essential to reduce this risk, since there is the possibility that specific radiographic parameters indicate a greater risk of periprosthetic fracture, for example, those with Dorr type A and type B conformation. In our sample, 42% of fractures occurred in type B canals and 50% in type A canals.

Fractures of the calcar or diaphysis tend to occur during canal preparation or implant insertion, since most uncemented stems use the pressfit concept, which increases tension in the bone cortex. Among the causes of fractures related to surgical conditions inherent to the surgery that occur in the proximal region, we can mention the mismatch between the drill used in the preparation and the definitive implant, or the excessive use of force during surgical exposure and/or preparation of the femoral canal. Finally, distal fractures generally occur due to collision of the straight tip of the implant with the curved cortex of the femur. The type of fracture in which the lesser trochanter is affected occurs secondary to the propagation of microfractures that may have occurred during the primary injury, in the case of a fracture, or during osteotomy. The pattern around the stem occurs due to the incompatibility of the metaphyseal-diaphyseal junction of the stem and the canal during implantation in osteoporotic femurs.[18]

The durability of the cementless stem has been shown to be greater in young patients, perhaps due to better bone quality, which reduces the risk of fractures.[19] However, the increased risk of intraoperative fracture and, consequently, its complications must be considered in relation to the longer survival of the implant, especially in patients in whom the proximal femur appears weak or in cases that require prolonged preparation and greater use of force, as in the cases Dorr A.[11]

The evaluation of the nail design is something that must always be taken into consideration, as the use of wedge nails reveals a 10 times greater risk of causing intraoperative fracture when compared to first generation nails.[20] In two cases presented in the present study, simple wedge femoral

implants with the *Fit-and-Fill* concept (Accolade II – Stryker Corporation, Kalamazoo, MI, USA) were used; this design is associated with a 3-fold increase in intraoperative fracture rates ($p < 0.001$) compared to with anatomical stems, fully coated and conical or rounded.[21] Four cases presented occurred using preservation rods such as Corall (São Paulo, SP, BR) or Bicontact (Tullingmen, GER). In a study that corelates the rod model with a greater risk of fracture, the rasp model in which metaphyseal bone impaction occurs, resulting in bone preservation, would increase the tension around the canal at the time of introduction of the definitive implant, thus increasing the chances of intraoperative fractures.[22]

It is important to analyze whether the indication for arthroplasty, due to fracture or osteoarthritis, interferes with the occurrence of intraoperative fractures. In our study, only 2 cases (16.6%) were indicated for neck fracture and 10 cases (83.3%) for osteoarthritis. The literature is controversial on this point. Those who advocate for the use of cemented stems use as an argument the increased risk of intraoperative fracture due to preexisting bone fragility that culminated in neck fracture; in parallel, the use of cemented stems could increase mortality due to complications resulting from femoral cementation and increased surgical time.[16]

Klein et al.,[23] in 2006, in a study that brought together 85 cases of neck fractures, with a mean age of 78 years, treated with cementless stem, demonstrated that there was no significant increase in the case of intraoperative fractures and that the patients showed good functional recovery. Richardson et al.,[24] in 2020, with the analysis of 5,883 cases of total arthroplasty in neck fractures, compared the mortality rates in both techniques and obtained as a result a reduction in mortality rates when using cemented stems 30, 90, and 365 days after surgery. This difference is mainly due to the occurrence of intraoperative fractures and, consequently, reoperations when using non-cemented stems. Ekman et al.,[25] in 2019, studied the effects of cementation in 10,677 total and partial arthroplasties, concluding that there was no difference in mortality. The literature is still very controversial on this point and requires further studies.

Considering that the biggest complication of intraoperative fracture is precisely not diagnosing it during surgery, it is important to pay attention to the signs of this complication. It is defined as a fracture identified during the surgical procedure or diagnosed on an immediate control radiograph; some signs, such as a sudden change in resistance during insertion of the definitive component, stopping of the definitive implant below the level of the osteotomy, audible noise, definitive implant with different size than planned and/or loss of stability; suggest a possible fracture.[5]

In general, the treatment of acute periprosthetic fractures is related to a high rate of complications (63%) and reoperations (23%), and intraoperative diagnosis results in favorable outcome and low complexity of the procedure. The tactic consists of applying a circumferential cerclage with steel wire above the lesser trochanter and using the same implant after the cerclage with stabilization of the fracture.[9]

In this study, the failure of the intraoperative diagnosis generated the need for a revision arthroplasty on the 13th postoperative day. The review of the exams showed that it was a hidden fracture, which, after intervention, evolved with consolidation of the fracture and full functional recovery. In three cases, the uncemented implant was exchanged for a cemented stem and cerclage was associated at the trochanter; this option being due to the greater femoral bone fragility, detected by the surgeon. All cases evolved with bone consolidation, full functional recovery of the patient, and without the implant loosening over the years.

When diagnosed intraoperatively and treated with the cerclage technique above the lesser trochanter, periprosthetic fracture has a high-resolution rate, and a good outcome is guaranteed. Late diagnosis leads to more complex treatment and greater chances of complications, and in these cases we should use the Vancouver classification for postoperative periprosthetic fractures, which will guide the most appropriate treatment strategy.[26]

Thus, the development of skills by the surgeon, such as recognizing a specific femoral morphology, can change surgical planning and even the selection of the femoral stem.[27]

This study provides information on the incidence, risks, and factors associated with intraoperative periprosthetic femur fracture during total hip arthroplasty. Understanding how it occurs and identifying possible factors that indicate such a complication is essential so that we can reduce complications, as once diagnosed intraoperatively, it has a less complex treatment and better results.

Conclusions

Data analysis allows us to state that the risk of intraoperative periprosthetic fracture is greater in women and with the use of cementless stems. The occurrence of these in the present study had a rate of less than 1%.

Financial Support
The authors declare that there was no financial support from public, commercial, or non-profit sources.

Conflict of Interests
The authors have no conflict of interests to declare.

References

1 Galia CR, Diesel CV, Guimarães MR, Ribeiro TA. Atualização em artroplastia total de quadril: uma técnica ainda em desenvolvimento. Rev Bras Ortop 2017;52(05):521–527
2 Hoskins W, Bingham R, Lorimer M, Hatton A, de Steiger RN. Early rate of revision of total hip arthroplasty related to surgical approach: an analysis of 122,345 primary total hip arthroplasties. J Bone Joint Surg Am 2020;102(21):1874–1882
3 Mayle RE, Della Valle CJ. Intra-operative fractures during THA: see it before it sees us. J Bone Joint Surg Br 2012;94(11, Suppl A)26–31
4 Davidson D, Pike J, Garbuz D, Duncan CP, Masri BA. Intraoperative periprosthetic fractures during total hip arthroplasty. Evaluation and management. J Bone Joint Surg Am 2008;90(09):2000–2012
5 Liu B, Ma W, Li H, Wu T, Huo J, Han Y. Incidence, classification, and risk factors for intraoperative periprosthetic femoral fractures in

patients undergoing total hip arthroplasty with a single stem: a retrospective study. J Arthroplasty 2019;34(07):1400–1411
6 Dorr LD, Faugere MC, Mackel AM, Gruen TA, Bognar B, Malluche HH. Structural and cellular assessment of bone quality of proximal femur. Bone 1993;14(03):231–242
7 Miettinen SS, Mäkinen TJ, Kostensalo I, et al. Risk factors for intraoperative calcar fracture in cementless total hip arthroplasty. Acta Orthop 2016;87(02):113–119
8 Ponzio DY, Shahi A, Park AG, Purtill JJ. Intraoperative Proximal Femoral Fracture in Primary Cementless Total Hip Arthroplasty. J Arthroplasty 2015;30(08):1418–1422
9 Sheth NP, Brown NM, Moric M, Berger RA, Della Valle CJ. Operative treatment of early peri-prosthetic femur fractures following primary total hip arthroplasty. J Arthroplasty 2013;28(02): 286–291
10 Haynes JA, Hopper RH Jr, Ho H, McDonald JF III, Parks NL, Hamilton WG. Direct Anterior Approach for Primary Total Hip Arthroplasty Lowers the Risk of Dislocation Compared to the Posterior Approach: A Single Institution Experience. J Arthroplasty 2022;37 (03):495–500
11 Lamb JN, Matharu GS, Redmond A, Judge A, West RM, Pandit HG. Risk Factors for Intraoperative Periprosthetic Femoral Fractures During Primary Total Hip Arthroplasty. An Analysis From the National Joint Registry for England and Wales and the Isle of Man. J Arthroplasty 2019;34(12):3065–3073.e1
12 Nichols CI, Vose JG, Nunley RM. Clinical outcomes and 90-day costs following hemiarthroplasty or total hip arthroplasty for hip fracture. J Arthroplasty 2017;32(9S):S128–S134
13 Trousdale WH, Abdel MP, Viste A, Trousdale RT, Callaghan JJ, Berry DJ. Seasonality of periprosthetic femur fractures in 12,700 primary and revision total hip arthroplasties. J Arthroplasty 2017;32 (06):2000–2004
14 Abdel MP, Watts CD, Houdek MT, Lewallen DG, Berry DJ. Epidemiology of periprosthetic fracture of the femur in 32 644 primary total hip arthroplasties: a 40-year experience. [published correction appears in Bone Joint J 2020;102-B(12):1782]Bone Joint J 2016;98-B(04):461–467
15 Osterhoff G, Morgan EF, Shefelbine SJ, Karim L, McNamara LM, Augat P. Bone mechanical properties and changes with osteoporosis. Injury 2016;47(Suppl 2)S11–S20
16 Olsen F, Kotyra M, Houltz E, Ricksten SE. Bone cement implantation syndrome in cemented hemiarthroplasty for femoral neck fracture: incidence, risk factors, and effect on outcome. Br J Anaesth 2014;113(05):800–806
17 Gundtoft PH, Varnum C, Pedersen AB, Overgaard S. The Danish Hip Arthroplasty Register. Clin Epidemiol 2016;8:509–514
18 Chana R, Mansouri R, Jack C, et al. The suitability of an uncemented hydroxyapatite coated (HAC) hip hemiarthroplasty stem for intra-capsular femoral neck fractures in osteoporotic elderly patients: the Metaphyseal-Diaphyseal Index, a solution to preventing intra-operative periprosthetic fracture. J Orthop Surg Res 2011;6:59
19 Wangen H, Havelin LI, Fenstad AM, et al. Reverse hybrid total hip arthroplasty. Acta Orthop 2017;88(03):248–254
20 Colacchio ND, Robbins CE, Aghazadeh MS, Talmo CT, Bono JV. Total Hip Intraoperative Femur Fracture: Do the Design Enhancements of a Second-Generation Tapered-Wedge Stem Reduce the Incidence? J Arthroplasty 2017;32(10):3163–3168
21 Carli AV, Negus JJ, Haddad FS. Periprosthetic femoral fractures and trying to avoid them: what is the contribution of femoral component design to the increased risk of periprosthetic femoral fracture? Bone Joint J 2017;99-B(1, Supple A)50–59
22 Zhao R, Cai H, Liu Y, Tian H, Zhang K, Liu Z. Risk factors for intraoperative proximal femoral fracture during primary cementless THA. Orthopedics 2017;40(02):e281–e287
23 Klein GR, Parvizi J, Vegari DN, Rothman RH, Purtill JJ. Total hip arthroplasty for acute femoral neck fractures using a cementless tapered femoral stem. J Arthroplasty 2006;21(08):1134–1140
24 Richardson CG, Lethbridge LN, Dunbar MJ. Increased mortality with the use of cementless fixation for femoral neck fractures: analysis of 5883 hip arthroplasty cases. J Arthroplasty 2020;35 (12):3627–3630
25 Ekman E, Laaksonen I, Isotalo K, Liukas A, Vahlberg T, Mäkelä K Cementing does not increase the immediate postoperative risk of death after total hip arthroplasty or hemiarthroplasty: a hospital-based study of 10,677 patients. Acta Orthop 2019;90(03): 270–274
26 Berend KR, Lombardi AV Jr. Intraoperative femur fracture is associated with stem and instrument design in primary total hip arthroplasty. Clin Orthop Relat Res 2010;468(09):2377–2381
27 Bigart KC, Nahhas CR, Ruzich GP, et al. Does Femoral Morphology Predict the Risk of Periprosthetic Fracture After Cementless Total Hip Arthroplasty? J Arthroplasty 2020;35(6S):S359–S363

A Retrospective Cohort Study of the Effects of Canal Filling Ratio and Femoral Bone Density Change on the Outcomes of Anatomical and Double-tapered Wedge Stems

Um estudo de coorte retrospectiva dos efeitos da taxa de preenchimento do canal e da alteração da densidade óssea femoral nos desfechos de hastes anatômicas e cônicas de cunha dupla

Thakrit Chompoosang[1] Patcharavit Ploynumpon[1]

[1] Department of Orthopedics, Faculty of Medicine, Rajavithi Hospital, Bangkok, Thailand

Address for correspondence Patcharavit Ploynumpon, 2 Phayathai Road, Ratchathewi District, Bangkok 10400, Thailand (e-mail: Patcharavitortho@gmail.com).

Rev Bras Ortop 2024;59(5):e752–e757.

Abstract

Objective This study aims to compare the proximal femoral bone density changes in follow-up X-ray imaging and the proximal filling ratios of stems between anatomical and double-tapered wedge stem designs.

Methods Patients aged between 18 and 80 years who received primary total hip arthroplasty using both types of stems between 2017 and 2019 and had follow-up tests for up to a year were included in the study. Canal filling ratios at 3 levels (lesser trochanter [LT], 2 cm above LT, and 7 cm below LT) using the optimal densitometry method. Femoral bone density changes were measured using the Gruen zoning method.

Results A total of 92 patients (76% female and 24% male) met the inclusion criteria for this study. The mean age was 53.86 ± 13.00 years. The canal filling ratio in the double-tapered wedge group (Accolade II) was significantly higher than that in the anatomical stem group (ABGII) ($p < 0.001$, $p < 0.001$, and $p = 0.013$) for all levels of measurement. No significant difference was observed between both types of stems in femoral bone density changes in zones 1 and 4. However, there were significant differences in femoral bone change, with bone loss being higher in the anatomical stem group in zone 7 (−25% versus −17%; $p = 0.010$).

Conclusion Double-tapered wedge stem had a significantly higher canal filling ratio than the anatomical stem at all levels but had less femoral bone density loss in the

Keywords
- bone remodeling
- femur
- hip prosthesis
- prosthesis design

Work carried out at the Department of Orthopedics, Faculty of Medicine, Rajavithi Hospital, Bangkok, Thailand.

received
January 12, 2024
accepted
February 20, 2024

DOI https://doi.org/10.1055/s-0044-1787770.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

follow-up postoperative imaging in zone 7. Furthermore, in zones 1 and 4, there was no significant difference in femoral bone density loss.

Resumo

Objetivo Este estudo teve como objetivo comparar as alterações na densidade óssea femoral proximal em radiografias de acompanhamento e as taxas de preenchimento proximal das hastes anatômicas ou cônicas de cunha dupla.

Métodos O estudo incluiu pacientes com idade entre 18 e 80 anos submetidos à artroplastia total primária do quadril com os dois tipos de hastes entre 2017 e 2019 e que tinham radiografias de acompanhamento por até um ano. As taxas de preenchimento do canal em três níveis (trocânter menor [TM], 2 cm acima do TM e 7 cm abaixo do TM) foram determinadas pelo método de densitometria ideal. As alterações na densidade óssea femoral foram medidas pelo método de zoneamento de Gruen.

Resultados Ao todo, 92 pacientes (76% do sexo feminino e 24% do sexo masculino) atenderam aos critérios de inclusão deste estudo. A média de idade foi de $53{,}86 \pm 13{,}00$ anos. A taxa de preenchimento do canal no grupo com hastes cônicas de cunha dupla (Accolade II) foi significativamente maior do que no grupo com haste anatômica (ABGII) ($p < 0{,}001$, $p < 0{,}001$ e $p = 0{,}013$) em todos os níveis de medição. Não foi notada diferença significativa entre os dois tipos de hastes nas alterações da densidade óssea femoral nas zonas 1 e 4. Porém, diferenças significativas na alteração óssea femoral foram detectadas, já que a perda óssea foi maior no grupo com haste anatômica, na zona 7 (-25% *versus* -17%, $p = 0{,}010$).

Conclusão A haste cônica de cunha dupla gerou uma taxa de preenchimento do canal significativamente maior do que a haste anatômica em todos os níveis, mas com menor perda de densidade óssea femoral em radiografias pós-operatórias de acompanhamento na zona 7. Além disso, nas zonas 1 e 4, não houve perda significativa de densidade óssea femoral.

Palavras-chave
- desenho de prótese
- fêmur
- prótese de quadril
- remodelação óssea

Introduction

Total hip arthroplasty is one of the most common orthopedic surgical procedures. As the number of surgeries increased, the stem design became one of the most important factors affecting overall prosthesis longevity and patient satisfaction. One of the stems that provide good results and long-term outcomes is the cementless one, invented in 1950.[1] Several studies have reported early loosening and instability associated with the initial design, which may be caused by proximal femoral osteopenia resulting from the stress shielding effect.[2] Many modern stems have been developed by promoting proximal engagement, using hydroxyapatite porous coating, which is more compatible with the patient proximal femoral dense bone. By utilizing taper and anatomical designs, they can decrease the distal stem engagement and employ shorter stems, which can reduce proximal bone loss by up to 14%.[3] Moreover, many studies have shown that the stem design revolution reduced stem subsidence, thigh pain, and loosening.[4,5] Nevertheless, no previous research has compared the progression of bone integration and proximal bone loss between a double-tapered wedge stems (Accolade II, Stryker, Portage, MI, USA) and anatomical stems (ABGII, Stryker). Therefore, this study compares proximal femoral filling differences between such stem designs, using immediate postoperative imaging and proximal bone loss utilizing follow-up X-ray. The results will provide a better choice of stem, decrease early complications, and increase satisfaction with the total hip replacement operation.

Materials and Methods

Study Design

This study is a retrospective descriptive-cohort study of immediate and postoperative follow-up imaging from total hip arthroplasty surgery performed from 2017 to 2019. The hospital's Ethics Committee (ID: 62133) approved the research protocol and waived the requirement for informed consent for this study. All patients' collected data and identifiers were made fully anonymous.

Samples

Inclusion Criteria

With permission from the radiology department of Rajavithi, patients aged between 18 and 80 years who received primary total hip arthroplasty using both types of stems between 2017 and 2019 and had follow-up imaging for up to a year were included in this study.

Exclusion Criteria

Patients who were under 18 years of age, received revision hip arthroplasty, had prior hip dysplasia, had any postoperative complication, and with follow-up imaging of less than 1 year were excluded.

Data Collection and Measurement

We obtained immediate and postoperative follow-up imaging from the radiology department for patients who underwent total hip arthroplasty, covering a period of up to 1 year. Data analysis was based on the femoral canal filling ratio method, used by the orthopedic surgeon responsible for adult hip and knee reconstruction.[6] The data included measurements of the proximal femoral and stem diameter in the anteroposterior view at three levels: lesser trochanter (LT), 2 cm proximal to the LT, and 6 cm distal to the LT (►**Fig. 1**).

The follow-up imaging was analyzed for proximal femoral bone density changes using the optimal densitometry method,[7] employing Image J (public domain), a digital optical image analysis software for windows, which measured bone changes in zones 1, 4, and 7 according to the Gruen fixation zone[8] (►**Fig. 2**).



Fig. 2 Measurement of the proximal femoral bone density using optimal densitometry method.

Statical Analysis

Descriptive statistics (number, percentage, mean, median, standard deviation, as well as minimum and maximum values) were used to describe the characteristics of the samples. The Chi-squared test was employed to compare categorical data. The paired *t* test was utilized to compare independent data such as stem and femoral types. Furthermore, the *t* test was employed to compare dependent data such as postoperative imaging. The level of significance was defined as a p-value < 0.05. All statistical analyses were performed using the IBM SPSS Statistics for Windows (IBM Corp., Armonk, NY, USA) software, version 20.0.

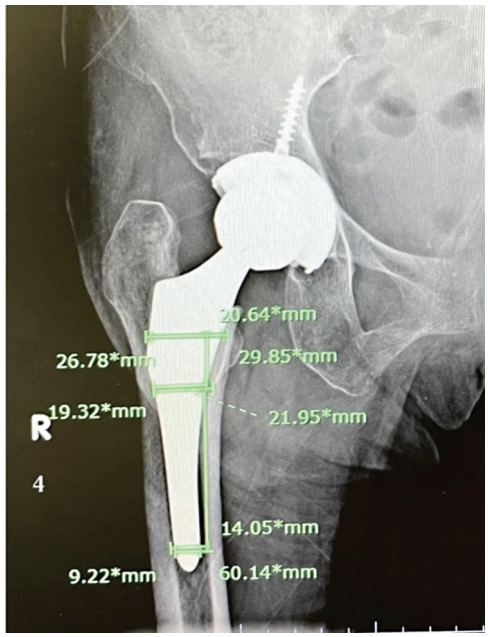


Fig. 1 Measurement of canal filling ratios at the lesser trochanter (LT), 2 cm proximal to LT, and 6 cm distal to LT.

Results

Demographics Data

A total sample of 92 patients (22 males and 70 females) was included in this study. The mean age was of 53.86 ± 13.00 years. There were 34 patients in the anatomical stem group (ABGII) and 58 patients in the double-tapered wedge stem group (Accolade II).

When comparing canal filling ratios between both stems, the canal filling ratio in the double-tapered wedge stem was significantly higher than that in the anatomical stem group at all 3 measurement levels ($p < 0.001$, $p < 0.001$, and $p = 0.013$), as shown in ►**Table 1**.

►**Table 2** presents the femoral bone density changes in each stem type in Gruen zones 1, 4, and 7. Both stems showed a femoral proximal bone loss from the baseline to every time point.

1. Proximal bone density changes in anatomical stem
   At 6-months postoperatively, there were significant differences in femoral bone loss in zones 1, 4, and 7 ($p = 0.024$, $p < 0.001$, and $p = 0.006$, respectively); the highest femoral bone loss was observed in zone 4 (5.74%). At 1-year postoperatively, there was a significant difference in femoral bone loss in zones 1, 4, and 7 ($p < 0.001$); the highest femoral bone loss was found in zone 7 (20.65%). At 2 years postoperatively, significant differences in femoral bone loss were observed in zones 1 ($p < 0.001$), 4 ($p = 0.004$), and 7 ($p < 0.001$); the highest femoral bone loss was seen in zone 1 (34.48%).
2. Proximal bone density changes in double-tapered wedge stem

Table 1 Comparison of canal filling ratios between two types of stems

Level	Anatomical stem (n = 34)	Double-tapered wedge stem (n = 58)	Difference (95% confidence interval)	*p*-value
Lesser trochanter	81.56	88.13	−6.57 (−9.74 to −3.39)	< 0.001*
2 cm above the lesser trochanter	85.98	93.49	−7.51 (−10.07 to −4.95)	< 0.001*
6 cm below the lesser trochanter	78.58	85.64	−7.06 (−12.56 to −1.56)	0.013*

Note: *Statistical significant (*p*-value <0.05).

Table 2 Femoral bone density changes in each stem type in Gruen zones 1, 4, and 7

Femur	Anatomical stem (n = 34)				Double-tapered wedge stem (n = 58)			
	Postoperative (baseline)	6 months	1 year	2 years	Postoperative (baseline)	6 months	1 year	2 years
Zone 1 FBD (%; mean ± SD) Change (%)	(135.59 ± 12.20)	(131.15 ± 10.53) −4.44	(117.35 ± 14.19) −13.79	(84.74 ± 7.29) −34.48	(130.33 ± 13.30)	(122.05 ± 15.14) −8.28	(109.57 ± 12.09) −12.48	(91.63 ± 9.06) −22.37
p-value		0.024*	< 0.001*	< 0.001*		< 0.001*	< 0.001*	< 0.001*
Zone 4 FBD (%; mean ± SD) Change (%)	(164.03 ± 16.41)	(158.29 ± 17.11) −5.74	(145.74 ± 16.92) −12.56	(135.39 ± 12.74) −13.65	(152.86 ± 29.44)	(148.14 ± 24.19) −4.72	(138.64 ± 18.49) −9.50	(129.77 ± 11.34) −16.23
p-value		0.001*	< 0.001*	0.004*		0.098	< 0.001*	< 0.001*
Zone 7 FBD (%; mean ± SD) Change (%)	(157.85 ± 13.84)	(152.71 ± 11.31) −5.15	(132.06 ± 12.33) −20.65	(107.83 ± 19.79) −29.57	(152.29 ± 13.11)	(144.29 ± 14.85) −8.00	(135.12 ± 14.89) −9.17	(126.87 ± 10.59) −11.13
p-value		0.006	< 0.001*	< 0.001*		< 0.001*	< 0.001*	< 0.001*

Abbreviations: FBD, femoral bone density; SD, standard deviation.
Note: *Statistical significant (*p*-value <0.05).

At 6-months postoperatively, there was a significant difference in femoral bone loss in zones 1, 4, and 7 ($p < 0.001$); the highest femoral bone loss was observed in zone 1 (8.28%). At 1-year postoperatively, there was a significant difference in femoral bone loss in zones 1, 4, and 7 ($p < 0.001$); the highest femoral bone loss was seen in zone 1 (12.48%). At 2-years postoperatively, a significant difference in the femoral bone loss was found in zones 1, 4, and 7 ($p < 0.001$); the highest femoral bone loss was seen in zone 1 (22.37%).

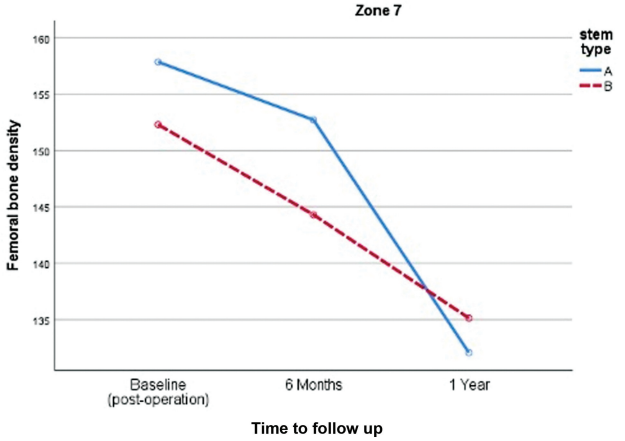


Fig. 3 Comparison of the proximal femoral bone density changes in the Gruen zone 7 of both stems (A, anatomical stem; B, double-tapered wedge stem).

Comparing proximal femoral bone loss between both designs, the double-tapered wedge stem demonstrated significantly less proximal femoral bone loss in the Gruen zone 7 (►**Fig. 3**). However, there was no significant difference in proximal femoral bone loss in zones 1 and 4, as shown in (►**Figs. 4**–**5**) and ►**Table 3**.

►**Table 3** showed that only zone 7 had significant differences in femoral bone density changes between both stems ($p = 0.01$).

Discussion

Cementless total hip arthroplasty is a popular procedure, particularly for younger patients,[9] with a good long-term outcome. However, it was reported to have proximal femoral osteopenia and early aseptic loosening in early designs[4] due

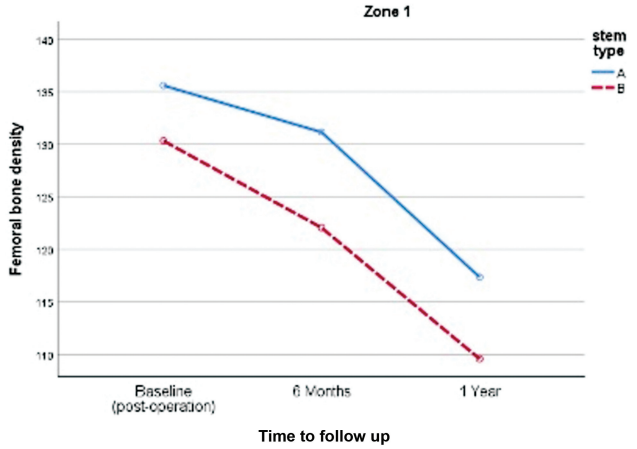


Fig. 4 Comparison of the proximal femoral bone density changes in the Gruen zone 1 of both stems (A, anatomical stem; B, double-tapered wedge stem).

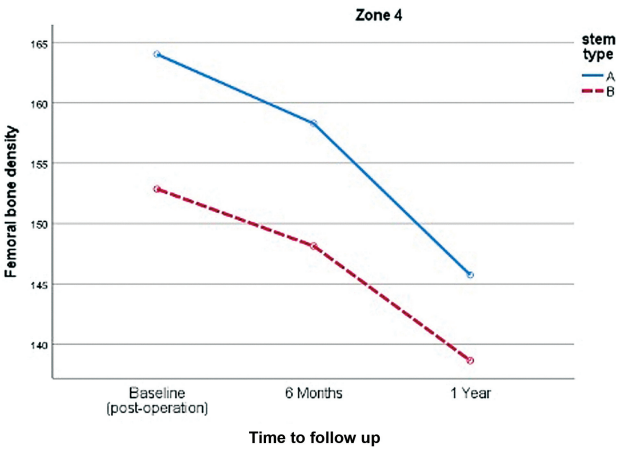


Fig. 5 Comparison of the proximal femoral bone density changes in the Gruen zone 4 of both stems (A, anatomical stem; B, double-tapered wedge stem).

to the stress shielding effect and proximal micromotion of the stem. Later, the stem was refined by improvement in surface and coating material, decrease in the material's stiffness, and variants of the femoral stem length all greatly improve the survival and lessens chance of complications in the procedure.[10]

For canal filling of femoral canal, our study found the canal filling ratio in the double-tapered wedge stem was significantly higher than that in the anatomical stem group at all levels (LT, 2 cm above LT, and 6 cm below LT). It is worth noting that the higher femoral canal filling and canal filling ratio observed in our study may increase the risk of failure of osteointegration, as suggested by the study by Cooper et al.,[11] who noted that an increase in the mid and distal filling, as well as and canal-flare index, are the most important risk factors for osteointegration failure.

According to our study on changes in periprosthetic bone density, the immediate postoperative bone mineral density on the operated side should be used as the baseline value to exclude bone loss due to the operation procedure.[12] Despite

Table 3 Comparison of femoral bone density changes in each zone in both types of stems

Femoral bone density	Stem type		*p*-value
	Anatomical stem (n = 34)	Double-tapered wedge stem (n = 58)	
Zone 1			
Postoperative (baseline)	135.59 ± 12.20	130.33 ± 13.30	0.062
6 months	131.15 ± 10.53	122.05 ± 15.14	0.003*
1 year	117.35 ± 14.19	109.57 ± 12.09	0.006*
2 years	84.74 ± 7.29	91.63 ± 9.06	0.004*
Change (1-year postoperatively)	−18.24 ± 20.48	−20.76 ± 9.36	0.501
Zone 4			
Postoperative (baseline)	164.03 ± 16.41	152.86 ± 29.44	0.022*
6 months	158.29 ± 17.11	148.14 ± 24.19	0.021*
1 year	145.74 ± 16.92	138.64 ± 18.49	0.070
2 years	135.39 ± 12.74	129.77 ± 11.34	0.096
Change (1-year postoperatively)	−18.29 ± 14.79	−14.22 ± 24.22	0.320
Zone 7			
Postoperative (baseline)	157.85 ± 13.84	152.29 ± 13.11	0.058
6 months	152.71 ± 11.31	144.29 ± 14.85	0.005*
1 year	132.06 ± 12.33	135.12 ± 14.89	0.314
2 years	107.83 ± 19.79	126.87 ± 10.59	< 0.001*
Change (1-year postoperatively)	−25.79 ± 15.85	−17.17 ± 13.23	0.010*

Note: *Statistical significant (*p*-value <0.05).

this method, our study found bone density loss in both stems from the baseline, which we attribute to stress-shielding in the area. This finding is consistent with the Venesmaa et al.[13] study, which reported a general decrease in all regions of interest until 6 months, particularly in the Calcar region, and only minor changes after this time period. However, our study observed a decrease in bone density up to 1 year postoperatively. We found that in zone 7, the anatomical stem had a significantly higher femoral bone density loss than that the double-tapered wedge stem (−25% versus −17%, $p = 0.010$). Nevertheless, no significant femoral bone density loss was observed in zones 1 and 4.

The main strength of this study is that it was conducted by a single surgeon in a single center, which minimized confounding factors from surgical technique and postoperative patient care. However, this study has limitations. First, its retrospective nature, which limited data collection on all factors that may have influenced bone loss in our patient population. Additionally, the sample size was relatively small, which prevented us from conducting a meaningful subgroup analysis to investigate the impact of various factors on bone loss. Second, the follow-up period was short (12 months), although we believe it was adequate, as periprosthetic bone density loss was most pronounced in the first postoperative year, with minimal changes thereafter. This finding is consistent with previous studies that highlighted the initial periprosthetic bone remodeling process occurring within the first 12 postoperative months.[14]

Conclusion

Double-tapered wedge stem design had a significantly higher canal filling ratio than the anatomical stem at all levels, with a lower femoral bone density loss identified in the follow-up postoperative imaging at zone 7. However, in zones 1 and 4, no significant difference in femoral bone density loss was observed.

Author Contributions

TK: Conceptualization, methodology, validation, data collection, pilot experiment, writing of the original draft, and writing—review and editing. PP: formal analysis and writing—review and editing. All authors have read and agreed to the published version of the manuscript.

Financial Support

The authors declare that they have received no financial support from agencies in the public, private, or nonprofit sectors to conduct the present study.

Conflict of Interests

The authors have no conflict of interests to declare.

References

1 van der Wal BC, de Kramer BJ, Grimm B, Vencken W, Heyligers IC, Tonino AJ. Femoral fit in ABG-II hip stems, influence on clinical outcome and bone remodeling: a radiographic study. Arch Orthop Trauma Surg 2008;128(10):1065–1072
2 Herrera A, Canales V, Anderson J, García-Araujo C, Murcia-Mazón A, Tonino AJ. Seven to 10 years followup of an anatomic hip prosthesis: an international study. Clin Orthop Relat Res 2004;(423):129–137
3 Panisello JJ, Canales V, Herrero L, Herrera A, Mateo J, Caballero MJ. Changes in periprosthetic bone remodelling after redesigning an anatomic cementless stem. Int Orthop 2009;33(02):373–379
4 de Boer FA, Sariali E. Comparison of anatomic vs. straight femoral stem design in total hip replacement - femoral canal fill in vivo. Hip Int 2017;27(03):241–244
5 Laine HJ, Puolakka TJ, Moilanen T, Pajamäki KJ, Wirta J, Lehto MU. The effects of cementless femoral stem shape and proximal surface texture on 'fit-and-fill' characteristics and on bone remodeling. Int Orthop 2000;24(04):184–190
6 Umer M, Sepah YJ, Khan A, Wazir A, Ahmed M, Jawad MU. Morphology of the proximal femur in a Pakistani population. J Orthop Surg (Hong Kong) 2010;18(03):279–281
7 Hernandez-Vaquero D, Garcia-Sandoval MA, Fernandez-Carreira JM, Suarez-Vázquez A, Perez-Hernández D. Measurement of bone mineral density is possible with standard radiographs: a study involving total knee replacement. Acta Orthop 2005;76(06):791–795
8 Gruen TA, McNeice GM, Amstutz HC. "Modes of failure" of cemented stem-type femoral components: a radiographic analysis of loosening. Clin Orthop Relat Res 1979;(141):17–27
9 Stea S, Comfort T, Sedrakyan A, et al. Multinational comprehensive evaluation of the fixation method used in hip replacement: interaction with age in context. J Bone Joint Surg Am 2014;96(Suppl 1, Suppl 1)42–51
10 Khanuja HS, Vakil JJ, Goddard MS, Mont MA. Cementless femoral fixation in total hip arthroplasty. J Bone Joint Surg Am 2011;93(05):500–509
11 Cooper HJ, Jacob AP, Rodriguez JA. Distal fixation of proximally coated tapered stems may predispose to a failure of osteointegration. J Arthroplasty 2011;26(6, Suppl)78–83
12 Inaba Y, Kobayashi N, Oba M, Ike H, Kubota S, Saito T. Difference in postoperative Periprosthetic bone mineral density changes between 3 major designs of Uncemented stems: a 3-year follow-up study. J Arthroplasty 2016;31(08):1836–1841
13 Venesmaa PK, Kröger HP, Miettinen HJ, Jurvelin JS, Suomalainen OT, Alhava EM. Monitoring of periprosthetic BMD after uncemented total hip arthroplasty with dual-energy X-ray absorptiometry–a 3-year follow-up study. J Bone Miner Res 2001;16(06):1056–1061
14 Christiansen JD, Laursen MB, Ejaz A, Nielsen PT. Bone remodelling of the proximal femur after total hip arthroplasty with 2 different hip implant designs: 15 years follow-up of the thrust plate prosthesis and the Bi-Metric stem. Hip Int 2018;28(06):606–612

Proximal Biceps Tenodesis – Biomechanical Analysis in Sheep: Comparison between Metallic Anchor, Onlay Bioabsorbable Knotless Anchor, and Interference Screw

Tenodese de bíceps proximal – Análise biomecânica em ovinos: Comparação entre âncora metálica, âncora sem nós bioabsorvível onlay *e parafuso de interferência*

Amauri João Orso Júnior[1] Mateus Franceschi Dallanora[1] Paulo Cesar Faiad Piluski[1] Carlos Humberto Castillo Rodriguez[1] João Artur Bonadiman[1] Osvandré Lech[1]

[1] Orthopedics and Traumatology Service, Hospital São Vicente de Paulo/Instituto de Ortopedia e Traumatologia, Passo Fundo, RS, Brazil

Address for correspondence Amauri João Orso Júnior, Rua Morom, number 2624, ap 901, Bairro Centro, Passo Fundo, RS, 99010-035, Brazil (e-mail: amauriorsojr@gmail.com).

Rev Bras Ortop 2024;59(5):e758–e764.

Abstract

Objective To biomechanically evaluate different fixation devices for the proximal biceps in the humerus of sheep, comparing their fixation strength to failure, tendon displacement, and failure site in each technique.

Methods A total of 27 humerus tests were performed on sheep, separating them into 3 groups: group A with tenodesis with metallic anchors ($n = 11$), group B with biocomposite knotless devices ($n = 8$) and group C with metallic interference screws ($n = 8$), performing tenodesis with the sheep's own biceps, maintaining its native distal insertion. The three methods were submitted to a universal tensile testing machine.

Results There was no statistically significant difference in the strength of fixation until failure and displacement between the tendons fixed by the different techniques. Regarding the pattern of ruptures, it was observed that most ruptures of the metallic anchors occurred at the level of the myotendinous junction, most of the bioabsorbable knotless anchors failed due to slippage of the wire-screw interface, and all interference screws failed via tendon slip.

Keywords
- biomechanical phenomena
- models, animal
- orthopedic fixation devices
- tenodesis

Work carried out at the Orthopedics and Traumatology Service of Hospital São Vicente de Paulo/Instituto de Ortopedia e Traumatologia, Passo Fundo, RS, Brazil.

received
June 8, 2022
accepted
October 4, 2022

DOI https://doi.org/10.1055/s-0043-1768616.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Conclusion The three techniques with metal anchor, onlay bioabsorbable knotless anchors, and interference screws are largely resistant to tensile loads for long head of the biceps tenodesis in sheep. There was no statistical difference between the three groups. Cyclic load resistance studies can provide more valuable data for comparing groups.

Resumo

Objetivo Avaliar biomecanicamente diferentes dispositivos de fixação do bíceps proximal no úmero de ovinos, comparando sua força de fixação até a falha, deslocamento do tendão e local de falha em cada técnica.

Métodos Foram realizados 27 ensaios em úmero de ovinos, separando-os em 3 grupos: grupo A com tenodese com âncoras metálicas ($n = 11$), grupo B com âncoras bioabsorvíveis sem nós ($n = 8$) e grupo C com parafusos de interferência metálicos ($n = 8$), realizando a tenodese com o próprio bíceps dos ovinos mantendo sua inserção distal nativa. Os três métodos foram submetidos a máquina universal de ensaio de tração.

Resultados Não se observou diferença estatisticamente significativa quanto à força de fixação até a falha e deslocamento entre os tendões fixados pelas diferentes técnicas. Em relação ao padrão de rupturas, observou-se que a maioria das rupturas das âncoras metálicas aconteceu ao nível da junção miotendínea, a maioria âncoras de suturas sem nós teve falha por escorregamento da interface fio-parafuso e todos os parafusos de interferência tiveram falha via escorregamento do tendão.

Conclusão As três técnicas com âncora metálica, âncora bioabsorvível sem nós e parafuso de interferência mostraram-se amplamente resistentes às cargas de tração para tenodese do cabo longo do bíceps em ovinos. Não houve diferença estatisticamente significativa entre os três grupos. Estudos com resistência em carga cíclica podem fornecer dados mais valiosos para a comparação dos grupos.

Palavras-chave
- dispositivos de fixação ortopédica
- fenômenos biomecânicos
- modelos animais
- tenodese

Introduction

The anatomy of the brachial biceps is important for shoulder function. Proximally, it has two origins – one intra-articular and the other extra-articular.[1] Both bellies converge ~ 7 cm proximal to the elbow, inserting themselves in the proximal radius.[2,3]

The brachial biceps has the supination of the forearm as its primary function and, secondarily, acts as a flexor of the elbow. Proximally, its function has been constantly studied about its passive role in the superior stability of the glenohumeral joint.[3]

Tendinopathies and ruptures of the proximal biceps are common sources of shoulder pain, making up 90% of all biceps lesions.[3,4] These conditions are usually related to previous tissue degeneration, having inflammatory, degenerative, traumatic and excessive use-related causes.[5] They have an important association with SLAP and rotator cuff pathologies, mainly subscapular tendon ruptures, which are closely related anatomically.[5]

Decision-making regarding the treatment of biceps long-cord (BLC) pathologies may be conservative or surgical. Depending on the clinical presentation, provocative physical examinations, association with other shoulder pathologies and failure of conservative treatment.[2,3,5]

In cases in which surgical treatment is indicated, several techniques are described, such as tenotomy and tenodesis, which may be open or arthroscopic.[4–7]

The indication of tenodesis usually occurs in younger patients, athletes, and manual workers, and those who wish to avoid aesthetic deformities. Tenodesis allows the preservation of the length-tension ratio of the biceps, which can prevent postoperative muscle atrophy as well as feelings of fatigue cramps, helping to maintain the normal contour of the muscle.[2–6] The reinsertion site may also vary according to the profile and demand of the patient, the surgical technique employed, the underlying pathology, associated procedures, and surgeon preference.[1–8]

There are several techniques described in the literature to perform BLC tenodesis, from the "rocambole" technique described by Godinho et al.[4] to techniques using fixation devices such as anchors, interference screw, and, more recently, bioabsorbable anchors without onlay nodes.[2,5,7,9–12]

The present study aims to biomechanically evaluate the fixation of the BLC tendon in the humerus of sheep with bone metal anchors, bioabsorbable anchors without nodes, and interference screw, considering the resistance force, displacement of the tendon in relation to each device employed, and causes of failures of each technique.

Materials and Methods

After approval by the ethics committee of the local educational institution, an experimental study was conducted in a biomechanics laboratory with 27 unfrozen fresh sheep humeri with a slaughter period of < 72 hours, aged between 8 and 12 months old. None of the samples appeared to have joint, bone, or tendon defect.

The weight of the pieces varied between 1,600 and 2,100 kg, with tests being performed at room temperature, with the samples taken from the cold chamber only for preparation of the parts. Afterwards, they were once again taken to the cold chamber at non-freezing temperature and tested with an interval of no more than 12 hours, to preserve the best quality of the piece.

It was chosen to use sheep shoulder joints because they reproduce an anatomy and bone density close, but not identical, to the human shoulder.[8,13] The shoulders were dissected evenly, keeping the humerus and distal insertion of the biceps with intact tendon for analysis. After dissection, BLC tenotomy was performed next to the supraglenoidal tubercle (►**Fig. 1**).

The fixation of the tenodesis in the bicipital drip was located 3 cm distal to the top of the large tuberosity. The Krakow-type stitch was used for the tenodesis technique.

The tenodeses were randomly divided into 3 groups: Group A with fixation with 5.5 mm metal anchor loaded with two high-strength Orthocord wires (Johnson & Johnson, Raynham, MA, USA), group B using the 5.5×20 mm SwiveLock (Arthrex, Naples, FL, USA) device, Group C with the 8×20 mm interference screw (Traumédica, Campinas, SP, Brazil).

In group A, the fixation point was made with a specific initiator, obtaining a secure fixation to the humerus (►**Fig. 2**).

For group B, the entry point was made with a specific initiator, and, after fixation, it was performed next to the tie with Krakow stitches to the tendon (►**Fig. 3**).

In group C, its entry point was performed with an adequate drill and, after fixation of the tendon, to the hole with the screw (►**Fig. 4**).



Fig. 1 Anatomical part with native tendon, maintaining its distal origin and insertion.



Fig. 2 Fastening with metal anchor.

Biomechanical Study

Biomechanical tests were applied using a universal continuous load machine until failure, with a speed of 20 mm/min. The force parameters were recorded through an 8-channel Spider data acquisition system (HBM, Darmstadt, Germany). The data processing software used was Catman Easy 3.1 (HBM, Darmstadt, Germany).

The humerus was fixed at the base by means of pressure on its articular surface and tuberosities. At the other point, the ulna and the radio were fixed by a metal clip, in a way that the tendon was completely free, and without tension, aligned on the axis with the anchoring device employed**,** maintaining an axial vector by the machine (►**Fig. 5**).

The parameters used for analysis were strength for resistance to failure of the system expressed in Newtons (N) and displacement in millimeters (mm), being established as system failure when there was a sudden drop in force during the test.

Statistical Analysis

The data table was constructed using Microsoft Excel and statistical analysis was performed using IBM SPSS Statistics version 26 for Windows.

The numerical variables were expressed as mean $\pm$ standard deviation (SD) and categorical variables as absolute and relative frequency.

For peer-to-peer comparations, the *least significant difference* method was used, and the mean differences were expressed with the respective 95% confidence intervals.

Comparisons of rupture force and displacement with reference values were performed using variance analysis for repeated measurement, considering the difference



Fig. 3 Anchor fixation without onlay bioabsorbable nodes.



Fig. 4 Tendon fixation with interference screw.

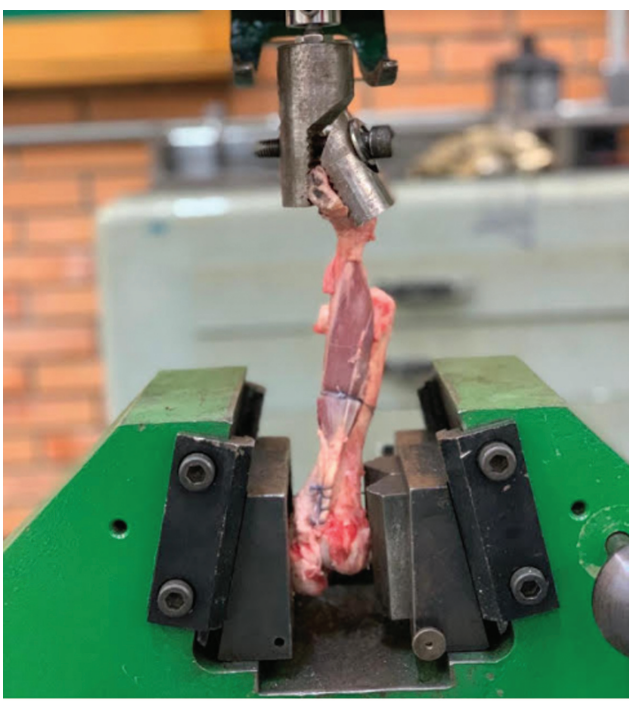


Fig. 5 System mounted with metal anchor.

between the observed value and the reference value as intra-subject effect and the fixation technique as a between-subject effect. The probability value was < 0.05.

Results

There was no statistically significant difference in the rupture force between the tendons fixed by metallic anchor (167.7 ± 67.4 N), bioabsorbable anchor without nodes (140 ± 45.5 N), and interference screw (146.9 ± 73.3 N) (►**Fig. 6**).

It was observed that the displacement of tendons fixed with interference screw was significantly lower in relation to those fixed with bioabsorbable anchors without nodes, with a mean difference of 25.4 mm (95% confidence interval [CI]: 8.9 ± 42.0mm; $p = 0.004$). However, in the population in question, the displacement of the tendons fixed with interference screw was smaller than those fixed with metallic anchor; this difference was not statistically significant (mean difference: 14.1 mm; 95%CI: - 1.3 ± 29.5 mm; $p = 0.072$) (►**Table 1**).

Similarly, the difference in the displacement of tendons fixed with metallic anchor and bioabsorbable anchor without nodes was not statistically significant, having been on average 11.4 mm (4.0 ± 26.8 mm; $p = 0.141$).

Regarding the site of ruptures, in group A, of the 11 samples, 7 (63.6%) occurred at the level of the myotendinous junction, 3 (27.2%) at the Krakow suture level, and 1 (9.09%) case of anchor pullout. In group B, of the 8 samples, 7 (87.5%) resulted in failure with slipping of the wire fixation on the device, maintaining the high strength wire with tension until

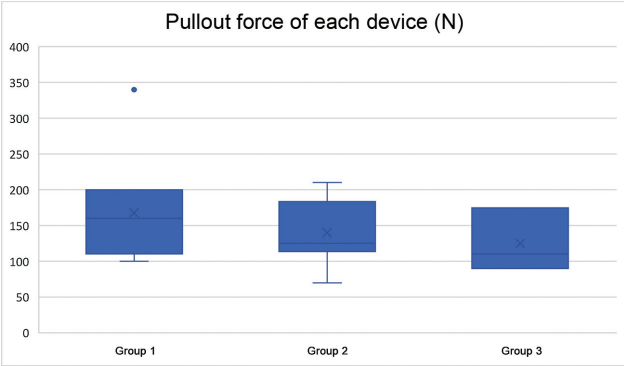


Fig. 6 Boxplot presenting the pullout force of each device. Group 1: Metallic anchors ($n = 11$), Group 2: Anchors without bioabsorbable nodes ($n = 8$), Group 3: Interference screw ($n = 8$).

the final pullout of the device, while in 1 case (12.5%) there was failure with device breakage. In relation to group C, all samples had slipping of the screw-tendon interface (100%), as shown in ►**Table 2**.

Regarding the maximum force until failure, the metal anchor supported more load (340 N) when compared with the bioabsorbable anchor without nodes (210 N) and the interference screws (330N) (►**Table 3**).

Discussion

The present study compared the results of biomechanical linear tensile strength of the three fixation methods previously described.

It was observed that fixation with metallic anchor (167.7 ± 67.4 N) had greater fixation force than the bioabsorbable anchor without nodes (140 ± 45.5N) and than the interference screws (146.9 ± 73.3 N), but without statistical significance. Corroborating the article by Kilicoglu et al.,[8] in which they evaluated 3 different biceps tenodesis techniques (soft tissue suture, anchors, and interference screw) in 45 shoulders of sheep *in vivo*, performing histological analysis at 0, 3, 6 and 9 weeks, demonstrating that the 3 groups had equivalent fixation strength at all times tested.[8]

Table 3 Forces of devices in N

	Metallic anchor	Anchor without bioabsorbable nodes	Interference screw
Minor	100	110	25
Major	340	210	330

AlQahtani et al.[14] evaluated different options of BLC tenodesis and their clinical outcomes. In this review, the authors mention that BLC fixation is more commonly performed with the use of interference screws, due to its biomechanical superiorities regarding the pullout force of the screw and tendon. Although there was no statistically significant difference, our study showed that metal anchors have higher pullout resistance (167.7 ± 67.4 N) when compared with interference screws (146.9 ± 73.3 N). We can infer that this is because in fixation with the metallic anchor, there is a greater preservation of the cortical bone when compared with other devices that have a larger diameter, which could weaken the cortical components and reduce the force of the general fixation.

Regarding the mean values in relation to tensile strength, the analysis published by Ramos et al.[15] presented an average of 95 ± 35.3 N for bone anchors, 152.7 ± 52.7 N for interference screw, and 104.7 ± 23.54 N for soft tissue

Table 1 Comparison of the observed values for rupture and displacement force in the three different techniques evaluated ($n = 27$)

	Technique			
	Metallic anchor	Anchor without bioabsorbable nodes	Interference screw	*p-value*
Breaking force (N)	167.7 ± 67.4	140.0 ± 45.5	146.9 ± 73.3	0.704
Offset (mm)	38.8 ± 18.7	50.2 ± 13.0	24.8 ± 14.8	0.015

Values expressed as mean ± standard deviation.
p: probability value.

Table 2 Type of rupture

	Myotendinous	Slip fixing wire-device	Device pullout	Distal insertion rupture	Level breakage of the knot	Slip fixing tendon - device	Material breakage
Metallic Anchor ($n = 11$)	5	0	1	2	3	0	0
Anchors without bioabsorbable nodes onlay ($n = 8$)	0	7	0	0	0	0	1
Interference screw ($n = 8$)	0	0	0	0	0	8	0

suture. Comparing with the data obtained in our study, we found very similar values when we analyzed the fixation method with interference screw (146.9 ± 73.3 N). However, when comparing the mean tensile strength with the method of fixation by metallic anchors, our study presented a significantly higher average (167.7 ± 67.4 N versus 95 ± 35.3 N). This variation of values can be attributed to the different patterns of anchors; for example, in this article, the metal anchor was loaded only with an Ethibond 2 wire, while in our investigation the anchor was loaded with two high-strength Orthocord wires. In the biomechanical study by Jayamoorthy et al.,[16] the values obtained in the group with metallic interference screw were 210 ± 62 N, a considerably higher value compared with those obtained in our work with the interference screws (146.9 ± 73.3 N) and higher than that found by the analysis of Smuin et al.[17], in which the mean value for bicep fixations per interference screw was 170.00 (±24.50 N). These variations can be attributed to the fact that the research by Jayamoorthy et al.[16] was performed on corpses while ours was carried out in sheep. In addition, the diameter of the interference screw used was 7 mm while in our research and in the publication of Smuin et al.[17] the screw with a diameter of 8 mm was used.

Regarding tendon displacement to failure, group C presented the lowest mean: 24.8 mm ± 14.8 mm. Group B, on the other hand, showed the highest displacement, with an average of 50.2 mm ± 13.0 mm. Comparing with the data we have in the literature, most studies that analyze this data evaluate the same based on cyclic loads[9,17,18], which was not performed in our investigation. Biomechanical studies using anchors without bioabsorbable nodes for BLC tenodesis are still scarce. Lorbach et al.[18] performed a biomechanical evaluation comparing BLC fixation with conventional anchors and anchors without bioabsorbable SwiveLock nodes of 2 different diameters (5.5 and 8 mm). In this study, the 5.5 mm anchor presented a displacement after cyclic load greater than anchor fixation, which corroborates the findings in our study, in which, although we did not use cyclic load, the device with 5.5 mm diameter (Group B) was the one that presented the largest displacement until failure (►**Table 1**).

When analyzing the type of failure that occurred, it is observed that the variation occurred depending on the fixation method. In group A, among the 11 samples, only 1 case had device pullout (9.09%), while in group B, of the 8 samples, there was only 1 device break (12.5%) (►**Table 2**).

The seven failures due to myotendinous rupture of the three groups studied occurred in the longitudinal direction of the muscle fibers. Lopez-Vidriero et al.[19] observed a similar lesion in the longitudinal direction, but only in the tendon area, concluding that the quality of the tendon is important for this type of fixation.

There were three failures at the level of the surgical node in the metal anchor, due to its rupture. In these, the failure can happen due to fragility of the suture thread or even by the quality of the anchor that could have friction in the system. The eight failures of the interference screws occurred due to slipping of the tendon in relation to the screw, corroborating the findings in the literature.[15–20]

Mazzoca et al.[20] performed an assay comparing four different proximal biceps tenodesis techniques (subpectoral biotenodesis interference screw, subpectoral bone tunnel technique, keyhole technique, or suture anchor) in a cyclic load in cadavers, demonstrating that there was no difference between resistance techniques until final failure, which is similar to the results of our analysis, in which all the techniques employed proved to be biomechanically similar and effective.

The present study used young ovine specimens at the point of slaughter to avoid maximum tendon, muscular and bone degeneration of the anatomical part. Although biomechanical investigations with animals (such as pigs, sheep, and cattle) are often found in the literature and can provide us with important comparative information[15,21–23], we must consider that their applicability when compared to human bone is not equivalent.[24,25]

Among the limitations that need to be mentioned in the present study, in addition to the nonequivalence between the bone structure of sheep and humans, our research evaluated the resistance of devices under a continuous, noncyclic, linear load, which would be more physiological and would be more like the reproduction performed i*n vivo*. Because we performed the analysis is *in vitro,* we do not consider the osteointegration factor of the implant to the bone, which occurs *in vivo.* We should also mention as a limitation the fact that we work with an *in vitro* tendon without any degeneration, since when performing the *in vivo* tenodesis we deal with a degenerate tendon.

Conclusion

The three techniques: metallic anchor, no-knot anchor bioabsorbable onlay, and interference screw proved to be widely resistant to tensile loads for long biceps cable tenodesis in sheep. There was no statistically significant difference between the three groups. Studies with cyclic load resistance may provide more physiological data for group comparison.

Financial Support
The authors declare that the present study received no financial support from either public, commercial, or not-for-profit sources.

Ethics
According to law number 11.794/2008, intended for the use of live animals in scientific research and teaching activities, the use of cadavers or parts of animals slaughtered for consumption is not scope of the legislation, and the study is exempt from being approved by the Commission of Ethics in the Use of Animals.

Conflict of Interests
The authors have no conflict of interests to declare. Dr. Paulo Cesar Faiad Piluski reported grants or contracts from Implantcast Corporation as consultant. Dr. Osvandré

Lech reported grants or contracts from Implantcast Corporation as speaker; *Revista Brasileira de Ortopedia* (RBO) as article editor; payment from Hypera, BioLab, Marjan, and Aché for manuscript writing; and is the president of the International Board of Shoulder and Elbow Surgery (IBSES).

References

1 Ikemoto RY, Pileggi PE, Murachovsky J, et al. Tenotomia com ou sem tenodese da cabeça longa do bíceps no reparo artroscópico do manguito rotador. Rev Bras Ortop 2012;47(06):736–740
2 Geaney LE, Mazzocca AD. Biceps brachii tendon ruptures: a review of diagnosis and treatment of proximal and distal biceps tendon ruptures. Phys Sportsmed 2010;38(02):117–125
3 Denard PJ, Dai X, Hanypsiak BT, Burkhart SS. Anatomy of the biceps tendon: implications for restoring physiological length-tension relation during biceps tenodesis with interference screw fixation. Arthroscopy 2012;28(10):1352–1358
4 Godinho GG, Mesquita FA, França FdeO, Freitas JM. "Rocambole-Like" Biceps Tenodesis: Technique and Results. Rev Bras Ortop 2015;46(06):691–696
5 Nho SJ, Strauss EJ, Lenart BA, et al. Long head of the biceps tendinopathy: diagnosis and management. J Am Acad Orthop Surg 2010;18(11):645–656
6 Kerschbaum M, Alt V, Pfeifer C. The All-inside arthroscopic loop tenodesis procedure to treat long head of biceps tendon pathologies. Arthrosc Tech 2019;8(12):e1551–e1554
7 Patzer T, Kircher J, Krauspe R. All-arthroscopic suprapectoral long head of biceps tendon tenodesis with interference screw-like tendon fixation after modified lasso-loop stitch tendon securing. Arthrosc Tech 2012;1(01):e53–e56
8 Kilicoglu O, Koyuncu O, Demirhan M, et al. Time-dependent changes in failure loads of 3 biceps tenodesis techniques: in vivo study in a sheep model. Am J Sports Med 2005;33(10):1536–1544
9 Lacheta L, Rosenberg SI, Brady AW, Dornan GJ, Millett PJ. Biomechanical Comparison of Subpectoral Biceps Tenodesis Onlay Techniques. Orthop J Sports Med 2019;7(10):2325967119876276
10 Sethi PM, Rajaram A, Beitzel K, Hackett TR, Chowaniec DM, Mazzocca AD. Biomechanical performance of subpectoral biceps tenodesis: a comparison of interference screw fixation, cortical button fixation, and interference screw diameter. J Shoulder Elbow Surg 2013;22(04):451–457
11 Boileau P, Krishnan SG, Coste JS, Walch G. Arthroscopic biceps tenodesis: a new technique using bioabsorbable interference screw fixation. Tech Shoulder Elbow Surg 2001;2(03):153–165
12 Khalid MA, Morris RP, Black N, Maassen NH. Biomechanical Evaluation of Humerus Fracture After Subpectoral Biceps Tenodesis With Interference Screw Versus Unicortical Button. Arthroscopy 2020;36(05):1253–1260
13 Bigham-Sadegh A, Oryan A. Selection of animal models for preclinical strategies in evaluating the fracture healing, bone graft substitutes and bone tissue regeneration and engineering. Connect Tissue Res 2015;56(03):175–194
14 AlQahtani SM, Bicknell RT. Outcomes following long head of biceps tendon tenodesis. Curr Rev Musculoskelet Med 2016;9 (04):378–387
15 Ramos CH, Coelho JC. Avaliação biomecânica da fixação do tendão da cabeça longa do bíceps braquial por três técnicas: modelo em ovinos. Rev Bras Ortop 2017;52(01):52–60
16 Jayamoorthy T, Field JR, Costi JJ, Martin DK, Stanley RM, Hearn TC. Biceps tenodesis: a biomechanical study of fixation methods. J Shoulder Elbow Surg 2004;13(02):160–164
17 Smuin DM, Vannatta E, Ammerman B, Stauch CM, Lewis GS, Dhawan A. Increased load to failure in biceps tenodesis with all-suture suture anchor compared with interference screw: A cadaveric biomechanical study. Arthroscopy 2021;37(10): 3016–3021
18 Lorbach O, Trennheuser C, Kohn D, Anagnostakos K. The biomechanical performance of a new forked knotless biceps tenodesis compared to a knotless and suture anchor tenodesis. Knee Surg Sports Traumatol Arthrosc 2016;24(07):2174–2180
19 Lopez-Vidriero E, Costic RS, Fu FH, Rodosky MW. Biomechanical evaluation of 2 arthroscopic biceps tenodeses: double-anchor versus percutaneous intra-articular transtendon (PITT) techniques. Am J Sports Med 2010;38(01):146–152
20 Mazzocca AD, Bicos J, Santangelo S, Romeo AA, Arciero RA. The biomechanical evaluation of four fixation techniques for proximal biceps tenodesis. Arthroscopy 2005;21(11):1296–1306
21 Uruc V, Ozden R, Dogramacı Y, Kalacı A, Hallaceli H, Küçükdurmaz F. A new anchor augmentation technique with a cancellous screw in osteoporotic rotator cuff repair: an in vitro biomechanical study on sheep humerus specimens. Arthroscopy 2014;30(01): 16–21
22 Dobke LS, Bonadiman JA, Lopes OV Junior, Saggin PR, Israel CL, de Freitas Spinelli L. Estudo biomecânico de diferentes dispositivos de fixação femoral na reconstrução do ligamento patelofemoral medial em joelhos de suínos. Rev Bras Ortop 2020;55(06): 771–777
23 Costa RN, Nadal RR, Saggin PRF, Lopes OV Junior, de Freitas Spinelli L, Israel CL. Avaliação biomecânica de diferentes métodos de fixação tibial na reconstrução do ligamento anterolateral em ossos suínos. Rev Bras Ortop 2019;54(02):183–189
24 Aslani FJ, Hukins DW, Shepherd DE. Applicability of sheep and pig models for cancellous bone in human vertebral bodies. Proc Inst Mech Eng H 2012;226(01):76–78
25 Pietschmann MF, Hölzer A, Rösl C, et al. What humeri are suitable for comparative testing of suture anchors? An ultrastructural bone analysis and biomechanical study of ovine, bovine and human humeri and four different anchor types. J Biomech 2010;43(06):1125–1130

Validation of the Brazilian Portuguese Version of the Western Ontario Shoulder Instability Index (WOSI) Questionnaire

Validação da versão em português brasileiro do questionário Western Ontario Shoulder Instability Index (WOSI)

Jose Carlos Souza Vilela[1] Tadeu Fonseca Barbosa[1,2] Daniel Oliveira Araujo[1,2]
Yuri Vinicius Teles Gomes[3] Thalles Leandro Abreu Machado[1,4]

[1] Shoulder and Elbow Surgery, Orthopedics and Traumatology Service, Hospital Unimed Belo Horizonte, Belo Horizonte, MG, Brazil
[2] Shoulder and Elbow Surgery, Hospital Madre Teresa, Belo Horizonte, MG, Brazil
[3] Fundação Hospitalar do Estado de Minas Gerais (FHEMIG), Belo Horizonte, MG, Brazil
[4] Shoulder and Elbow Surgery, Hospital Governador Israel Pinheiro (HGIP), Instituto de Previdência dos Servidores do Estado de Minas Gerais (IPSEMG), Belo Horizonte, MG, Brazil

Address for correspondence Yuri Vinicius Teles Gomes, Alameda Vereador Álvaro Celso, 100, Santa Efigênia, Belo Horizonte, MG, 30150-260, Brazil (e-mail: yuritelesgomes@gmail.com).

Rev Bras Ortop 2024;59(5):e765–e770.

Abstract

Objective To evaluate the validity of the Brazilian Portuguese version of the Western Ontario Shoulder Instability Index (WOSI).

Methods We assessed 51 patients aged 18 to 40 years who were divided into 3 groups: 17 patients with shoulder instability undergoing conservative treatment, 17 with shoulder instability treated surgically, and 17 without shoulder instability. The patients underwent functional and health assessments using the following scores: WOSI, Rowe, Visual Analog Scale (VAS), Subjective Shoulder Value (SSV), Disabilities of the Arm, Shoulder and Hand (DASH), and University of California-Los Angeles (UCLA) Shoulder Scale.

Results The variables sex and age were homogeneous among the groups ($p > 0.05$). A comparative analysis of the scores revealed that patients undergoing treatment (either surgical or conservative) showed significant differences compared with the control group ($p < 0.05$). The determination of score correlation was made using the Spearman correlation coefficient. All instruments analyzed showed a significant relationship among themselves but at different levels: the correlation between the WOSI and DASH instruments was perfectly positive ($r = 0.96$); the comparison of the WOSI and UCLA ($r = 0.87$), DASH and UCLA ($r = 0.86$), SSV and Rowe ($r = 0.80$), VAS and DASH ($r = 0.75$), VAS and UCLA ($r = 0.74$), and WOSI and VAS ($r = 0.72$) also showed a trend

Keywords
- arthroscopy
- joint instability
- shoulder joint
- sports medicine
- surveys and questionnaires
- translations

Work carried out at the Hospital Unimed Belo Horizonte, Belo Horizonte, MG, Brazil.

received
December 1, 2021
accepted
June 23, 2024

DOI https://doi.org/10.1055/s-0044-1790216.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

towards positive linearity among measurements; and the comparison of the instruments WOSI and SSV, WOSI and Rowe, DASH and Rowe, SSV and UCLA ($r = -0.83$), SSV and DASH ($r = -0.79$), Rowe and UCLA ($r = -0.78$), VAS and SSV ($r = -0.68$), and VAS and Rowe ($r = -0.60$) revealed a negative correlation.
Conclusion The Brazilian Portuguese version of the WOSI presents good validity.

Resumo

Objetivo Avaliar a validade da versão em português do Brasil do Western Ontario Shoulder Instability Index (WOSI).
Métodos Foram avaliados 51 pacientes, com idades entre 18 e 40 anos, que foram separados em 3 grupos: 17 pacientes com instabilidade do ombro em tratamento conservador, 17 com instabilidade do ombro tratados cirurgicamente e 17 sem instabilidade do ombro. Os pacientes foram submetidos a avaliações funcional e de saúde pelos seguintes escores: WOSI, Rowe, Escala Visual Analógica (EVA), Subjective Shoulder Value (SSV), Disabilities of the Arm, Shoulder and Hand (DASH), e University of California-Los Angeles (UCLA) Shoulder Scale.
Resultados As variáveis sexo e idade se mostraram homogêneas entre os grupos ($p > 0,05$). Após análise comparativa dos escores, os pacientes submetidos a tratamento (cirúrgico ou conservador) apresentaram diferenças significativas na comparação com o grupo de controle ($p < 0,05$). A correlação entre os escores foi avaliada submetendo as medidas ao coeficiente de correlação de Spearman. Todos os instrumentos analisados apresentaram relação significativa entre si. Entretanto, o nível de correlação foi distinto: foi observada correlação positiva perfeita entre os instrumentos WOSI e DASH ($r = 0,96$); os instrumentos WOSI e UCLA ($r = 0,87$), DASH e UCLA ($r = 0,86$), SSV e Rowe ($r = 0,80$), EVA e DASH ($r = 0,75$), EVA e UCLA ($r = 0,74$) e WOSI e EVA ($r = 0,72$) também apresentaram tendência de linearidade positiva entre as medidas; já os instrumentos WOSI e SSV, WOSI e Rowe, DASH e Rowe, SSV e UCLA ($r = -0,83$), SSV e DASH ($r = -0,79$), Rowe e UCLA ($r = -0,78$), EVA e SSV ($r = -0,68$) e EVA e Rowe ($r = -0,60$) apresentaram correlação negativa.
Conclusão A versão do WOSI em português do Brasil apresenta boa validade.

Palavras-chave
- articulação do ombro
- artroscopia
- inquéritos e questionários
- instabilidade articular
- medicina esportiva
- traduções

Introduction

Complaints of shoulder abnormalities are frequent in the orthopedic practice. The shoulder can present clinical manifestations with painful complaints of varying degrees and episodes of instability.[1] The particular biomechanics of the shoulder partly explain these abnormalities, since daily and sporting activities require a high shoulder joint range of motion and mechanical demands. Shoulder instability is a common issue that mainly affects patients in the second and third decades of life.[2] The incidence of traumatic dislocation is of approximately 1.7% in the general population.[3] After the first episode, symptoms of chronic shoulder instability may appear with variable intensity and frequency. Although pain may be present, it is not the main symptom. The predominant complaints are apprehension and loss of confidence, resulting in reduced participation in sporting activities and a general decrease in quality of life.[4,5]

Many treatments have been proposed for different types of instability; however, few assessment instruments prove the effectiveness of these treatments.[2] The clinical examination alone does not adequately reflect the functional impairments experienced by patients. Thus, a subjective analysis of the patient1s quality of life becomes a significant criterion.[4]

Initially, the best method to evaluate posttreatment outcomes was observation. However, observation ignores the patient's perception of their health condition. Several studies[6] have demonstrated that objective functional assessments of the shoulder can be inconsistent and susceptible to errors.

Thus, self-administered questionnaires have been recommended as an effective method to assess the functional status and perception of symptoms by the patient, valuing their opinion about their health condition.[7]

Different scores, indices, and scales evaluate the functional impact of shoulder conditions and health in general. These tools comprise generic assessment (such as the 36-Item

Short Form Health Survey, SF-36),[8] limb-specific (such as the Disabilities of the Arm, Shoulder, and Hand [DASH] questionnaire and its shortened version, the QuickDASH),[9] shoulder-specific (such as the American Shoulder and Elbow Surgeons Score [ASES], the Constant-Murley score, the University of California-Los Angeles [UCLA] Shoulder Scale, the Subjective Shoulder Value [SSV]),[10] and condition-specific instruments (such as the Rowe score, the Western Ontario Shoulder Instability Index [WOSI], the Western Ontario Rotator Cuff [WORC], the Melbourne Instability Shoulder Scale [MISS], and the Oxford Shoulder Instability Questionnaire [OSIQ]).[6,11–13]

Specific self-administered questionnaires for shoulder instability have been developed recently, such as the WOSI, OSIQ, and MISS. However, the MISS has shown less satisfactory psychometric properties than the WOSI.[4]

The WOSI is simpler, more effective, and more reproducible compared with other instruments. Due to these characteristics, many consider it the best assessment method for patients with shoulder instability.[7,14] Furthermore, it is easy to use (with an estimated completion time of 3 minutes), reliable, reproducible, sensitive to changes, and it has undergone validation in multiple languages.[2,4,5,7,15–22]

The WOSI is a quality-of-life questionnaire developed for use in English. The study of its psychometric properties showed a strong correlation with the DASH and the UCLA instruments. In the assessment of reproducibility, the intraclass correlation coefficient was excellent. It was developed and validated to be applied to patients with shoulder instability. As a specific instrument, it encompasses aspects of quality of life relevant to this disease. It contains 21 questions covering 4 domains: 1) physical symptoms; 2) sports, recreation, and work; 3) lifestyle; and 4) emotional status.[2,5]

The answers to the WOSI questions are provided through the Visual Analog Scale (VAS). All questions have the same weight value. Therefore, each item may receive a score from 0 to 100 on the VAS, and the final result ranges from 0 to 2,100. The closer the final result is to the lower limit, the lower the disease impact and the less significant the change in quality of life.[5]

The development of translation and cultural adaptation methods have enabled the use of an instrument developed in a given language and culture in another language and another cultural context after translation and adaptation.[23,24] Barbosa et al.[5] performed this process in 2012, obtaining the Brazilian Portuguese version of the questionnaire.[5,13]

The validation stage consists of checking whether the new instrument retained the characteristics of the original version. This entire process is relevant so that the new tool is equivalent to the original version and culturally accepted in the country in question.[5]

Therefore, although the original WOSI already had its psychometric properties studied, the objective of the present study is to evaluate its validity in the Brazilian Portuguese version.

Materials and Methods

Patient Selection

The inclusion criteria were the following: Patients who attended the shoulder and elbow outpatient clinic at Hospital Unimed Belo Horizonte, in the state of Minas Gerais, Brazil, and underwent an assessment for regular follow-up after treatment for shoulder instability. We divided these subjects into those receiving surgical and conservative treatments. The control group consisted of patients with other shoulder conditions but no instability and volunteers without orthopedic shoulder complaints. We excluded patients who chose not to sign the informed consent form (ICF), and those unable to fill out the forms due to psychiatric or psychological issues, neurological conditions, systemic inflammatory diseases, neoplasms, or cervical radiculopathy. All patients participating in the study signed the ICF.

Sample calculation followed the principles set out by Cochran[25] and Pereira.[26] The Cochran[25] formula calculates an ideal sample with predetermined precision levels (margin of error) and confidence intervals. For our population, we chose a 95% confidence interval (95%CI) and a 5% margin of error. Pereira's[26] formula assesses the sample size in linear correlation studies, as in the current study. Per this author,[26] the sample calculation employs the Spearman correlation coefficient. For the present study, we used the coefficient reported by Perrin et al.,[4] who validated the WOSI for French using scores similar to those analyzed by our group. We found a maximum variation of three patients for the sample calculation employing the different variables under analysis (scores). Therefore, as there is more than one variable in the current study, we used the highest value derived from the sample calculation, finding a minimum number of 17 patients per group and totaling 51 subjects. We separated the patients into three groups:

- Conservative group, consisting of 17 patients with shoulder instability who did not undergo surgical treatment;
- Postoperative group, consisting of 17 patients with shoulder instability who underwent surgical treatment with a minimum follow-up of 12 months; and
- Control group, with 17 patients without shoulder instability.

Data Collection

Two orthopedists specializing in shoulder and elbow surgery assessed all the patients and applied the following functional and health assessment scores: WOSI, Rowe, VAS, SSV, DASH, and UCLA (►**Appendix 1**).

Results

We evaluated 51 patients, including 34 with anterior shoulder instability, 17 undergoing surgical treatment, and 17 undergoing conservative treatment. The other 17 subjects from the control group did not have shoulder instability.

►**Table 1** presents the demographic variables sex and age. The groups were homogeneous, with no significant difference among them ($p > 0.05$).

The comparative score analysis occurred as follows: normality test (Shapiro-Wilk and Kolmogorov-Smirnov), median and percentile measurements (25th and 75th percentiles – P25 and P75 respectively), and statistical data analysis (Kruskal-Wallis test followed by the Dunn test).

Regardless of the score, the postoperative and conservative groups showed significant differences compared with the control group ($p < 0.05$), except for the postoperative group in the Rowe score.

Only the VAS score was unable to demonstrate a statistical difference when comparing the postoperative and conservative groups ($p > 0.05$) (►**Table 2**).

The correlation among scores was assessed through the Spearman correlation coefficient, which evaluates the intensity degree in the relationship between two nonparametric variables. This coefficient correlation ranges from -1 and +1, and the higher the absolute value, the stronger the relationship among scores.

All instruments presented a significant relationship among themselves according to Spearman coefficient ($p < 0.05$). However, the correlation level was different, as follows:

- The correlation was perfectly positive (with an *r*-value close to 1) for the WOSI and the DASH instruments ($r = 0.96$). This result indicates that the measurements from both indicators increase significantly at the same intensity.
- The comparison of the WOSI and UCLA ($r = 0.87$), DASH and UCLA ($r = 0.86$), SSV and Rowe ($r = 0.80$), VAS and DASH ($r = 0.75$), VAS and UCLA ($r = 0.74$), and WOSI and VAS ($r = 0.72$) also showed a trend towards positive linearity between measurements.
- The correlation of the WOSI and SSV, WOSI and Rowe, DASH and Rowe, SSV and UCLA ($r = -0.83$), SSV and DASH ($r = -0.79$), Rowe and UCLA ($r = -0.78$), VAS and SSV ($r = -0.68$), and VAS and Rowe ($r = -0.60$) was negative.

Discussion

The assessment and analysis of the outcomes of certain medical treatments have evolved in recent times. The patient's perception of their problem has become more valued in the current context. Thus, scores relying on a more subjective analysis have become the most recommended methods.

Although there are other assessment methods for shoulder instability, the WOSI has been considered the best one,[7,14] and it has already been validated in several languages.[2,4,5,7,15–22] The choice of the analysis method for the current study relied on previously published articles validating this score.

The selected scores considered the potential comparison with other WOSI validation studies and encompass different assessment instruments, whether generic (VAS), limb-specific (DASH), shoulder-specific (UCLA, SSV), or condition-specific (Rowe). The DASH has been validated in Brazilian Portuguese, and the UCLA[10] and Rowe[11] scores have undergone translation and cultural adaptation to Brazilian Portuguese. The use of the VAS use in its Brazilian Portuguese version is widespread despite the lack of a published specific validation. We attribute this to the fact that it is easily understandable, since it is a visual scale, with no complex questions that would depend on cultural adaptation. Likewise, the SSV is a subjective assessment performed by the patient and expressed as a percentage, using 100% as a reference value for a completely normal shoulder.

All patients in the postoperative and conservative groups presented anterior instability (to reduce bias in result interpretation). The average age of the study patients (of 27.35 ± 5.43 years) and the sex distribution (44 men [82.36%] and 7 women [17.64%]) were consistent with that of previous studies[4,7,18] and homogeneous at group comparison (►**Table 1**).

The analysis of the validity of the WOSI in Brazilian Portuguese, according to Spearman coefficient, revealed a significant good or excellent correlation among all scores (presenting values close to -1 or 1). This coefficient is

Table 1 Characterization of the study sample per sex and age

	Sex: n (%)		*p*-value
	Male	Female	
Postoperative group (n = 17)	15 (88.24%)	2 (11.76%)	0.8553[T]
Conservative group (n = 17)	15 (88.24%)	2 (11.76%)	
Control group (n = 17)	14 (86.28%)	3 (13.72%)	
Total (n = 51)	44 (82.36%)	7 (17.64%)	
	Age (years): mean(± standard deviation)		*p*-value
Postoperative group (n = 17)	26.88(± 6.33)		0.2391[T]
Conservative group (n = 17)	29.12(± 5.20)		
Control group (n = 17)	26.0 (± 4.42)		
Total (n = 51)	27.35(± 5.43)		

Note: [T]Tukey test, suitable for data with parametric distribution

Table 2 Comparison of the WOSI, VAS, SSV, Rowe, DASH, and UCLA scores of the sample on the instruments used

	Posperative (n = 17)	Conservative (n = 17)	Control (n = 17)	Total (n = 51)	
	Median (25P–75P)	Median (25P–75P)	Median (25P–75P)	Median (25P–75P)	*p*-value
WOSI	425.0*$ (112.5–97.5)	1000.0* (870.0–348.0)	0.0 (0.0–122.5)	360.0 (10.0–340.0)	< 0.0001[KW]
VAS	2.0* (0.0–4.0)	4.0* (1.5–6.0)	0.0 (0.0–1.0)	1.0 (0.0–4.0)	0.0004[KW]
SSV	80.0*$ (55.0–97.5)	50.0* (45.0–65.0)	100.0 (99.0–100.0)	80 (50.0–100.0)	< 0.0001[KW]
Rowe	100.0$ (85.0–100.0)	50.0* (40.0–75.0)	100.0 (99.0–100.0)	95.0 (55.0–100.0)	< 0.0001[KW]
DASH	7.5*$ (1.3–13.8)	25.8* (17.5–38.8)	0.0 (0.0–2.1)	7.5 (0.0–19.2)	< 0.0001[KW]
UCLA	33.0*$ (29.0–35.0)	29.0* (22. –29.0)	35.0 (35.0–35.0)	33.0 (29.0–35.0)	< 0.0001[KW]

Abbreviations: 25P, 25th percentile; 75P, 75th percentile; DASH, Disabilities of the Arm, Shoulder and Hand; SSV, Subjective Shoulder Value; VAS, Visual Analog Scale; UCLA, University of California-Los Angeles; WOSI, Western Ontario Shoulder Instability Index.
Notes: *Significantly different than the control group. $Significantly different than the conservative group. [KW]Kruskal-Wallis test (suitable for non-parametric data comparison).

classified as excellent (> 0.91), good (0.90–0.71), fair (0.70–0.51), poor (0.50–0.31), and null (<c0.31).[4]

Individually, the WOSI presents an almost a perfect correlation with the DASH score (0.96) and a high correlation with the UCLA (0.87) and VAS (0.72) scores (►**Table 3**). These results are consistent with those of the original article (DASH = 0.77; UCLA = 0.65)[2] regarding the French (QuickDASH = 0.78; VAS = 0.83),[4] Turkish (DASH = 0.67),[7] German (UCLA = 0.61),[21] Dutch (DASH = 0.81),[20] Swedish (VAS = 0.80),[15] Italian (DASH = 0.79),[18] and Japanese (QuickDASH = 0. 63) validations.[17] All showed a positive linearity for such scores, especially the DASH and UCLA.

The Rowe score correlation (-0.83) presented good negative linearity, similar to the French (-0.54)[4] and Turkish (-0.57)[7] analysis, and the original (0. 61),[2] German (0.62),[21] and Swedish papers (0.59),[15] but with positive linearity. The SSV presented good negative linearity (-0.83), but no comparison with other studies.

The positive points of the present work include the number of analyzed scores (five, higher than other validation studies using three or four scores), group homogeneity, the representation of shoulder instability epidemiology, and the high significant correlation among the scores. The negative points include the small but significant sample size

Table 3 Correlation analysis (Spearman coefficient) of the scores on the WOSI, VAS, SSV, Rowe, DASH, and UCLA instruments

		WOSI	VAS	SSV	Rowe	DASH	UCLA
WOSI	*r*-value		0.72	-0.83	-0.83	0.96	0.87
	p-value		< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
VAS	*r*-value	0.72		-0.68	-0.60	0.75	0.74
	p-value	< 0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
SSV	*r*-value	-0.83	-0.68		0.80	-0.79	-0.83
	p-value	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001
Rowe	*r*-value	-0.83	-0.60	0.80		-0.83	-0.78
	p-value	< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001
DASH	*r*-value	0.96	0.75	-0.79	-0.83		0.86
	p-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001		< 0.0001
UCLA	*r*-value	0.87	0.74	-0.83	-0.78	0.86	
	p-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	

Abbreviations: DASH, Disabilities of the Arm, Shoulder and Hand; SSV, Subjective Shoulder Value; VAS, Visual Analog Scale; UCLA, University of California-Los Angeles; WOSI, Western Ontario Shoulder Instability Index.

and the failure to perform test-retest and interobserver analysis.

Conclusion

We concluded that the Brazilian Portuguese version of the WOSI presents good validity.

Financial Support
The authors declare that they did not receive financial support from agencies in the public, private, or non-profit sectors to conduct the present study.

Conflict of Interests
The authors have no conflict of interests to declare.

References

1 Yogi LS. Estudo comparativo entre métodos de avaliação funcional do ombro nas cirurgias de descompressão subacromial e capsuloplastia: avaliação de 60 pacientes com métodos "ASES, CONSTANT, ROWE, SST, SF-36 E UCLA shoulder rating" [dissertação]. São Paulo: Faculdade de Medicina, Universidade de São Paulo; 2005
2 Kirkley A, Griffin S, McLintock H, Ng L. The development and evaluation of a disease-specific quality of life measurement tool for shoulder instability. The Western Ontario Shoulder Instability Index (WOSI). Am J Sports Med 1998;26(06):764–772
3 Dumont GD, Russell RD, Robertson WJ. Anterior shoulder instability: a review of pathoanatomy, diagnosis and treatment. Curr Rev Musculoskelet Med 2011;4(04):200–207
4 Perrin C, Khiami F, Beguin L, Calmels P, Gresta G, Edouard P. Translation and validation of the French version of the Western Ontario Shoulder Instability Index (WOSI): WOSI-Fr. Orthop Traumatol Surg Res 2017;103(02):141–149
5 Barbosa G, Leme L, Saccol MF, Pocchini A, Ejnisman B, Griffin S. Tradução e adaptação cultural para o português do Brasil do Western Ontario Shoulder Instability Index (WOSI). Rev Bras Med Esporte 2012;18(01):35–37
6 Rockwood CA Jr, Matsen FA III. The Shoulder. 5th ed. Philadelphia: Elsevier; 2017
7 Basar S, Gunaydin G, Hazar Kanik Z, et al. Western Ontario Shoulder Instability Index: cross-cultural adaptation and validation of the Turkish version. Rheumatol Int 2017;37(09):1559–1565
8 Ciconelli RM. Tradução para o português e validação do questionário genérico de avaliação de qualidade de vida "medical outcomes study 36-item short-form health surgery (SF-36)" [tese]. São Paulo: Escola Paulista de Medicina, Universidade Federal de São Paulo; 1997
9 Orfale AG, Araújo PM, Ferraz MB, Natour J. Translation into Brazilian Portuguese, cultural adaptation and evaluation of the reliability of the Disabilities of the Arm, Shoulder and Hand Questionnaire. Braz J Med Biol Res 2005;38(02):293–302
10 Oku EC, Andrade AP, Stadiniky SP, Carrera EF, Tellini GG. Translation and Cultural Adaptation of the Modified-University of California at Los Angeles Shoulder Rating Scale to Portuguese Language. Rev Bras Reumatol 2006;46(04):246–252
11 Marcondes FB, Vasconcelos RA, Marchetto A, Andrade ALL, Zoppi Filho A, Etchebehere M. Tradução e adaptação cultural do Rowe Score para a língua portuguesa. Acta Ortop Bras 2012;20(06):346–350
12 Angst F, Schwyzer HK, Aeschlimann A, Simmen BR, Goldhahn J. Measures of adult shoulder function: Disabilities of the Arm, Shoulder, and Hand Questionnaire (DASH) and its short version (QuickDASH), Shoulder Pain and Disability Index (SPADI), American Shoulder and Elbow Surgeons (ASES) Society standardized shoulder assessment form, Constant (Murley) Score (CS), Simple Shoulder Test (SST), Oxford Shoulder Score (OSS), Shoulder Disability Questionnaire (SDQ), and Western Ontario Shoulder Instability Index (WOSI). Arthritis Care Res (Hoboken) 2011;63 (Suppl 11):S174–S188
13 Gil LM. Proposta de protocolo de avaliação funcional do complexo do ombro em sujeitos submetidos à cirurgia para reconstrução do manguito rotador e/ou retificação de instabilidade glenoumeral [monografia]. Ribeirão Preto: Hospital das Clínicas da Faculdade de Medicina de Ribeirão Preto da Universidade de São Paulo; 2015
14 Kemp KA, Sheps DM, Beaupre LA, Styles-Tripp F, Luciak-Corea C, Balyk R. An evaluation of the responsiveness and discriminant validity of shoulder questionnaires among patients receiving surgical correction of shoulder instability. ScientificWorldJournal 2012;2012:410125
15 Salomonsson B, Ahlström S, Dalén N, Lillkrona U. The Western Ontario Shoulder Instability Index (WOSI): validity, reliability, and responsiveness retested with a Swedish translation. Acta Orthop 2009;80(02):233–238
16 Drerup S, Angst F, Griffin S, Flury MP, Simmen BR, Goldhahn J. [Western Ontario shoulder instability index (WOSI): translation and cross-cultural adaptation for use by German speakers]. Orthopade 2010;39(07):711–718
17 Hatta T, Shinozaki N, Omi R, et al. Reliability and validity of the Western Ontario Shoulder Instability Index (WOSI) in the Japanese population. J Orthop Sci 2011;16(06):732–736
18 Cacchio A, Paoloni M, Griffin SH, et al. Cross-cultural adaptation and measurement properties of an Italian version of the Western Ontario Shoulder Instability Index (WOSI). J Orthop Sports Phys Ther 2012;42(06):559–567
19 Wiertsema SH, Rietberg MB, Hekman KM, et al. Measurement properties of the Dutch version of the Western Ontario Shoulder Instability Index (WOSI). J Orthop Sci 2014;19(02):242–249
20 van der Linde JA, Willems WJ, van Kampen DA, van Beers LW, van Deurzen DF, Terwee CB. Measurement properties of the Western Ontario Shoulder Instability index in Dutch patients with shoulder instability. BMC Musculoskelet Disord 2014;15:211
21 Hofstaetter JG, Hanslik-Schnabel B, Hofstaetter SG, Wurnig C, Huber W. Cross-cultural adaptation and validation of the German version of the Western Ontario Shoulder Instability index. Arch Orthop Trauma Surg 2010;130(06):787–796
22 Gaudelli C, Balg F, Godbout V, et al. Validity, reliability and responsiveness of the French language translation of the Western Ontario Shoulder Instability Index (WOSI). Orthop Traumatol Surg Res 2014;100(01):99–103
23 Nigri PZ, Peccin MS, Almeida GJM, Cohen M. Tradução, validação e adaptação cultural da escala de atividade de vida diária. Acta Ortop Bras 2007;15(02):101–104
24 Puga VO, Lopes AD, Costa LO. Assessment of cross-cultural adaptations and measurement properties of self-report outcome measures relevant to shoulder disability in Portuguese: a systematic review. Rev Bras Fisioter 2012;16(02):85–93
25 Cochran WG. Sampling techniques. 3rd ed. New York: John Wiley & Sons; 1967
26 Pereira MG. Epidemiologia - Teoria e Prática. Rio de Janeiro: Guanabara Koogan; 2005

Comparative Clinical Evaluation of Two Techniques in the Arthroscopic Treatment of Partial Articular Rotator Cuff Tears after Six Years of Follow-up

Avaliação clínica comparativa de duas técnicas no tratamento artroscópico das lesões parciais articulares do manguito rotador após seis anos de seguimento

Guilherme do Val Sella[1] Luciana Andrade da Silva[1] Ricardo Makoto Okamoto[1] Hector Carmona Marmille[1] Pedro Gabriel Pelegrino do Val[1] Alberto Naoki Miyazaki[1]

[1] Shoulder Surgery Group, Department of Orthopedics and Traumatology, Faculdade de Ciências Médicas, Santa Casa de São Paulo, Pavilhão Fernandinho Simonsen, São Paulo, SP, Brazil

Rev Bras Ortop 2024;59(5):e771–e778.

Address for correspondence Guilherme do Val Sella, MSc, PhD, Shoulder Surgery Group, Department of Orthopedics and Traumatology, Faculdade de Ciências Médicas, Santa Casa de São Paulo, Pavilhão Fernandinho Simonsen, Rua Dr. Cesário Mota Júnior 112, Vila Buarque, 01220-020, São Paulo, SP, Brazil (e-mail: gvsella@gmail.com).

Abstract

Objective To clinically evaluate the medium-term results of the arthroscopic treatment of partial-thickness rotator cuff tears (PTRCT) using the transtendon repair (TTR) technique and the tear completion repair (TCR) technique through the modified University of California, Los Angeles (UCLA) Shoulder Rating Scale, the Constant-Murley score, and force analysis.

Methods The present was a retrospective reevaluation study of cases operated on arthroscopically for PTRCT after a minimum follow-up of 6 years. There were 34 patients, 18 of whom underwent TTR and 16, TCR. We compared the current UCLA and Constant-Murley scores, the mean strength between the techniques, and the UCLA score currently and 2 years after surgery for the same group, as published in a previous study, to assess whether or not the results changed throughout time.

Results There was no statistical difference regarding the scores. The current UCLA scores were of 33.8 for the TTR and of 32.9 for the TCR ($p = 0.113$), and the current Constant-Murley scores were of 91.9 and 86.8 respectively ($p = 0.075$). For the TTR, the previous UCLA score was (2 years postoperatively) of 32.4 and the current score was of 33.8 ($p = 0.374$); for the TCR, the score after 2 years was of 32.4, and the current score was of 32.9 ($p = 0.859$). In the TTR, the mean strength was statistically higher on the dominant side (11 kg) than on the non-dominant side (7.80 kg) ($p = 0.023$) and those of the TCR (8.25 kg) ($p = 0.042$).

Keywords
- arthroscopy
- rotator cuff
- treatment

Work carried out at the Shoulder Surgery Group, Orthopedics and Traumatology Department, Faculdade de Ciências Médicas, Santa Casa de São Paulo (FCMSCSP), Pavilhão Fernandinho Simonsen, São Paulo, SP, Brazil.

received
February 29, 2024
accepted
July 1, 2024

DOI https://doi.org/10.1055/s-0044-1790211.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Conclusion There was no statistical difference in the medium term when comparing the UCLA and Constant-Murley scores concerning the technique used (TTR or TCR), nor was there any change in UCLA scores between 2 and 6 years postoperatively. Among the patients submitted to TTR, the mean strength was statistically higher on the dominant side than on the non-dominant side, and higher than that of the patients submitted to TCR.

Resumo

Objetivo Avaliar clinicamente a médio prazo os resultados do tratamento artroscópico das lesões parciais da porção articular do manguito rotador (LPPAMR) pelas técnicas de reparo transtendão (RTT) e reparo após completada a lesão (RPCL) utilizando-se a Escala Modificada de Avaliação do Ombro da University of California, Los Angeles (UCLA), a escala de Constant-Murley e análise de força.

Métodos Estudo retrospectivo de reavaliação, após seguimento mínimo de 6 anos, de casos de LPPAMR operados artroscopicamente, envolvendo um total de 34 pacientes, sendo 18 submetidos ao RTT e 16 ao RPCL. Foram comparadas as pontuações atuais nas escala da UCLA e de Constant-Murley, a força média entre as técnicas, e as pontuações na UCLA atualmente e com 2 anos de pós-operatório do mesmo grupo, conforme publicado em estudo anterior, a fim de avaliarmos se houve ou não modificação dos resultados ao longo do tempo.

Resultados Não houve diferença estatística entre as pontuações nas escalas. As pontuações na escala da UCLA atual foram de 33,8 para o RTT e de 32,9 para o RPCL ($p = 0{,}113$), e na escala de Constant-Murley, foram de 91,9 e 86,8, respectivamente ($p = 0{,}075$). Para o RTT, a pontuação anterior na escala da UCLA (com 2 anos de pós-operatório) foi 32,4, e a atual, de 33,8 ($p = 0{,}374$); para o RPCL, foi de 32,4 com 2 anos de pós-operatório, e de 32,9 atualmente ($p = 0{,}859$). No RTT, a força média foi estatisticamente maior do lado dominante (11 kg) do que no não dominante (7,80 kg) ($p = 0{,}023$) e aqueles do RPCL (8,25 kg) ($p = 0{,}042$).

Conclusão Não houve diferença estatística em médio prazo na comparação das pontuações nas escalas da UCLA e de Constant-Murley em relação à técnica utilizada (RTT ou RPCL), nem alteração nas pontuações na escala da UCLA entre 2 e 6 anos de pós-operatório. Nos pacientes submetidos à RTT, a força média foi estatisticamente maior do lado dominante do que no não dominante, e maior do que nos pacientes submetidos à RPCL.

Palavras-chave
- artroscopia
- manguito rotador
- tratamento

Introduction

Partial rotator cuff injury is a major cause of shoulder dysfunction and pain.[1] Its incidence is not yet a consensus in the literature, although there are studies[2–4] showing values of 14.5[4] to 32%.[3] Fukuda also describes that around 1/3 (27%) of these lesions affect the joint portion.[4]

Ellman was the first to propose, based on arthroscopic findings, a system to classify partial lesions in terms of their location (A: articular; B: bursal; C: intratendinous) and their extent (grade 1: < 3 mm; grade 2: 3–6 mm; grade 3: > 6 mm).[5]

The pathophysiology of partial-thickness rotator cuff tears (PTRCT) is believed to involve both intrinsic (areas of hypovascularization and age-related metabolic alterations) and extrinsic mechanisms (internal superior posterior impingement, acute traumatic events, and repetitive microtraumas), or even a combination of these.[6,7]

The initial treatment of PTRCTs is carried out with conservative measures, such as physiotherapy and changing habits to prevent the progression of the lesion[8]. Surgical treatment is indicated in the failure of this or in cases in which the lesion affects more than 50% of the tendon thickness due to a risk of up to 40% in its progression.[1,9]

Different arthroscopic surgical techniques have been described to approach this type of injury, such as simple arthroscopic debridement of the tendon,[2,6,10–12] or tendon repair. The repair techniques used are the TTR, initially described by Snyder,[13] or the tear completion repair (TCR).[8,11,14–19] There are studies with short-term evaluations comparing which surgical technique would be the best to treat PTRCT clinically,[8,16–18,20–22] and all of them concluded that there is no statistical difference between them. A few works[1,23–25] carry out this comparison in the long and medium terms. The aim of the present work is to reevaluate patients operated on through both of the aforementioned techniques, whose results were previously published,[21] now with medium-term follow-up and with analysis of the current strength to assess whether there has been a change in the results.

Materials and Methods

From October 1999 to December 2016, 39 patients diagnosed with PTRCT underwent arthroscopic surgical treatment by our institution's shoulder group. All operated cases were classified as Ellman 3 (partial lesion greater than 50% of tendon thickness). None of the cases had been submitted only to surgical debridement, and repair of the lesion was performed in all cases. Two arthroscopic repair techniques were used: TTR on 19 patients (group I), and postinjury repair (TCR) on 20 patients (group II). The choice of surgical technique was at the surgeon's discretion, and the evaluation was retrospective. Have been clinically evaluated and compared in a previous study[21] after a minimum of 2 years of follow-up.

For the current study, 18 patients (94.7% of the initial group) operated on through the TTR technique (group III) and 16 (80% of the initial group) submitted to the TCR technique (group IV) were contacted.

Group III had a mean follow-up of 105.6 months (8.8 years; range: 6–15 years); 12 patients were male (66.7%), and 6 were female. The mean age was of 52.2 (range: 38–74) years. A total of 72.2% of the cases affected the dominant side (DS), and 15 patients (83.3%) practiced sports. In nine cases, there was history of trauma (in these cases, acromioplasty had not been performed), and in six cases, there was a diagnosis of superior labrum, anterior to posterior (SLAP) injury, for which tenotomy and tenodesis were performed in five cases, and in one case, debridement.

Group IV had a mean follow-up of 91.2 months (7.6 years; range: 6–14 years); 9 patients were male (56.2%), and 7 were female. The mean age was of 55.3 (range: 32–78) years. In 75% of the cases, the DS was affected, and 11 patients (68.8%) practiced sports. In two cases, there was history of trauma (in these cases, acromioplasty had not been performed), and in four cases, there was a diagnosis of SLAP injury, for which tenotomy and tenodesis were performed in wo cases, and in two cases, debridement.

After collecting the data from groups III and IV, we calculated the scores on the modified University of California, Los Angeles (UCLA) Shoulder Rating Scale,[26] the Constant-Murley score,[27] and the strength of the operated shoulder of all patients. To measure the isometric contraction force, the KERN CH50 K 50 digital dynamometer (Kern & Sohn GmbH, Balingen, Germany) was used (►**Fig.1**), calibrated according to the primary standards of the Brazilian Calibration Network (Rede Brasileira de Calibração, RBC, in Portuguese) of the Brazilian National Institute of Metrology, Quality and Technology (Instituto Nacional de Metrologia, Qualidade e Tecnologia, INMETRO, in Portuguese), as recommended by the Constant-Murley score (►**Fig. 2**).

The Anderson-Darling, Ryan-Joiner, and Kolmogorov-Smirnov tests were used to determine the normality of the distributions. When the distribution was normal, the Student *t*-test was used to calculate the confidence intervals for the mean, and the Fisher F-test was used to compare the variances. Otherwise, Wilcoxon confidence intervals were calculated, and the Mann-Whitney test was used to analyze the means. The means of the variables strength (kg), current UCLA score, and Constant-Murley score regarding sex, age, and dominance were then analyzed and compared between groups III and IV. To test, in the interval of both evaluations, if there was a change in the mean UCLA score between groups I and III and between groups II and IV, the Wilcoxon test was used.



Fig. 1 Front photo of the properly-calibrated Kern CH50 K 50 digital dynamometer, which measures isometric shoulder force.



Fig. 2 Patient performing an isometric strength test of the right shoulder using the properly-calibrated digital dynamometer KERN CH50 K 50.

The analyses were performed using the Minitab Statistical Software, version 21 (Minitab, LLC, State College, PA, USA), and all hypotheses with descriptive levels (p-value) lower than 0.05 were rejected.

The present work was submitted to the institutional Research Ethics Committee and approved according to CAAE: 79428617.2.0000.5479.

Results

Regarding group III, the mean UCLA score was of 33.8, with 12 excellent results (66.7%), 6 good results (33.3%), and no unsatisfactory results. There was no statistical difference between the mean current UCLA score according to sex ($p = 0.277$), affection or not of the DS, ($p = 0.755$), or age ($p = 0.755$). The mean Constant-Murley score was of 91.9, with 13 excellent results (72.2%), 4 good results (22.2%), and 1 satisfactory result (score of 72; case 11) that lost points in the mobility and strength questions and presented 31 points on the current UCLA scale, losing points in the function analysis (►**Table 1**). There was no statistical difference between the mean Constant-Murley score according to sex ($p = 0.962$), affection or not of the DS, ($p = 0.254$), or age ($p = 0.404$). Concerning the mean strength, there was a statistical difference in cases of DS affection ($p = 0.023$); therefore, it is possible to say that the DS presented a higher mean strength (11 kg) compared to the non-dominant side (NDS; 7.8 kg).

Regarding group IV, the mean UCLA score was of 32.9, with 6 excellent results (37.5%), 9 good results (56.2%), and 1 unsatisfactory result (6.3%). In the second evaluation, a case that had presented an excellent result in the first evaluation[21] (case 8), with a score of 35, had its score decreased to 27 mainly due to pain and decreased function and strength after falling to the ground and trauma 8 months earlier. Due to the coronavirus disease 2019 (COVID-19) pandemic, the patient did not want to seek medical assistance (►**Table 2**). There was no statistical difference between the mean current UCLA score according to sex ($p = 0.298$), affection or not of the DS ($p = 0.781$), or age ($p = 1.000$). The mean Constant-Murley score was of 86.8, with 6 excellent results (37.5%), 8 good results (50%), 1 satisfactory result (6.25%), and 1 regular result (6.25%). The patient with the satisfactory result on the Constant-Murley score (case 9) lost points in the strength question (9 points), although they remained with a satisfactory UCLA score, of 33 points. The case with a regular score (case 8) was the same one that presented a low UCLA score due to the fall suffered 8 months earlier. There was a statistical difference between the mean Constant-Murley score according to sex, strength, and age, and, proportionally, men ($p = 0.012$) under 60 years of age ($p = 0.043$) obtained, in a statistically significant way ($p = 0.003$), a higher score (mean of 91.6) mainly due to greater strength (mean strength of 10.4 kg). Concerning the mean strength, there was no statistical difference in terms of age ($p = 0.059$), despite the p-value being very close to the significance level,

Table 1 Clinical data after the second evaluation of patients undergoing transtendon repair (TTR); group III

PN	Case	Sex	Age (years)	Dom	Δtt (years)	UCLA	Strength (kg)	Rounded strength (P)	Constant-Murley Score
1	1	F	53		6	35	11	24	97
2	2	M	74		6	35	9	20	91
3	3	F	52	+	6	33	12	25	97
4	4	F	43	+	6	35	10	22	93
5	5	M	54	+	6	35	12	25	99
6	7	M	53	+	6	35	10	22	91
7	8	M	43	+	12	31	10	22	90
8	9	M	38	+	6	35	10	22	93
9	10	M	47	+	12	34	12	25	90
10	11	F	59		12	31	4	9	72
11	12	M	44	+	15	35	12	25	96
12	13	F	58	+	6	33	11	24	99
13	14	M	56	+	13	32	9	20	90
14	15	M	62		8	34	6	13	84
15	16	M	62	+	12	34	11	24	93
16	17	F	56		8	33	9	20	91
17	18	M	47	+	8	34	12	25	95
18	19	M	38	+	10	35	12	25	94

Abbreviations: Δtt, postoperative follow-up time; Dom, dominance; F, female; kg, kilograms; P, pounds; M, male; PN, patient number; UCLA, modified University of California, Los Angeles Shoulder Rating Scale.

Table 2 Clinical data after the second evaluation of patients undergoing repair after completing the lesion (TCR); group IV

PN	Case	Sex	Age (years)	Dom	Δtt (years)	UCLA	Strength (kg)	Rounded strength (P)	Constant-Murley Score	COMP
1	1	M	62	+	6	35	12	25	98	
2	4	F	71	+	6	33	4	9	82	
3	5	M	78		6	34	7	15	82	
4	6	F	60		8	33	4	9	82	
5	7	M	42	+	11	34	10	22	91	
6	8	F	76	+	8	27	2	4	65	T
7	9	F	63	+	6	33	4	9	78	
8	11	M	42	+	6	33	12	25	94	
9	12	F	32	+	14	33	10	22	93	
10	14	M	46	+	6	33	10	22	88	
11	15	F	54		11	32	4	9	82	
12	16	M	42	+	9	32	9	20	87	
13	17	M	53	+	6	31	10	22	88	
14	18	M	54	+	6	34	10	22	95	
15	19	M	59		6	35	12	25	98	
16	20	F	51	+	6	35	6	13	86	

Abbreviations: Δtt, postoperative follow-up time; COMP, complication; Dom, dominance; F, female; kg, kilograms; P, pounds; M, male; PN, patient number; T, Trauma; UCLA, modified University of California, Los Angeles Shoulder Rating Scale.

showing a trend among elderly patients (over 60 years old) to present lower mean strength (5.5 kg) compared to younger patients (9.3 kg). Regarding the mean force and whether or not the DS was affected, there was no statistical difference ($p = 0.129$), with the mean force of 8.25 kg on the DS against 6.75 kg on the NDS.

When comparing groups III and IV, we did not notice statistical differences in relation to sex ($p = 0.533$), age ($p = 0.488$), and dominance ($p = 0.693$), showing that both groups were statistically similar. When the mean UCLA score was compared between them, there was no statistical difference ($p = 0.113$), with a mean total final result of 33.8 for group III (range: 31–35) and of 32.9 for group IV (range: 27–35). When the mean Constant-Murley score was compared between them, there was no statistical difference ($p = 0.075$), with a mean final result of 91.9 for group III (range: 72–99) and of 86.8 for group IV (range: 65–98) (►**Table 3**).

When comparing the mean DS strength between groups III and IV, there was a statistical difference: group III presented a higher mean force (11 kg) than group IV (8.25 kg), with $p = 0.042$.

When evaluating patients subjected to the TTR technique, groups I[21] and III, the mean previous and current UCLA scores were, and no statistical difference was observed ($p = 0.374$) (►**Table 4**).

When evaluating patients subjected to the TCR technique, groups II[21] and IV, the mean previous and current UCLA scores were compared, and no statistical difference was observed ($p = 0.859$) (►**Table 5**).

Discussion

Regarding the TCR technique, Shin (2012) mentions that the disinsertion of the entire lateral margin of the rotator cuff by transforming the partial injury into a complete one can lead to the risk of non-anatomical repair, altering the biomechanics and thus causing an early degeneration of the tendon, which can increase the rates of rerupture.[16] Ono et al.[20] show that the postrepair rupture index varies on average from 1.8 to 6.1% according to the technique used, with the techniques being TTR and TCR respectively, but the final results were good/excellent regardless of the techniques and after 40.5 months of follow-up. In the present study, we may have a case of posttraumatic rupture (case 8, group IV), an event unrelated to the procedure performed, but which could not be confirmed because the patient did not want to seek medical assistance. Apart from this case, we have no clinical suspicion of any case that could have reruptured once, since, according to the UCLA scale, as all cases fall between good and excellent.

Table 3 Comparison of the mean UCLA and Constant-Murley scores of groups III and IV

	Group III	Group IV	*p*-value
UCLA	33.8	32.9	0.113
Constant-Murley	91.9	86.8	0.075

Abbreviation: UCLA, modified University of California, Los Angeles Shoulder Rating Scale.

Table 4 Comparison of the UCLA score on the evaluations of patients operated on through the TTR technique

PN	Case	UCLA 1[21]	UCLA 2 (second evaluation)	*p*-value
1	1	35	35	
2	2	35	35	
3	3	35	33	
4	4	35	35	
5	5	35	35	
6	7	35	35	
7	8	32	31	
8	9	35	35	
9	10	32	34	
10	11	31	31	
11	12	34	35	
12	13	32	33	
13	14	31	32	
14	15	23	34	
15	16	34	34	
16	17	33	33	
17	18	33	34	
18	19	33	35	
Average		32.9	33.8	0.374

Abbreviations: PN, patient number; TTR, transtendon repair; UCLA, modified University of California, Los Angeles Shoulder Rating Scale .

Table 5 Comparison of the UCLA score on the evaluations of patients operated on with the TCR technique

PN	Case	UCLA[21]	UCLA (second evaluation)	*p*-value
1	1	32	35	
2	4	33	33	
3	5	34	34	
4	6	34	33	
5	7	32	34	
6	8	35	27	
7	9	32	33	
8	11	33	33	
9	12	34	33	
10	14	32	33	
11	15	33	32	
12	16	32	32	
13	17	33	31	
14	18	32	34	
15	19	33	35	
16	20	35	35	
Average		33.1	32.9	0.859

Abbreviations: PN, patient number; TCR, tear completion repair; UCLA, modified University of California, Los Angeles Shoulder Rating Scale.

The literature shows the relationship involving the results obtained according to the scores studied and the time of postoperative evolution. Few studies have extensive postoperative follow-up, longer than 2 years.[1,23–25] Stuart et al.[1] evaluated patients with PTRCT in 2 postoperative moments (1 and 12 years) and noticed that there was no change between evaluations after the statistically significant improvement in the first evaluation. Vap et al.[23] showed that, after 5 years after PTRCT, the functional and patient satisfaction results were excellent, corroborating the idea that these results remain high in the medium term. Rossi et al.[24] observed excellent results in more than 80% of their patients with PTRCT after a minimum of 8 years of postoperative follow-up. Similarly, Dey Hazra et al.[25] performed 3 postoperative reevaluations of their patients with PTRCT (2, 5, and 10 years) and noticed that, after the improvement in the first evaluation, the result remained without statistical difference. In the present work, the same thing occurred as in the aforementioned studies. Sella et al.[21] observed mostly good and excellent results 2 years postoperatively, and in the second evaluation, at a minimum of 6 years of postoperative follow-up, the evaluation parameters were not statistically altered.

Clinically, when performing this current evaluation in our patients, we noticed a significant increase ($p = 0.042$) in the mean strength of patients in group III (DS: 11 kg,; NDS: 7.8 kg) in relation to group IV (DS: 8.25 kg; NDS: 6.75 kg), although no statistical difference was observed between the Constant-Murley scores.[27] In our opinion, it is highly likely that these higher values are due to the fact that part of the tendon remains native to its original insertion in the TTR technique. None of the articles that perform the clinical comparison between the methods report that there was a statistical difference between the final forces found, since they do not discuss the force variable, although all use the Constant-Murley score in their evaluations.[8,11,16–18,20,22] It is understood that the strength variable improves regardless of the surgical method chosen because the vast majority of studies affirm that there is an improvement in the score. This is confirmed when we analyze separately those articles that use only one surgical technique in their study and that evaluate the final strength of their patients in some way. Castagna et al.[28] clinically evaluated only patients subjected to the TTR technique. They describe that they used a muscle test system named Lafayette, but the results do not specify values, and they only report a significant increase in the Constant-Murley score, and that all parameters of this score improved. For example, Fama et al.[19] obtained a significant increase in patients' final strength when using the TCR technique. They creported preoperative and postoperative mean strength values of 4.4 kg and 9.9 kg, but did not specify whether the shoulder in question was on the DS or the NDS.[19]

We understand that the follow-up of patients for longer periods always helps us to better understand the long-term

evolution. Compared to our previous work,[21] we almost doubled the follow-up time, but mainly increased the minimum follow-up time to 6 years. Regarding the few studies with long-term follow-up, our minimum follow-up was higher than the one adopted by Vap et al.[23] The present is the first study published so far, in English, in which there is a clinical comparison of the techniques used specifically discussing the strength variable, which was even statistically significant in favor of patients undergoing the TTR technique. We consider this a strong point and an important factor for dissemination among experts.

As a definition of conduct, our group chooses to repair PTRCT by the TTR technique in young patients whose injury is of traumatic origin and in those who perform sports that require upper limb strength, since this is the only variable that obtains statistically significant improvement. In elderly patients whose injury is of degenerative origin and who do not require substantial strength gain for sports practice, the TCR is chosen due to technical ease and reduced surgical time. This technique will certainly bring significant improvement in shoulder pain and function.

Conclusion

We conclude that the arthroscopic treatment of PTRCT, both by the TTR and the TCR techniques, resulted in satisfactory mean UCLA scores, with no statistical difference. We also obtained satisfactory mean Constant-Murley scores for both techniques, with no statistical difference between them. Considering the same technique used, neither was there statistical difference between the first and second evaluations.

After 6 years, patients treated through the TTR technique achieved statistically higher mean DS strength compared to their NDS and to the patients treated through the TCR technique.

Financial Support
The authors declare that they did not receive financial support from agencies in the public, private, or non-profit sectors to conduct the present study.

Conflict of Interests
The authors have no conflict of interests to declare.

References

1 Stuart KD, Karzel RP, Ganjianpour M, Snyder SJ. Long-term outcome for arthroscopic repair of partial articular-sided supraspinatus tendon avulsion. Arthroscopy 2013;29(05):818–823
2 Andrews JR, Broussard TS, Carson WG. Arthroscopy of the shoulder in the management of partial tears of the rotator cuff: a preliminary report. Arthroscopy 1985;1(02):117–122
3 Loehr JF, Uhthoff HK. The pathogenesis of degenerative rotator cuff tears. Orthop Trans 1987;11:237–243
4 Fukuda H. Partial-thickness rotator cuff tears: a modern view on Codman's classic. J Shoulder Elbow Surg 2000;9(02):163–168
5 Ellman H. Diagnosis and treatment of incomplete rotator cuff tears. Clin Orthop Relat Res 1990;(254):64–74
6 Finnan RP, Crosby LA. Partial-thickness rotator cuff tears. J Shoulder Elbow Surg 2010;19(04):609–616
7 Carvalho CD, Cohen C, Belangero PS, et al. Lesão parcial do manguito rotador no atleta – bursal ou articular? Rev Bras Ortop 2015;50(04):416–421
8 Kim YS, Lee HJ, Bae SH, Jin H, Song HS. Outcome comparison between in situ repair versus tear completion repair for partial thickness rotator cuff tears. Arthroscopy 2015;31(11):2191–2198
9 Mall NA, Kim HM, Keener JD, et al. Symptomatic progression of asymptomatic rotator cuff tears: a prospective study of clinical and sonographic variables. J Bone Joint Surg Am 2010;92(16): 2623–2633
10 Matava MJ, Purcell DB, Rudzki JR. Partial-thickness rotator cuff tears. Am J Sports Med 2005;33(09):1405–1417
11 Godinho GG, França FO, Freitas JMA, et al. Avaliação funcional a longo prazo do tratamento videoartroscópico das lesões parciais do manguito rotador. Rev Bras Ortop 2015;50(02):200–205
12 Veado MAC, Bertolini FM, Almeida Filho IA. Eficácia do desbridamento artroscópico nas lesões parciais do manguito rotador. Rev Bras Ortop 2006;41(1/2):22–28
13 Snyder SJ. Arthroscopic repair of partial articular supraespinatus tendon avulsion: PASTA lesions of the rotator cuff tendon. In: Snyder SJ, ed. Shoulder Arthoscopy. 2nd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2003:219–229
14 Deutsch A. Arthroscopic repair of partial-thickness tears of the rotator cuff. J Shoulder Elbow Surg 2007;16(02):193–201
15 Kamath G, Galatz LM, Keener JD, Teefey S, Middleton W, Yamaguchi K. Tendon integrity and functional outcome after arthroscopic repair of high-grade partial-thickness supraspinatus tears. [published correction appears in J Bone Joint Surg Am 2009 Aug;91(8):1995] J Bone Joint Surg Am 2009;91(05):1055–1062
16 Shin SJ. A comparison of 2 repair techniques for partial-thickness articular-sided rotator cuff tears. Arthroscopy 2012;28(01): 25–33
17 Franceschi F, Papalia R, Del Buono A, et al. Articular-sided rotator cuff tears: which is the best repair? A three-year prospective randomised controlled trial. Int Orthop 2013;37 (08):1487–1493
18 Castagna A, Borroni M, Garofalo R, et al. Deep partial rotator cuff tear: transtendon repair or tear completion and repair? A randomized clinical trial. Knee Surg Sports Traumatol Arthrosc 2015; 23(02):460–463
19 Fama G, Tagliapietra J, Belluzzi E, Pozzuoli A, Biz C, Ruggieri P. Mid-Term outcomes after arthroscopic "Tear completion repair" of partial thickness rotator cuff tears. Medicina (Kaunas) 2021;57 (01):74
20 Ono Y, Woodmass JM, Bois AJ, Boorman RS, Thornton GM, Lo IK. Arthroscopic Repair of Articular Surface Partial-Thickness Rotator Cuff Tears: Transtendon Technique versus Repair after Completion of the Tear-A Meta-Analysis. Adv Orthop 2016;2016; 7468054
21 Sella GDV, Silva LAD, Checchia CS, Marmille HC, Santili C, Miyazaki AN. Comparative Clinical Evaluation of Two Techniques of Arthroscopic Treatment of Partial Articular Rotator Cuff Tears. Rev Bras Ortop 2021;56(06):726–732
22 Thamrongskulsiri N, Limskul D, Itthipanichpong T, Tanpowpong T, Kuptniratsaikul S. Similar outcomes between transtendon repair and tear completion repair techniques for partial articular-sided supraspinatus tendon avulsion lesions: a systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc 2023;31(10):4575–4584
23 Vap AR, Mannava S, Katthagen JC, et al. Five-year outcomes after arthroscopic repair of partial-thickness supraspinatus tears. Arthroscopy 2018;34(01):75–81
24 Rossi LA, Atala NA, Bertona A, et al. Long-term outcomes after in situ arthroscopic repair of partial rotator cuff tears. Arthroscopy 2019;35(03):698–702

25 Dey Hazra RO, Dey Hazra ME, Hanson JA, et al. Minimum 10-year outcomes after arthroscopic repair of partial-thickness supraspinatus rotator cuff tears. Am J Sports Med 2023;51(09):2404–2410
26 Ellman H, Hanker G, Bayer M. Repair of the rotator cuff. End-result study of factors influencing reconstruction. J Bone Joint Surg Am 1986;68(08):1136–1144
27 Barreto RPG, Barbosa MLL, Balbinotti MAA, Mothes FC, Rosa LHT, Silva MF. Versão Brasileira do Constant-Murley Score (CMS-BR): validade convergente e de constructo, consistência interna e unidimensionalidade. Rev Bras Ortop 2016;51(05): 515–520
28 Castagna A, Delle Rose G, Conti M, Snyder SJ, Borroni M, Garofalo R. Predictive factors of subtle residual shoulder symptoms after transtendinous arthroscopic cuff repair: a clinical study. Am J Sports Med 2009;37(01):103–108

Polypropylene Prosthesis in the Treatment of Extended Injuries and Coverage of Graft-free Donor Areas: Case Series

Prótese de polipropileno no tratamento de lesões extensas e cobertura de áreas doadoras sem enxerto: Série de casos

Raphael De Sá Vasconcelos Uchôa[1] Luís Filipe e Silva Lessa Ferreira[1]
Ana Luiza Simões de Brito Uchôa[2]

[1] Department of Hand Surgery and Microsurgery, Hospital Regional do Agreste, Caruaru, PE, Brazil
[2] Trauma Unit, Hospital Regional do Agreste, Caruaru, PE, Brazil

Address for correspondence Raphael de Sá Vasconcelos Uchôa, Rua Pastor Rubem Prado, 187, Caruaru, PE, 55014395, Brazil (e-mail: Raphael1310med@gmail.com).

Rev Bras Ortop 2024;59(5):e779–e785.

Abstract

Objective To evaluate the effectiveness of the use of polypropylene prostheses in the treatment of extensive limb injuries.

Methods There were 13 patients evaluated for the final aspects of the treatment, including the presence of epithelization and granulation, reduction of raw area, and coverage of deep structures.

Results A reduction greater than 40% of the raw area in all cases and complete coverage of noble structures were visualized.

Conclusion An effective, reproducible, low-cost alternative for treating extensive injuries has been demonstrated.

Keywords
- therapeutics
- wound closure techniques
- wounds and injuries

Resumo

Objetivo Avaliar a eficácia do uso das próteses de polipropileno no tratamento de ferimentos extensos nos membros.

Métodos Foram avaliados 13 pacientes quanto aos aspectos finais do tratamento, incluindo presença de epitelização e granulação, redução de área cruenta e cobertura de estruturas profundas.

Resultados Uma redução maior que 40% da área cruenta e cobertura completa de estruturas nobres foram visualizadas.

Conclusão Evidenciou-se uma alternativa eficaz, reprodutível e de baixo custo no tratamento de lesões extensas.

Palavras-chave
- ferimentos e lesões
- técnicas de fechamento de ferimentos
- terapêutica

Work carried out at the Hospital Regional do Agreste, Caruaru, PE, Brazil.

received
April 9, 2024
accepted
July 1, 2024

DOI https://doi.org/10.1055/s-0044-1791514.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Introduction

Injuries with integumentary loss in the limbs, associated or not with fractures, are common problems in traumatology, affecting mostly young and economically active individuals, causing them high morbidity and work absenteeism.[1–4] This context may involve factors such as prolonged hospitalization, high pharmacological cost, association with soft-tissue and bone infections, partial and precarious rehabilitation, in addition to increasing the risk of disability and death from systemic complications.[1,3,4]

Moreover, these injuries are difficult to treat, taking long periods to heal,[1,3,4] or requiring complex and often inaccessible therapeutic interventions, such as plastic surgery and negative-pressure therapy.[1,5–7]

Provisional coverage with polypropylene prosthesis has been cited as an alternative in treating these lesions and flap donor areas. The methodology gained notoriety in a recent study for demonstrating reepithelialization in fingertip lesions with loss of digital pulp;[8] however, it lacks further scientific evidence.

The present study aims to evaluate the effectiveness of polypropylene prostheses in treating extensive skin lesions on the limbs.

Materials and Methods

The study was previously approved by the Ethics Committee of the institution (CAAE: 46264121.6.0000.5666). All participants were informed about the research and signed an



Fig. 1 (**A**) Patient I (48 years old) coverage of sural flap donor area with polypropylene prosthesis in 2021; (**B**) appearance of the wound after removal of the prosthesis at 6 weeks of evolution; (**C**) appearance of the resulting scar tissue in 2024; (**D**) patient II (22 years old) in 2021, polypropylene prosthesis on the wound on the medial side of the leg; (**E**) appearance of the wound 6 weeks after removal of the prosthesis, (**F**) the same wound 8 weeks after removal; (**G**) resulting scar tissue in 2024. Both reported no complaints about the scars.

informed consent form. We recruited 25 patients and interns in a tertiary hospital's Traumatology and Orthopedics Center, which used polypropylene prostheses to treat extensive injuries or cover donor flap areas. After applying the exclusion criteria, 13 patients had their results evaluated. The participants were operated on and assisted by the same group of surgeons between September and December 2021.

The present study was designed as a long-term follow-up, in which recurrent follow-up would be carried out from the preoperative to the immediate postoperative period until removal of the prosthesis, and, finally, a last evaluation in the remote postoperative period in 2024. It was expected that after 3 years, having achieved complete maturation of the scar tissue of all participants, a reliable evaluation of data, such as structural and sensitive quality of the scar formed and related complications, could be carried out. However, after the planned period had elapsed, only 2 of the 13 patients evaluated had kept the same contact telephone number provided at the beginning. Thus, although both denied complaints and abnormalities about the scar, no definite conclusion was obtained, given the small remaining sample (►**Fig. 1**).

The inclusion criteria were patients with extensive traumatic injuries with skin loss in the upper or lower limbs, defined as areas $\geq 25\,cm^2$ ($5 \times 5\,cm$ in the largest diameters) with or without exposure to noble structures (bones, nerves, tendons, and vessels). We also included individuals subjected to skin flaps, in which the donor area would need a skin graft for closure.[9]

Individuals with previously infected wounds, peripheral vascular diseases, active smoking, anemia, and diabetes mellitus were excluded.

The participants were evaluated based on the protocol proposed by Figueiredo et al.[8] In this protocol, wounds with skin loss are covered with polypropylene prosthesis, which can be obtained from sterile hospital materials. The management includes maintenance of the prosthesis for an extended period, performing, from 7 days after the installation of the device, cleaning of the prosthesis and secondary coverage, with follow-up and periodic observation of the prosthesis for up to 6 weeks.[8]

Debridement of the wounds and initial photographic documentation were performed. After the installation of the polypropylene prosthesis, a new photographic record



Fig. 2 Example of a photographic record of a wound with a standard millimeter object to facilitate estimation of the wound area.

Table 1 Descriptive analysis of qualitative and numerical variables

Wound site	Age (years)	Sex	Initial raw area (cm^2)	Final raw area (cm^2)	Reduction of raw area	Treatment period (weeks)
Lateral side of left leg	23	M	196	79	60	6
Right forearm Chinese flap donor area	24	M	90	17	81	8
Back of left foot	20	F	37.9	9.6	75	7
Palmar side of left hand and wrist	43	M	124	35.9	71	8
Medial gastrocnemius flap on the proximal 1/3 of the left leg	31	M	60.9	26	56.9	8
Back left foot	61	F	55	26	52	6
Fasciotomy on the medial aspect of the left leg	22	M	80	46	42	6
Anterolateral side of right leg	18	M	147	64	56	6
Sural flap donor area on left leg	48	M	63.5	0	100	6
Medial surface of right leg	18	M	59	33	43	8
Back of the left forearm	43	M	130	41.8	67.7	6
Sural flap donor area on left leg	31	M	60	25.9	56,8	6
Sural flap donor area on left leg	33	M	45	9.6	78.5	8

was made. The photographs were obtained using a 25-megapixel camera with a resolution of 5,760 × 4,320 pixels.

The prosthesis was made on a case-by-case basis using the transparent polypropylene of the sterile bladder catheter collector to allow monitoring and documentation of healing. The prosthesis was sutured to the healthy margins of the wound through simple stitches, with a 1-cm distance between them, performed with 3–0 nylon thread, then secondary coverage. Hospital discharge was possible, in most cases, between the first and second postoperative days.

In general, the first dressing change occurred after 7 days, and from then on, daily dressing changes with appropriate cleaning of the prosthesis and the use of 70% alcohol on the stitches were advised. The participants were followed fortnightly from the first consultation. The removal of the prosthesis was scheduled between the 6th and 7th weeks, with the non-compliance of deep tissues to the granulation tissue as a criterion.

To evaluate the effectiveness of the treatment, we considered the reduction of the bruised area and the appearance of the resulting coverage after removal of the prosthesis. We



Fig. 3 Evolutionary phases of the treatment of an extensive wound on the lateral aspect of the left leg: (**A**) extensive wound with devitalized tissue; (**B**) extensive debridement, visualizing tendinous structures, superficial peroneal nerve, and division of muscle compartments; (**C**) polypropylene prosthesis to cover the wound; (**D**) first dressing change after 7 days, noting the accumulation of serous exudate; (**E**) second week: it is possible to see fibrin formation and the beginning of granulation; (**F**) fourth week: coating of the microenvironment with thick fibrin and the occurrence of hypertrophic granulation; (**G**) sixth week: removal of the prosthesis and a significant reduction in the raw area, epithelialization of the wound margins, the center with hypertrophic granulation tissue, and it is not possible to see deep structures in the wound bed; (**H**) eighth week of follow-up, with rapid progression of epithelialization.

considered a good result that which did not present residual exposure of deep structures in the wound bed.[9]

From the photographic records of each wound with a graduated standard object (►**Fig. 2**), using the software AutoCAD version 2022 (Autodesk, Inc., San Francisco, CA, USA), the comparative analysis between the initial raw area of each wound and the new measurement of the raw area after removal of the prosthesis was performed. For this purpose, the photographs were inserted in the working area of the software AutoCAD, where the edges of the wound and the standard object were demarcated, the latter with a previously known actual area. From the contours' boundary, the wound's raw area and the standard object's area were obtained in decimal numbers in the language of the software. In possession of these values and the previously known actual area of the standard object, with a simple rule of three, an estimation of the raw area of the wounds at the beginning and after removal of the prosthesis was performed in cm^2. The same researcher took the measures using AutoCAD. The reduction of the measures of the raw area of the wounds of each participant was standardized in percentage for statistical analysis. The significance level considered for performing all hypothesis tests was equal to 5%.

Results

Of the 13 participants evaluated, 11 (84.6%) were male and 2 (15.3%) were female. The median age was 31.9 years. The lesions affected the lower limbs more, with 10 patients (76.9%). The most frequent trauma mechanism was motorcycle accident, with 11 cases (84.6%), followed by 1 case of automobile accident (7.7%) and 1 case of accident with agricultural machinery (7.7%). The most affected segment was the left lower limb, with 8 cases (61.5%), followed by 2 cases of trauma to the right lower limb (15%) and 2 to the left upper limb (15%), and 1 case of injury to the right upper limb (7.7%). The epidemiological profile traced by this study follows what is reported in the literature.[9] Of the 13 patients evaluated, 4 (30%) had the initial traumatic wound treated with flaps and coverage of the donor area with polypropylene prosthesis. Of these 4, 3 were treated with flaps in the left lower limb—sural flap—and 1 (25%) in the right upper limb—Chinese flap (►**Table 1**).

The following stages of evolution were observed among the participants, suggesting some degree of predictability of the treatment: in the first week, accumulation of serous exudate, translucent, straw yellow, and odorless. After about 2 weeks, the appearance of islands of granulation and a decrease in exudate with the formation of thick fibrin were observed, which coated the entire surface of the "microenvironment" around the 3rd and 4th weeks. The thick fibrin layer was gradually replaced by hypertrophic granulation tissue between the 3rd and 4th week. This granulation tissue fills, to a large extent, the raw area of the lesion, with less expressiveness in the initially deeper wounds or in those in which the prosthesis was in direct contact with the bone surface. After about 5 to 6 weeks, it is possible to verify the presence of reepithelialization at the wound margins, with variable thickness, under the transparent prosthesis in coexistence with granulation tissue in the central area (►**Fig. 3**). During these stages, patients presented with no clinical complaints and no systemic or local signs of infection or exuberant inflammation. The prosthesis was removed in most cases between the 6th and 7th week. In all cases, a reduction greater than 40% of the raw area was visualized, with epithelization of the edges of the lesion and center presenting residual granulation tissue, with measurements varying from case to case (►**Fig. 4**). In the follow-up, the rapid epithelization of the residual granulation tissue is noticeable, resulting in scar tissue of color and morphology similar to the adjacent healthy skin, painless, and with preserved sensitivity.



Fig. 4 Sural flap donor area on the left leg, after removal of the polypropylene device in the 6th week, showing a reduction in the raw area, epithelialization of the edges, and a center with hypertrophic granulation tissue.

The healing process seemed to occur more efficiently when the prosthesis was used on the upper limbs in comparison with the lower limbs (►**Fig. 5**). This aspect was not statistically significant due to the small number of cases with upper extremity injuries.

After the removal of the prosthesis, invariably, no deep tissues were observed in the wound bed, proving the effectiveness of the prosthesis in protecting noble tissues and reducing the morbidity of traumatic injuries. However, in deep wounds, the bed filling occurred more slowly, suggesting the need for a longer prosthesis stay or indication of flaps, corroborating what was previously reported in the literature.[5,6]

The average initial bruised area of the wounds was 88 cm^2 (37.9–196 cm^2), while the average final raw area was 31.8 cm^2 (0–79 cm^2). The average percentage of reduction of raw area was 64.6%. The average length of stay of the prosthesis was 6.8 weeks, ranging from 6 to 8 weeks. For



Fig. 5 Treatment of extensive wound on the back of the left forearm: (**A**) initial raw area with exposure of deep structures; (**B**) first week; (**C**) second week; (**D**) third week; (**E**) fourth week; (**F**) sixth week: loosening of the suture anchoring the prosthesis due to scar retraction and epithelialization of the edges; (**G**) sixth week: removal of the device, significant reduction of the raw area, with no deep structures visible; (**H**) tenth week of follow-up: wound completely healed.

statistical inference of the effectiveness of the protocol proposed by Figueiredo et al.[8] when implemented in extensive limb injuries, the portion of the sample that remained with the prosthesis for 6 weeks was analyzed. When performing the t-test for comparison of means, there was sufficient evidence to affirm that the polypropylene prosthesis reduced the raw area by more than 40% in 6 weeks, with a *p*-value equal to 0.019 and a confidence level of 95%.

There were no cases of infection during treatment with the polypropylene prosthesis, highlighting the role of prior wound care, especially when the injury is traumatic. In two cases, the formation of hypertrophic scar tissue occurred painlessly and with preserved sensitivity. In these two cases, the patients evolved with hypertrophic scarring of other adjacent raw areas not treated with the prosthesis, such as the flap pedicle region, which may suggest that this complication was not inherent to the method.

Discussion

The technique analyzed demonstrated the advantage of not requiring a donor area for coverage, reducing morbidity associated with traumatic injuries, hospital admission, total pharmacological cost, and materials for dressings, besides the rate of infection, amputations, and other complications, as well as speeding up the return to work activities.[8]

In addition, coverage with polypropylene prosthesis is an easy method that surgeons can use at the beginning of the learning curve to generate satisfactory results.

The device provides the accumulation of exudate rich in growth factors, cytokines, cellularity, proteins, and other components that create a moist microenvironment prone to faster tissue repair, restoring the anatomy of the affected region.[2,8,10] Such components, present in the humid microenvironment, are known to be essential for the scar repair process.[2] The body reacts to the device's presence with the acceleration of the healing phases in a coordinated manner, significantly impacting the healing quality.[8]

Another characteristic of the humid microenvironment is the accumulation of therapeutic agents, such as antibiotics in concentrations similar to plasma through accumulated exudate, which, added to the stratum corneum formed on the wound surface inside the microenvironment, allow no or little bacterial growth. In the latter case, we are referring to non-invasive germs.[10]

The main complications described are infectious processes, which have a low incidence rate when adequate debridement of devitalized tissues and decolonization of the wound with antibiotic therapy is performed before the installation of the prosthesis.[6,8]

Conclusion

The polypropylene prosthesis, used as a temporary cover for the treatment of extensive lesions in the limbs and donor areas of flaps, proved to be an effective, affordable, safe, and easy-to-perform technique. Given the encouraging results, this technique can be an alternative in services without the availability of resources such as negative-pressure dressing and lack of trained staff for reconstruction with flaps and grafts. This method can also demonstrate greater scope and versatility, requiring analysis of larger samples.

Financial Support
The authors declare that they did not receive financial support from agencies in the public, private, or non-profit sectors to conduct the present study.

Conflict of Interests
The authors have no conflict of interests to declare.

References

1 Coltro PS, Ferreira MC, Batista BP, Nakamoto HA, Milcheski DA, Tuma Júnior P. Role of plastic surgery on the treatment complex wounds. Rev Col Bras Cir 2011;38(06):381–386
2 Broughton G 2nd, Janis JE, Attinger CE. Wound healing: an overview. Plast Reconstr Surg 2006;117(07):1e–S-32e
3 Lindholm C, Searle R. Wound management for the 21st century: combining effectiveness and efficiency. Int Wound J 2016;13 (Suppl 2:5):5–14
4 MacKenzie EJ, Morris JA Jr, Jurkovich GJ, et al. Return to work following injury: the role of economic, social, and job-related factors. Am J Public Health 1998;88(11):1630–1637
5 Montenegro SS, Costa AC, Meves R. Reconstruction of the Lower Limb with Fasciocutaneous Flap of the Distal Pedicle - Modified Technique of Monteiro, Series of 15 Cases. Rev Bras Ortop 2020;55 (06):736–741
6 Ong YS, Levin LS. Lower limb salvage in trauma. Plast Reconstr Surg 2010;125(02):582–588
7 Robert N. Negative pressure wound therapy in orthopaedic surgery. Orthop Traumatol Surg Res 2017;103(1S):S99–S103
8 Figueiredo LA, Ribeiro RS, Melo ALB, Lima AL, Terra BB, Ventim FC. Polypropylene prosthesis for the treatment of fingertip injuries. Description of surgical technique and results. Rev Bras Ortop 2017;52(06):685–692
9 Rezende RBM, Macedo JLS, Rosa SC, Galli FS. Epidemiological profile and treatment of substance losses by trauma to the lower limbs. Rev Col Bras Cir 2017;44(05):444–451
10 Junker JP, Caterson EJ, Eriksson E. The microenvironment of wound healing. J Craniofac Surg 2013;24(01):12–16

Shanz-assisted Closed Reduction (SACR): A Novel Reduction Technique for Elastic Stable Intramedullary Nailing of Pediatric Forearm Fractures

Redução fechada assistida por Schanz (SACR): Uma nova técnica de redução para fixação intramedular elástica estável de fraturas pediátricas do antebraço

Julio Javier Masquijo[1]

[1] Department of Pediatric Orthopedics, Sanatorio Allende, Córdoba, Argentina

Address for correspondence Sanatorio Allende, MD, Pediatric Orthopedics, Independencia 757 1st floor, Cordoba, Cordoba 5009, Argentina (e-mail: jmasquijo@gmail.com).

Rev Bras Ortop 2024;59(5):e786–e788.

Abstract

Forearm fractures involving both bones are prevalent among pediatric patients. Elastic stable intramedullary nailing (ESIN) is an excellent option for forearm fractures that require surgical stabilization in children and adolescents. Proximal third fractures can be particularly challenging to reduce using closed techniques, and multiple unsuccessful attempts at nail insertion can increase the risk of compartment syndrome. In this article, we present a novel technique called Shanz-assisted closed reduction (SACR), which involves using a 4-mm Shanz to facilitate alignment and nail insertion while avoiding complications associated with longer operative times and open reduction.

Keywords

- child
- forearm injuries
- fracture fixation, intramedullary
- radius fractures

Resumo

Fraturas dos dois ossos do antebraço são prevalentes entre pacientes pediátricos. A haste intramedular elástica estável (ESIN, na sigla em inglês) é uma excelente opção para fraturas do antebraço que requerem estabilização cirúrgica em crianças e adolescentes. A redução fechada de fraturas do terço proximal pode ser particularmente difícil, e as múltiplas tentativas malsucedidas de inserção da haste podem aumentar o risco de síndrome compartimental. Este artigo apresenta uma nova técnica chamada redução fechada assistida por Schanz (SACR, na sigla em inglês) com uso de um Shanz de 4 mm para facilitar o alinhamento e a inserção da haste e evitar as complicações associadas a tempos operatórios mais longos e à redução aberta.

Palavras-chave

- criança
- fixação intramedular de fraturas
- fraturas do rádio
- lesões do antebraço

Work carried out at the Departamento de Ortopedia Infantil, Sanatorio Allende, Córdoba, Argentina.

received
April 27, 2023
accepted
September 19, 2023

DOI https://doi.org/10.1055/s-0044-1787548.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Introduction

Both-bone forearm fractures are among the most common pediatric fractures, accounting for approximately 40% of all cases.[1] Treatment typically involves closed reduction and casting, but surgical intervention may be necessary for significantly displaced, highly comminuted, or segmental fractures. Other surgical indications include open fractures, associated neurovascular injury, fractures refractory to closed reduction and casting, and concomitant ipsilateral humerus fractures (also known as floating elbow).[2] Elastic stable intramedullary nailing (ESIN) is an excellent option for forearm fractures in children and adolescents due to its minimally invasive approach. However, proximal third fractures can be particularly challenging to reduce using closed techniques, and multiple unsuccessful attempts at nail insertion can increase the risk of compartment syndrome.[3] If closed reduction is unsuccessful, open reduction with internal fixation (ORIF) may be necessary.

This article describes a novel technique using a 4-mm Shanz to facilitate nail insertion and avoid complications associated with longer operative times and open reduction (OR).

Technical Description

The patient is positioned in the supine position and given general anesthesia. The starting point for the radial nail is marked between the first and second dorsal compartments, 1 cm proximal to the physis. The ulnar starting point is marked on the posterior border of the ulna, distal to the physis. The radial bone is typically addressed first as reduction may be difficult after fixation of the ulna. Dissection is performed between the first and second dorsal extensor compartments with care taken to protect the superficial radial nerve. An opening is made in the distal radius cortex proximal to the physis, and a flexible nail is inserted under fluoroscopic guidance. The arm is manipulated to reduce the fracture. If unsuccessful after three attempts, the Shanz-assisted closed reduction (SACR) technique is utilized (►**Fig. 1**).

For the SACR technique, a 1- to 1.5 cm skin incision is made and gradually deepened using forceps and retractors until the bone is reached. A 4-mm Schanz pin is placed 3 cm proximal to the fracture site through a drill sleeve to protect soft tissues. A monocortical pin is used to manipulate the proximal fragments, allowing the surgeon to correct rotation, angulation, and translation until the elastic nail can be inserted. In proximal third forearm fractures, the supinator and biceps will tend to supinate the proximal segment, so the reduction maneuver involves pronation of the proximal fragment and supination of the distal segment. Once the elastic nail is inside the proximal fragment, the Schanz pin is removed. After addressing the radial bone, attention is turned to fixation of the ulna. Although the technique can also be used in the ulna, it is rarely required. An opening is made in the proximal ulna, and a flexible nail is inserted. Both nails (radius and ulna) are impacted to 1 cm short of the expected ending point, then cut flush to the skin and impacted an additional 1 cm below the skin. Postoperatively, the patient is immobilized in a long arm splint for 2 weeks, followed by full arm motion. Radiographs are taken at 6-week intervals to assess union, and the nails are typically removed at 9 to 12 months (►**Fig. 2**).

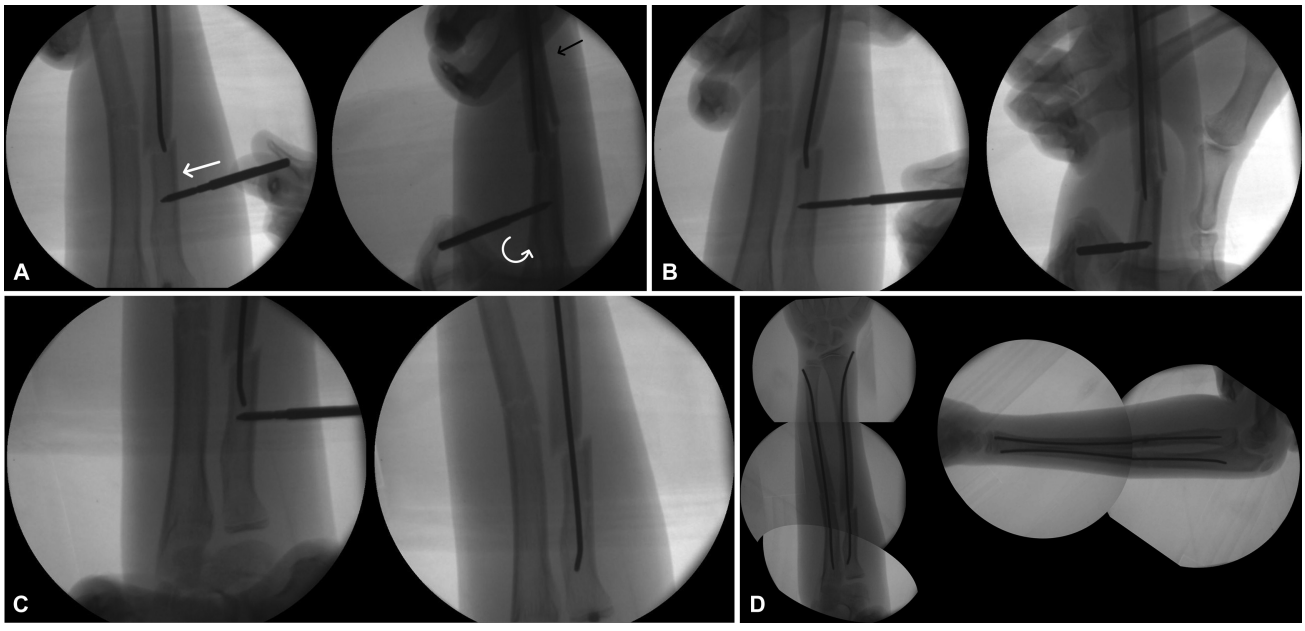


Fig. 1 A) The flexible nail is inserted under fluoroscopic guidance up to the fracture site. A monocortical 4-mm Schanz pin is placed three centimeters proximal to the fracture site. A drill sleeve is used to protect soft tissues. The reduction maneuver involves translation of the fragment in the coronal plane, pronation of the proximal fragment, and supination of the distal segment. B) The elastic nail is advanced to reach the proximal fragment. C) The Schanz pin is removed. D) Final construct.



Fig. 2 Anteroposterior and lateral radiograph at 6 months follow-up.

Discussion

Elastic intramedullary nailing of pediatric forearm fractures represents a popular technique to treat unstable fractures that fail closed reduction and casting in children. Surgical stabilization with ESIN fixation is minimally invasive, provides excellent alignment, facilitates postoperative care, and eliminates concerns about acceptable alignment.[4]

However, certain fracture patterns, such as those in the proximal third of the radius and ulna or comminuted midshaft, may require OR to facilitate nail insertion. Multiple attempts at closed reduction may increase the risk of compartment syndrome, which has been associated with longer operative times and increased intraoperative fluoroscopy burden.[2,5] For this reason, most pediatric orthopedic surgeons suggest performing OR after three unsuccessful attempts at closed reduction.[6] Other authors have proposed a Kapandji-like technique to avoid OR.[7] Using fluoroscopy, a 2.0-mm Kirschner wire can be inserted at the fracture site to elevate and reduce the fragments. Disadvantages of this technique are the risk of neurovascular injury and infection associated with multiple attempts.

Final Considerations

We describe a simple and reproducible surgical tip to ease nail insertion and avoid complications related with longer operative times and OR. While forearm proximal pin placement is generally associated with low morbidity, it is essential to consider the potential risks to the radial nerve, particularly the posterior interosseous nerve (PIN). The PIN is a branch of the radial nerve that originates from the radial nerve at the radiohumeral joint line. It then travels along the posterior aspect of the forearm, passing through the supinator muscle at the arcade of Frohse. Continuing its course, the nerve winds around the radial neck within the substance of the muscle, eventually reaching the posterior compartment of the forearm and the interosseous membrane of the forearm. It finally terminates as a source of sensation to the dorsal wrist capsule. Given the proximity of the PIN to the surgical site during forearm proximal pin placement, a thorough understanding of the forearm's anatomy is crucial to ensure safe and precise pin insertion. To minimize the risk of PIN injury during the procedure, surgeons utilize careful dissection techniques and employ a drill sleeve to safeguard surrounding soft tissues. The same principle can be applied to other long bones, like the femur, tibia, and humerus, that require ESIN. We have also used 4-mm Shanz to assist reduction in supracondylar fractures of the humerus to enable closed reduction and percutaneous pinning. In the forearm, the SACR technique allows a more effective manipulation of the proximal fragment to restore alignment and facilitate successful nailing in pediatric patients.

Ethics Committee

Our hospital does not require approval for this type of article.

Financial Support

The present study received no financial support from either public, commercial, or not-for-profit sources.

Conflict of Interests

The authors have no conflicts of interests to declare.

References

1 Chung KC, Spilson SV. The frequency and epidemiology of hand and forearm fractures in the United States. J Hand Surg Am 2001; 26(05):908–915
2 Nandyala S, Shore B, Hogue G. Pearls and Pitfalls of Forearm Nailing: Current Concept Review. JPOSNA 2021;3(01):1–13
3 Blackman AJ, Wall LB, Keeler KA, et al. Acute compartment syndrome after intramedullary nailing of isolated radius and ulna fractures in children. J Pediatr Orthop 2014;34(01):50–54
4 Price CT. Acceptable alignment of forearm fractures in children: Open reduction indications. J Pediatr Orthop 2010;30:S82–S84
5 Yuan PS, Pring ME, Gaynor TP, Mubarak SJ, Newton PO. Compartment syndrome following intramedullary fixation of pediatric forearm fractures. J Pediatr Orthop 2004;24(04):370–375
6 Upasani VV, Li Y. Elastic Intramedullary Nailing of Pediatric Both-Bone Forearm Fractures. JBJS Essential Surg Tech 2020;10(04): e19.00055
7 Pogorelić Z, Gulin M, Jukić M, Biliškov AN, Furlan D. Elastic stable intramedullary nailing for treatment of pediatric forearm fractures: A 15-year single centre retrospective study of 173 cases. Acta Orthop Traumatol Turc 2020;54(04):378–384

Kapandji-assisted Closed Reduction and Percutaneous K-wire Fixation for Proximal Humerus Fractures in Adolescents: A Technical Note

Redução fechada assistida por Kapandji e fixação percutânea com fio de Kirschner em fraturas do úmero proximal em adolescentes: Nota técnica

Florencia Turazza[1] Heloisa Zimmermann Faggion[2] Julio Javier Masquijo[1]

[1] Department of Pediatric Orthopedics, Sanatorio Allende, Córdoba, Argentina
[2] Hospital do Trabalhador, Curitiba, PR, Brazil

Address for correspondence Julio Javier Masquijo, MD, Sanatorio Allende, Pediatric Orthopaedics, Independencia 757 1st floor, Cordoba, Cordoba 5009, Argentina (e-mail: jmasquijo@gmail.com).

Rev Bras Ortop 2024;59(5):e789–e792.

Abstract

Proximal humerus fractures account for approximately 3 to 5% of all pediatric-adolescent fractures, with a higher incidence observed in older children, particularly between the ages of 10 and 15 years. Non-displaced or minimally displaced fractures can often be treated conservatively. However, the management of displaced or unstable proximal humerus fractures in adolescents may involve surgical intervention, with closed reduction and percutaneous pinning (CRPP) being commonly employed techniques. Closed reduction and percutaneous pinning is not without its challenges and potential difficulties. This article aims to describe a technique that can facilitate CRPP and minimize complications associated with this surgical approach.

Keywords
- adolescents
- closed reduction
- humeral fractures
- Kirschner wire

Resumo

As fraturas proximais do úmero representam aproximadamente 3 a 5% de todas as fraturas pediátricas e em adolescentes, com maior incidência em crianças mais velhas, principalmente entre 10 e 15 anos de idade. Fraturas sem luxação ou com luxação mínima geralmente podem ser tratadas de forma conservadora. No entanto, o manejo das fraturas proximais do úmero com luxação ou instabilidade em adolescentes pode exigir intervenção cirúrgica; nesses casos, a redução fechada e a fixação percutânea (CRPP, na sigla em inglês) são as técnicas mais empregadas. A CRPP não é isenta de possíveis desafios e dificuldades potenciais. Este artigo tem como objetivo descrever uma técnica que pode facilitar a CRPP e minimizar as complicações associadas a esta abordagem cirúrgica.

Palavras-chave
- adolescente
- fio de Kirschner
- fraturas do úmero
- redução fechada

Work carried out at the Department of Pediatric Orthopaedics, Sanatorio Allende, Córdoba, Argentina.

received
May 30, 2023
accepted after revision
November 6, 2023

DOI https://doi.org/10.1055/s-0044-1787549.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Introduction

Proximal humerus fractures account for approximately 3 to 5% of all pediatric fractures, with a higher incidence observed in older children, particularly between the ages of 10 and 15 years.[1] Male children tend to be more affected than females. These fractures commonly result from falls, sports-related injuries, or direct trauma to the shoulder region.

The management of proximal humerus fractures in adolescents depends on various factors, including fracture characteristics, age, and skeletal maturity. Non-displaced or minimally displaced fractures can often be treated conservatively with immobilization using slings or braces. However, displaced or unstable fractures in patients with a limited remodeling potential may require surgical intervention. Closed reduction and percutaneous pinning (CRPP) are commonly employed surgical techniques for the management of displaced or unstable proximal humerus fractures in adolescents.[2–4] While these procedures can be effective in achieving anatomical alignment and promoting fracture healing, they are not without challenges and potential difficulties. This article aims to describe a technique that can facilitate CRPP and minimize complications associated with this surgical approach.

Technical Description

The indications for surgical management of proximal humerus fractures are described in ►**Table 1**. Reduction is considered for fractures that are displaced by more than 33% (Neer III or IV) or fractures exhibiting an angulation of over 40 degrees in patients who are within 2 years of reaching skeletal maturity (boys aged $\geq$ 14 years and girls aged $\geq$ 12 years).[5] The patient is positioned in the supine or modified beach chair position to allow orthogonal imaging (►**Figs. 1** and **2**). Subsequently, the entire upper extremity is draped. With the arm in adduction, 2 2.0-mm Kirschner wires are percutaneously inserted and advanced to the fracture site. In this position, it is easier to introduce pins than with the arm in abduction and rotation. It is crucial to avoid the axillary nerve during percutaneous placement of the pins. The nerve is located within 6 cm of the anterolateral aspect of the acromion, and the pins are placed distal to this site. Once the position of the pins has been confirmed radiographically, a closed reduction of the fracture is performed with traction, abduction, and rotation. If the reduction is deemed inadequate, a 2.5-mm Steinmann pin is used to facilitate the reduction (Kapandji technique). Occasionally, the periosteum or the long head of the biceps may interfere at the fracture site, requiring an open reduction through a deltopectoral approach. Once reduction is achieved, the pins are advanced, and the Steinmann pin is removed. It is important to avoid penetrating the articular surface with the Kirschner wires. Subsequently, tests are performed with continuous fluoroscopy for maximum internal and external rotation to assess stability and the final position of the pins. If signs of fracture instability are observed, a third 2.0-mm crossed pin is inserted. The wires are then cut, bent, and kept outside the skin, thus allowing for their removal in the office.

Postoperatively, the affected limb is placed in a sling with a cushion to maintain a certain degree of abduction. The fracture is followed biweekly to assess healing, and the sling and pins are removed at 4 weeks in the office. Passive and progressive active shoulder range-of-motion exercises, including forward elevation and external rotation with the arm at the side, as well as pendulum exercises, are initiated following pin removal.

Table 1 Indications for surgical management of proximal humerus fractures in adolescents.

Indications
Open fractures
Fractures associated with neurovascular compromise
Skin tenting or risk of impending open fracture
Older children approaching skeletal maturity with displaced and angulated fractures
Polytrauma requiring early weight-bearing of the affected upper extremity
Ipsilateral extremity fractures (floating elbow)

Discussion

The proximal humeral physis exhibits remarkable potential for remodeling, enabling significant tolerance for deformities in skeletally immature children. However, surgical intervention may be necessary in certain situations. This article presents a straightforward and effective technique that facilitates CRPP, minimizing the operative time and complications associated with this surgical approach (►**Table 2**).

The utilization of CRPP encounters two main challenges: 1) reduction, as controlling the proximal fragment becomes quite challenging due to muscle forces, and 2) fixation, since achieving the required oblique entry angle for pins to traverse the fracture may pose difficulties.

The closed reduction maneuver involves the application of axial traction, abduction, and external rotation to the arm. However, inserting K-wires in this position presents significant challenges due to the oblique entry angle required to traverse the fracture in hard cortical bone. To overcome this difficulty, the use of a drill guide has been proposed to ensure a more secure wire anchoring. Nonetheless, it is common for the pins to skive when attempting a distal-to-proximal trajectory.[6] Based on our experience, we have found that percutaneously placing 2 2.0-mm Kirschner wires until reaching the fracture with the arm in adduction is easier than introducing the pins in the reduction position. Once the appropriate position of the pins is confirmed using fluoroscopy, a closed reduction of the fracture is performed, and the pins are advanced into the epiphysis. Traditionally, if this maneuver does not achieve satisfactory reduction, one would perform an open reduction with a deltopectoral

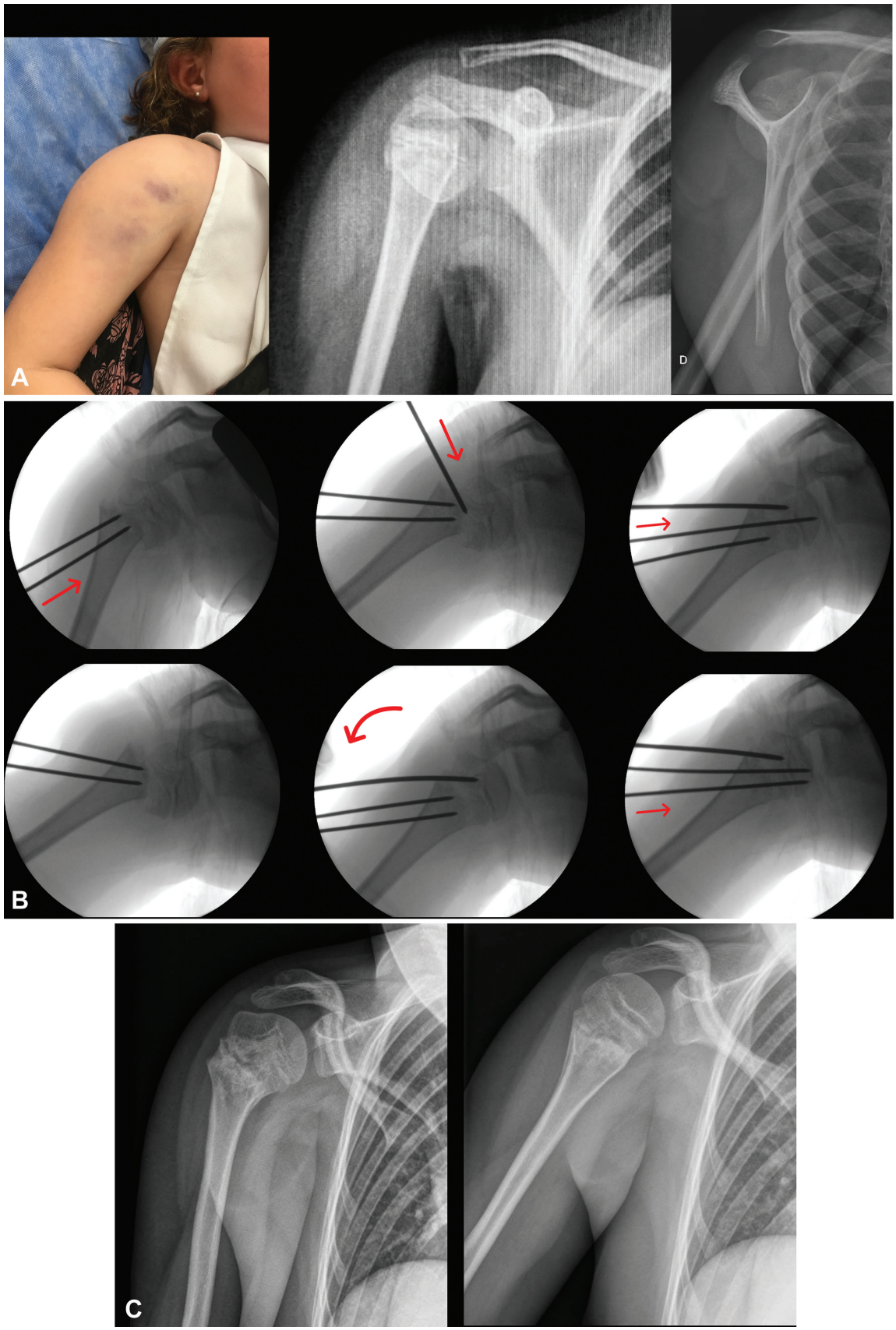


Fig. 1 A) Clinical image and radiographs at initial presentation. B) Fluoroscopic images during closed reduction and percutaneous pinning. C) Anteroposterior and lateral radiographs at 3 months follow-up.

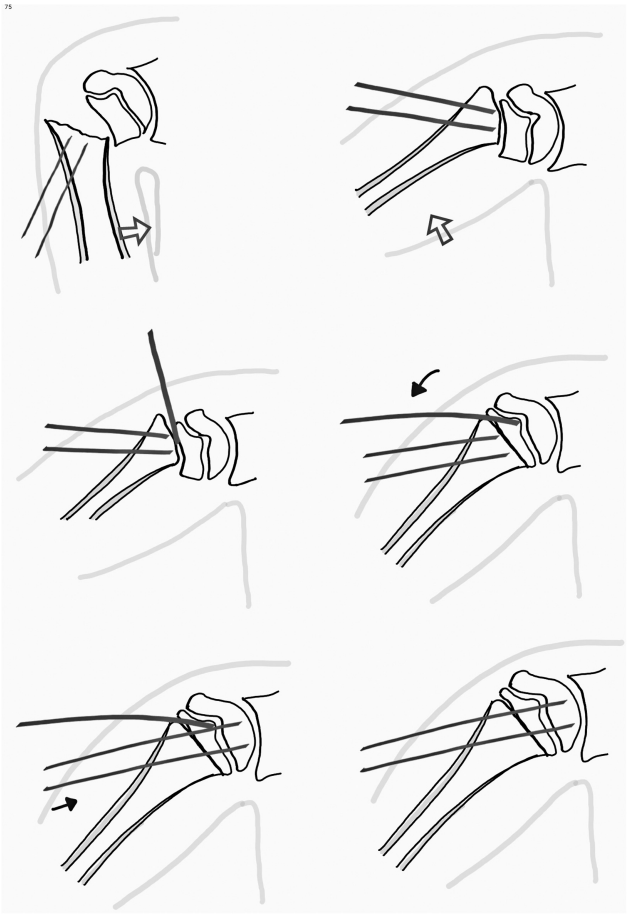


Fig. 2 Diagram showing the Kapandji-assisted closed reduction and percutaneous K-wire fixation for proximal humerus fractures.

Table 2 Recommendations on how to avoid common pitfalls in closed reduction and percutaneous pinning of proximal humerus fractures in adolescents

Pitfalls	How to avoid them
Axillary nerve injury	The nerve is located within 6 cm of the anterolateral aspect of the acromion, and the pins should be placed distal to this site
Articular surface penetration	Perform continuous fluoroscopy to assess the final position of the pins in all views
Loss of fixation	Perform continuous fluoroscopy for maximum internal and external rotation to assess stability
Skin necrosis	Evaluate the need of relaxing skin incisions at the site of pin insertion
Pin-site infection	Prophylactic antibiotics, pin care, and close observation

approach, which is not without risks. In our proposed technique, in situations in which the reduction is inadequate with closed maneuvers, a 2.5-mm Steinmann pin is employed to assist with the reduction using a Kapanji-type maneuver. This technique can aid in achieving proper alignment of the fracture avoiding an open reduction. Recently, Goldstein et al.[6] proposed the use of a blunt hemostat for similar purposes. This tool provides safe access to the fracture site, leverages the cortex of the distal fragment, and translates it to align with the proximal humerus.

Final Considerations

In summary, the majority of proximal humerus fractures in the pediatric-adolescent population can be managed without surgery owing to its remarkable remodeling potential. However, in cases in which angulation and displacement exceed the acceptable limits, our CRPP technique can provide a reliable approach for achieving satisfactory reduction and stable fixation. This method offers a reproducible means to address fractures that require surgical intervention.

Ethics Committee

The surgical technique type of study does not require IRB approval in our institutions.

Financial Support

The authors declare that they have not received financial support from public, private, or non-profit sources for the conduction of the present study.

Conflict of Interests

The authors declare that there is no conflict of interests.

References

1 Peterson CA, Peterson HA. Analysis of the incidence of injuries to the epiphyseal growth plate. J Trauma 1972;12(04):275–281
2 Dobbs MB, Luhmann SL, Gordon JE, Strecker WB, Schoenecker PL. Severely displaced proximal humeral epiphyseal fractures. J Pediatr Orthop 2003;23(02):208–215
3 Pahlavan S, Baldwin KD, Pandya NK, Namdari S, Hosalkar H. Proximal humerus fractures in the pediatric population: a systematic review. J Child Orthop 2011;5(03):187–194
4 Swarup I, Hughes MS, Bram JT, Horn BD, Ganley TJ. Percutaneous pinning of pediatric proximal humeral fractures. JBJS Essential Surg Tech 2019;9(04):e33.1–e33.6
5 Kim AE, Chi H, Niknam K, Swarup I. Management of Pediatric Proximal Humerus Fractures: Current Concept Review. JPOSNA 2023;5(01):1–12. Available from: https://www.jposna.org/index.php/jposna/article/view/580
6 Goldstein S, Swarup I, Noonan KJ. Percutaneous fixation of pediatric proximal humerus fractures: Master's surgical technique. JPOSNA 2023;5(02):1–10. Available from: https://www.jposna.org/index.php/jposna/article/view/703

Long-term Survival of Hip Cement Spacer: A Case Report

Sobrevida em longo prazo do espaçador cimentado para quadril: Relato de caso

Roshan Jacob[1] Mackenzie Sowers[1] Kelly Chandler[1] Mihir Patel[1] Ashish B. Shah[1] Sameer Mahadeorao Naranje[1]

[1] Department of Orthopedic Surgery, University of Alabama at Birmingham, Birmingham, Alabama, United States

Rev Bras Ortop 2024;59(6):e793–e796.

Address for correspondence Sameer Mahadeorao Naranje, MD, Department of Orthopedic Surgery, University of Alabama at Birmingham, 1313 13th Street South, Birminhgham, AL 35205, United States (e-mail: snaranje@uabmc.edu).

Abstract

We present a unique case of a 56-year-old male patient who ambulated on a hip cement spacer for 11 years. After hemiarthroplasty after a motor vehicle accident, the patient developed periprosthetic joint infection (PJI) several years later, and underwent stage-1 revision. With the resolution of the infection after stage 1, the patient refused the second stage due to satisfaction with the cement spacer for nearly 11 years.
To our knowledge, this is the longest reported case of a cement spacer remaining in an ambulating patient. This case demonstrates the mechanical reliability of metal-reinforced cement spacers, which can remain for long periods in selected patients.

Keywords
- arthroplasty, replacement, hip
- bone cements
- hip joint
- hip prosthesis
- prosthesis-related infections

Resumo

Apresentamos um caso único de um homem de 56 anos que deambulou com um espaçador cimentado para quadril durante 11 anos. Após ser submetido a uma hemiartroplastia em virtude de um acidente de carro, o paciente desenvolveu uma infecção articular periprotética (IAP) vários anos depois, sendo submetido à técnica de revisão da etapa 1. Com a resolução da infecção depois da etapa 1, o paciente recusou a segunda etapa, devido à satisfação com o espaçador cimentado por quase 11 anos.
Pelo que sabemos, este é o caso mais longo relatado de um espaçador cimentado em um paciente deambulando. Este caso demonstra a confiabilidade mecânica dos espaçadores cimentados reforçados com metal que podem ser mantidos por um prazo longo em pacientes selecionados.

Palavras-chave
- articulação do quadril
- artroplastia de quadril
- cimentos ósseos
- infecções relacionadas às próteses
- prótese de quadril

Work carried out at the Department of Orthopedic Surgery, University of Alabama at Birmingham, Birmingham, Alabama, United States.

received
December 7, 2020
accepted
February 11, 2021

DOI https://doi.org/10.1055/s-0041-1736341.
ISSN 0102-3616.

© 2021. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Introduction

While total hip arthroplasty (THA) is considered one of the most performed and successful elective surgeries in the United States, periprosthetic joint infection (PJI) is a devastating complication due to the reoperation and readmission necessary to treat the infection.[1] While the most frequently used technique to treat infected hip arthroplasty in the United States is two-stage revision using antibiotic-impregnated cement with an antibiotic spacer, the management of PJI and the treatment options should be individualized according to the needs of each patient.[2]

The purpose of the antibiotic spacer is to provide a higher concentration of medication directly around the area of infection, and this is achieved by placing a drug-eluting femoral stem with antibiotic-impregnated cement.[2] This is intended as a temporary measure, as cement hip spacers have been reported to have a dislocation rate of 7% and a fracture rate of 2%.[2] However, newer, prefabricated metal-reinforced spacers have been shown to have much higher mechanical strength, with spacer fracture reports as low as 0% in several studies.[3–6] The goal of reporting the present case is to describe and discuss the long-term results of an articulating hip spacer placed due to PJI, after which the patient continued to have full function of his hip for over 11 years before the second-stage revision. To our knowledge, this is the longest reported case of a retained spacer in a patient being treated for PJI.

Case Report

A 56-year-old morbidly obese male patient with a history of left hip fracture and hemiarthroplasty who presented with new hip pain. He had been involved in a motor vehicle collision (MVC) 25 years prior, and had undergone left hip hemiarthroplasty at another institution (►**Fig. 1**). The patient lived with pain for 14 years until he developed signs of PJI, presenting with elevated erythrocyte sedimentation rate (ESR, 36 mm/h) and elevated C reactive protein (CRP, 25 mg/L), and eventual sinus and drainage. After discussion, the patient agreed to undergo two-stage hip revision.



Fig. 1 Anteroposterior radiograph of the pelvis showing a hemiarthroplasty 14 years after surgery.

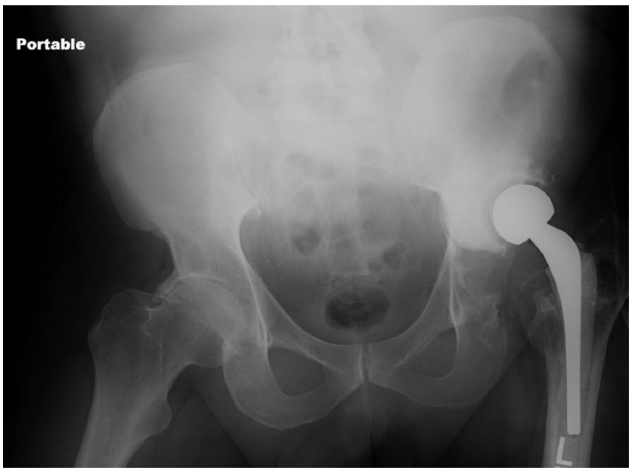


Fig. 2 Anteroposterior radiograph of the pelvis showing a Prostalac spacer immediately following stage-1 revision.

Using a posterior approach, an antibiotic cement and polytheline liner were placed without reaming on the acetabular side after cleaning and debriding it. Extraction of the femoral stem and head was performed with no bone loss, and the femoral canal was reamed and cleared of debris distally. After irrigation and debridement, the femoral canal was broached, and a size 3 Prostalac (Depuy-Synthes, Warsaw, IN, US) antibiotic cement stem and appropriately-sized head was placed. After hip reduction, a Hemovac drain (Zimmer Biomet, Warsaw, IN, US) was placed, and the wound was closed in a standard manner. There were no surgical complications (►**Fig. 2**). A microbiology report of fluid taken during surgery revealed *Staphylococcus lugdunensis* with no organisms isolated from blood samples.

The patient experienced gradual resolution of the infection and pain postoperatively after the appropriate antibiotic treatment. Over the following years, he continued his daily activities, including hunting and fishing. The patient refused the second stage of the revision as he was satisfied with the spacer. Eleven years later, he returned to the clinic complaining of pain in his left hip. He did not complain of any drainage or fevers. An imaging exam revealed loosening of the femoral component, and the patient agreed to second-stage revision of the THA (►**Fig. 3**). ESR (5 mm/h) and CRP (1.62 mg/L) returned to within normal limits before spacer removal, with no elevation in the white-cell count, satisfying the criteria by Parvizi et al.[7] for absence of PJI.

A classic posterior approach was used. The stem and liner were loose and removed uneventfully. There was no evidence of bone loss (type I in the Paprosky classification). The acetabulum was reamed, and an appropriately-sized revision cup was secured with multiple screws. The remaining bone deficit was filled with antibiotic cement. The femur was prepared using the standard technique for modular revision stem. An appropriately-sized modular stem and metal head were placed and easily implanted eith the use of the standard technique after initially performing a trial reduction. The hip reduced, and the wound was closed using the standard

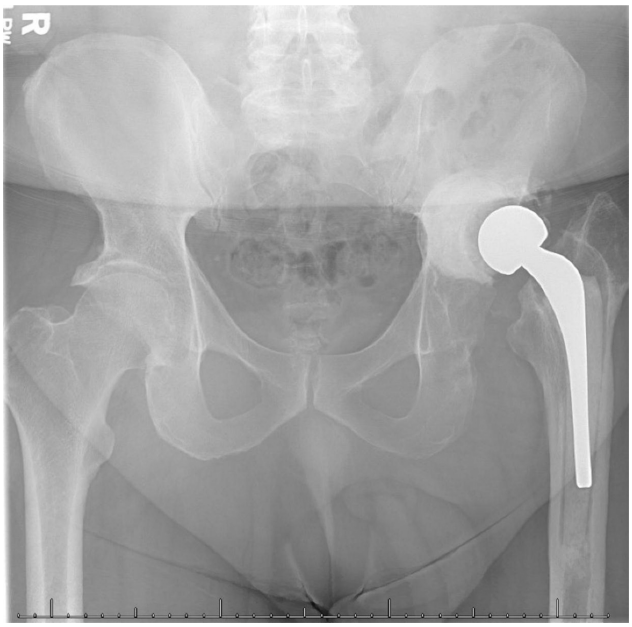


Fig. 3 Anteroposterior radiograph of the pelvis showing a Prostalac spacer retained for 11 years.

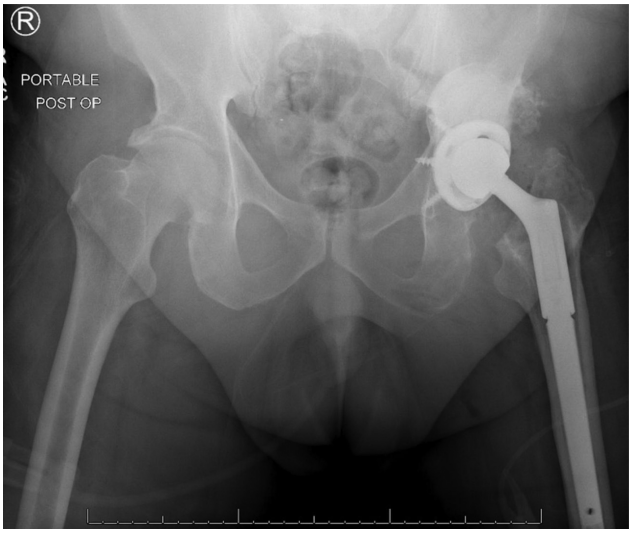


Fig. 4 Anteroposterior radiograph of the pelvis showing a total hip arthroplasty as stage-2 revision.

technique. The microbiology reports showed no organism growth from the cultures obtained intraoperatively. Upon his most recent follow-up, three months postoperatively, the patient was ambulating with no pain, no drainage from his operated hip, and no discrepancy regarding leg length (►**Fig. 4**).

Informed consent was obtained from the patient whose case is herein reported.

Discussion

While two-stage revision is the preferred technique for the management of PJI of the hip, the cement hip spacer is not considered the definitive implant in terms of long-term survival. These spacers are intended for short-term use only, until the infection is controlled. However, in the present case report, we discuss how a temporary cement hip spacer was tolerated by the patient over a long period of time (eleven years).

Mechanical strength and fixation are the greatest weak points of the cement hip spacer. A study[8] involving 35 patients with a median age of 56, with surgeon-made articulating polymethylmethacrylate (PMMA) spacers, showed a mechanical failure rate (subsidence or fracture) of 45% ($n = 14$), with an average period of 14.5 weeks between procedures. Spacer dislocation occurred in 19% of the patients ($n = 6$). The authors also found that failure rates were significantly higher in younger individuals due to the higher demand placed on the spacer.[8] Recently, surgeons have moved to using prefabricated spacers instead of surgeon-made PMMA spacers due to the superior results.[3,4,8] Prostalac spacers in particular have shown excellent mechanical stability in several studies, with several reports of these spacers maintaining stability for up to 6 years.[5,6,9–11] The patient presented here had a Prostalac stem and a polyethylene liner that maintained mechanical stability, and the patient maintained mobility for up to 11 years on the stem, without signs of stem fracture or dislocation.

In a retrospective study[11] on unplanned retained spacers, the authors reviewed 11 hips that had undergone stage 1 of the revision. Of these patients, 9 remained free of complications, while 1 patient experienced reinfection at 24 months, and the second patient developed aseptic subsidence at 72 months. The mean follow-up for the remaining 9 patients was of 48 months, during which they had no spacer-related complaints and wished to delay surgery.[11]

In a separate study[6] following 25 patients with 2-year follow-up for Prostalac spacer revision, the authors found no spacer-related complications, with 68% of the patients not having undergone reimplantation at 24 months. The patients that did undergo revision in this period were younger, more physically demanding patients. It appears that a large proportion of patients can remain with a spacer for several years without serious complications. Given that many of these patients have comorbidities and contraindications to surgery, this gives both the patient and surgeon an alternate to reimplantation in high-risk cases.

To our knowledge, this is the longest reported case of a retained, prefabricated hip spacer for PJI. We suggest that these spacers can remain in selected patients with good functional long-term results. This is beneficial, as it gives surgeons a wider scope of options when it comes to treating higher-risk patients who are not suitable or unwilling to have the second-stage procedure.

Financial Support
The authors declare that there was no financial support from public, commercial, or non-profit sources.

Conflict of Interests
The authors have no conflict of interests to declare.

References

1 Gundtoft PH, Pedersen AB, Varnum C, Overgaard S. Increased Mortality After Prosthetic Joint Infection in Primary THA. Clin Orthop Relat Res 2017;475(11):2623–2631

2 Charette RS, Melnic CM. Two-Stage Revision Arthroplasty for the Treatment of Prosthetic Joint Infection. Curr Rev Musculoskelet Med 2018;11(03):332–340

3 Citak M, Masri BA, Springer B, Argenson J-N, Kendoff DO. Are Preformed Articulating Spacers Superior To Surgeon-Made Articulating Spacers in the Treatment Of PJI in THA? A Literature Review. Open Orthop J 2015;9:255–261

4 D'Angelo F, Negri L, Binda T, Zatti G, Cherubino P. The use of a preformed spacer in two-stage revision of infected hip arthroplasties. Musculoskelet Surg 2011;95(02):115–120

5 Scharfenberger A, Clark M, Lavoie G, O'Connor G, Masson E, Beaupre LA. Treatment of an infected total hip replacement with the PROSTALAC system. Part 1: Infection resolution. Can J Surg 2007;50(01):24–28

6 Beaupre LA, Stampe K, Masson E, et al. Health-related quality of life with long-term retention of the PROSthesis of Antibiotic Loaded Acrylic Cement system following infection resolution in low demand patients. J Orthop Surg (Hong Kong) 2017;25(02): 2309499017716257

7 Parvizi J, Tan TL, Goswami K, et al. The 2018 Definition of Periprosthetic Hip and Knee Infection: An Evidence-Based and Validated Criteria. J Arthroplasty 2018;33(05):1309–1314.e2

8 Yang FS, Lu YD, Wu CT, Blevins K, Lee MS, Kuo FC. Mechanical failure of articulating polymethylmethacrylate (PMMA) spacers in two-stage revision hip arthroplasty: the risk factors and the impact on interim function. BMC Musculoskelet Disord 2019;20(01):372

9 Regis D, Sandri A, Magnan B, Bartolozzi P. Six-year follow-up of a preformed spacer for the management of chronically infected total hip arthroplasty. Arch Orthop Trauma Surg 2010;130(09): 1111–1115

10 Luk MH, Ng FY, Fu H, Chan PK, Yan CH, Chiu KY. Retention of prosthetic articulating spacer after infected hip arthroplasty as a semipermanent implant: A case report. J Orthop Trauma Rehabil 2019;26(02):105–107

11 Choi H-R, Freiberg AA, Malchau H, Rubash HE, Kwon Y-M. The fate of unplanned retention of prosthetic articulating spacers for infected total hip and total knee arthroplasty. J Arthroplasty 2014;29(04):690–693

Van Neck-Odelberg Disease — A Rare or Underdiagnosed Condition?

Doença de Van Neck-Odelberg — Entidade rara ou subdiagnosticada?

Mafalda Moreira[1] Diana Alba[1] Hélder Nogueira[1] Sandra Teixeira[1]

[1] Pediatrics and Neonatology Service, Centro Hospitalar do Tâmega e Sousa, Penafiel, Portugal

Address for correspondence Mafalda Moreira, Pediatrics Resident, Centro Hospitalar do Tâmega e Sousa, Porto, Portugal (e-mail: mafalda.moreira@campus.ul.pt).

Rev Bras Ortop 2024;59(6):e797–e800.

Abstract

Van Neck-Odelberg (VNO) disease is a rare osteochondrosis affecting the ischiopubic synchondrosis (IPS). This condition should be included in the differential diagnosis of children with lameness, inguinal pain, and functional limitation of the hip. In imaging tests, it is characterized by asymmetric IPS hypertrophy. We present the clinical case of a 4-year-old child, previously healthy, who visited the emergency department for left inguinal pain and lameness starting on the same day. There was no previous history of trauma or changes in inflammatory parameters. The patient underwent a pelvic radiography and magnetic resonance imaging (MRI), which revealed a radiopaque image with well-defined contours in the left ischiopubic branch, and IPS swelling. With a presumed diagnosis of VNO disease, the patient was medicated symptomatically, with complete recovery in 10 days. Lameness is a frequent reason for medical evaluation in the pediatric population. In subjects up to 5 years old, the most common causes of lameness include transient hip synovitis, septic arthritis, and Legg-Calvé-Perthes disease. In the absence of a history of trauma or infection-related clinical findings, VNO disease should be considered as a hypothesis. Its diagnosis requires a pelvic radiography, usually showing a unilateral fusiform opacification at the ischial level; an MRI may be necessary. The recommended treatment is conservative, with symptomatic recovery in 2 weeks. The knowledge and diagnosis of VNO disease allow a targeted approach, without the emotional burden for the patient and his/her family that may be associated to other conditions.

Keywords

- child
- intermittent claudication
- osteochondrosis

Resumo

A doença de Van Neck-Odelberg (VNO) é uma osteocondrose rara, que acomete a sincondrose isquiopúbica (SIP). Esta entidade deve ser incluída no diagnóstico

Work carried out at the Centro Hospitalar do Tâmega e Sousa, Penafiel, Portugal.

received
December 14, 2020
accepted
February 11, 2021

DOI https://doi.org/10.1055/s-0041-1739402.
ISSN 0102-3616.

© 2022. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

diferencial de crianças com claudicação na marcha, dor inguinal e limitação funcional do quadril. Imagiologicamente é caracterizada por hipertrofia assimétrica da SIP. Apresentamos o caso clínico de uma criança de 4 anos, previamente saudável, atendida no serviço de emergência devido a dor inguinal no lado esquerdo e claudicação na marcha com início no mesmo dia. Não havia história prévia de trauma ou alteração dos parâmetros inflamatórios. Foi realizada uma radiografia da bacia e ressonância magnética nuclear (RMN) que evidenciou imagem radiopaca de contornos bem definidos no ramo isquiopúbico esquerdo e edema na SIP. Com diagnóstico provável de doença de VNO, o paciente foi medicado sintomaticamente, com resolução completa ao fim de 10 dias. A claudicação na marcha é um motivo frequente de avaliação médica na população pediátrica. Até os 5 anos de idade, as causas mais comuns são sinovite transitória do quadril, artrite séptica e Doença de Legg-Calvé-Perthes. Na ausência de história de trauma ou clínica sugestiva de infeção deverá ser equacionada a hipótese de doença de VNO. Para o seu diagnóstico, é fundamental a realização de radiografia da bacia, cujo achado mais comum é uma opacificação fusiforme unilateral, no nível do ísquion, podendo ser necessária a realização de RMN. O tratamento recomendado é conservador, com recuperação sintomática em 2 semanas. O conhecimento e o diagnóstico desta entidade permitem uma abordagem direcionada e sem a carga emocional para o paciente e seus familiares que outras patologias poderiam transmitir.

Palavras-chave
- claudicação intermitente
- criança
- osteocondrose

Introduction

Osteochondrosis, also called osteochondritis by some authors, results from changes in endochondral ossification at the level of developing bone nuclei at epiphyses and apophyses.[1,2] Although its etiology remains unknown, vascular and microtraumatic changes seem to be play a role.[2] Osteochondrosis predominates in childhood and adolescence, and it is associated with growth spurts and hormonal changes. The most frequent osteochondroses include Köhler disease, Freiberg disease, Sever disease, and Osgood-Schlatter disease; in contrast, ischiopubic osteochondritis, or Van Neck-Odelberg (VNO) disease, is a rarely diagnosed osteochondrosis.[1]

The first description of ischiopubic osteochondritis was made in 1923 by Van Neck, and later complemented by Odelberg in 1924; as such, it is known today as Van Neck-Odelberg disease.[3,4] It is a benign, self-limiting condition characterized by imaging evidence of asymmetric ischiopubic synchondrosis (IPS) hypertrophy, associated with lameness, unilateral inguinal pain, and functional limitation of the hip.[3,4] The differential diagnoses list include stress fracture, infectious conditions (i.e., osteomyelitis), or neoplastic diseases; some cases require magnetic resonance imaging (MRI) for diagnosis.[3,5,6]

Case Report

A 4-year-old girl, otherwise healthy, visited the emergency department with lameness and left inguinal pain for 24 hours, with progressive worsening. She presented no fever, constitutional symptoms, or local inflammatory signs. There was no previous history of trauma or recent infectious complications. An objective examination revealed pain during hip mobilization, with no local inflammatory signs.

An analytical study, including complete blood count, erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP), revealed no major changes. A pelvic radiography showed a radiopaque image, about 1.8×1.4 cm in size, with well-defined contours, at the level of the left ischiopubic branch (►**Figs. 1** and **2**). For etiological clarification, an MRI of the pelvis was performed, which showed edema at the level of the left ischiopubic synchondrosis, with no abnormalities in the adjacent soft tissues (►**Fig. 3**).



Fig. 1 Radiography of the pelvis (anteroposterior view), revealing a radiopaque image at the level of the left ischiopubic branch, with well-defined contours.



Fig. 2 Radiography of the pelvis (outlet view).

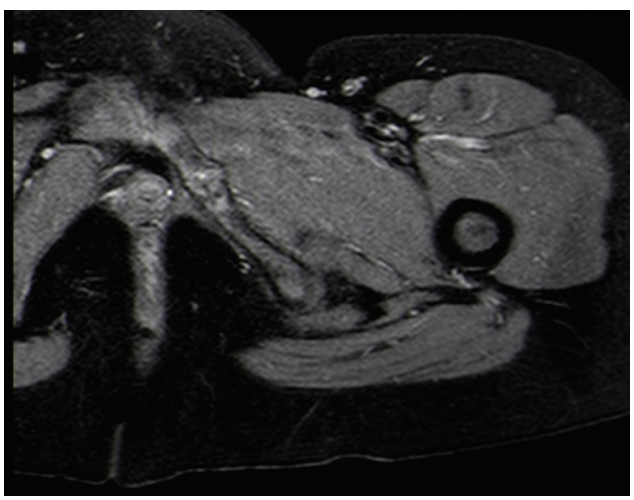


Fig. 3 Magnetic resonance imaging of the pelvis, revealing edema at the level of the left ischiopubic synchondrosis.

Excluding the hypotheses of infectious or tumoral etiology, a diagnosis of VNO disease was presumed. The patient was symptomatically medicated with oral antiinflammatory and rest. Ten days later, she was reassessed clinically, with no complaints.

A radiograph of the pelvis was repeated 6 months later and showed complete remodeling of the lesion area (►**Fig. 4**). The patient presented no new episodes.

Discussion

Lameness is a frequent complaint in the pediatric population. Its differential diagnosis is very challenging due to the multiple potential etiologies, which vary according to the age group. In children with unilateral inguinal pain and limited hip mobility but no fever, history of trauma, or recent infections, VNO disease is an important consideration.[6]



Fig. 4 Radiography of the pelvis (anteroposterior view), revealing complete recovery.

This condition results from the asymmetric ossification process of the IPS, which usually begins in childhood and ends before adolescence.[5] In most cases, it does not cause symptoms. However, some children may present inguinal or gluteal pain and joint mobility limitation.

Van Neck-Odelberg disease is usually more frequent in the non-dominant lower limb, mostly the left one, as in the case of our patient. Some authors believe that this is due to body weight support mainly by the non-dominant lower limb compared to the contralateral one, which is used preferentially for movement execution.[3,5] This force imbalance may delay the IPS closing at the non-dominant side, which, due to mechanical stress, may become painful.[3,5]

Van Neck-Odelberg osteochondritis is a diagnosis of exclusion in children with lameness.[6] Its diagnosis requires a pelvic radiography, which often reveals a unilateral fusiform opacification at the ischial level. Since IPS hypertrophy can mimic a tumor, an MRI is useful for differential diagnosis.[7] Although it is not a diagnostic criterion for VNO disease, the lack of increased levels of inflammatory parameters, that is, leukocytes, CRP, and ESR, supports this hypothesis.[6,8]

Conservative treatment is the most frequently recommended option, and it consists in antiinflammatory therapy and rest. It is associated with a favorable clinical evolution and disappearance of complaints in about 2 to 3 weeks.[3,5,8] Imaging resolution is more prolonged and may take from several months to 1 year.[3] When ossification is complete, the ischiopubic junction deformity disappears. It is important to note that radiological findings of delayed IPS fusion in

asymptomatic children do not result in an ischiopubic osteochondritis diagnosis.[5]

On the other hand, VNO disease knowledge and diagnosis as a benign, self-limited condition, allow a targeted approach, without the emotional burden for the patient and his/her family that may be associated to other conditions.

Financial Support
The authors declare that there was no financial support from public, commercial, or non-profit sources.

Conflict of Interests
The authors declare that there is no conflict of interests.

References

1 Danger F, Wasyliw C, Varich L. Osteochondroses. Semin Musculoskelet Radiol 2018;22(01):118–124
2 West EY, Jaramillo D. Imaging of osteochondrosis. Pediatr Radiol 2019;49(12):1610–1616
3 Chaudhari AP, Shah G, Patil SS, Ghodke AB, Kelkar SB. Van Neck-Odelberg Disease: A Rare Case Report. J Orthop Case Rep 2017;7 (01):24–27
4 Akkari M, Waisberg G, Reis Braga S, et al. Osteocondrite de Van Neck-Odelberg. Relato de 4 casos. Rev Bras Ortop 2010; 45:55–58
5 Oliveira F. Differential diagnosis in painful ischiopubic synchondrosis (IPS): a case report. Iowa Orthop J 2010;30(Suppl):195–200
6 Ferreira J. Van Neck-Odelber Disease: a rare cause of childhood limping. Nascer Crescer 2019;28(04):223–227
7 Morante Bolado I, Ortega Navaridas M, Clemente Garulo D, López Robledillo JC. Enfermedad de Van Neck-Odelberg: una causa más de cojera en la infancia. Reumatol Clin 2017;13(05): 299–300
8 Wait A, Gaskill T, Sarwar Z, Busch M. Van neck disease: osteochondrosis of the ischiopubic synchondrosis. J Pediatr Orthop 2011;31(05):520–524

Total Duplication of the Femur: Case Report with 23 Years Follow-up

Duplicação total do fêmur: Relato de caso com 23 anos de seguimento

Rafael Garcia de Oliveira[1] Giampaulo Marcelo Catelan[1] Cicero Ricardo Gomes[1]

[1] Department of Orthopedics, Rede Sarah de Hospitais de Reabilitação, Brasília, Federal District, Brazil

Rev Bras Ortop 2024;59(6):e801–e804.

Address for correspondence Rafael Garcia de Oliveira, MD, Rede Sarah de Hospitais de Reabilitação, SMHS 501, Bloco A, Brasília, Distrito Federal, 70.335-901, Brazil (e-mail: rafagaroli@gmail.com).

Abstract

Femur duplication is very rare, and the few cases described are of partial, proximal or distal duplications. Based on our literature review, the present is the first report of a case of total duplication. The patient was followed up, without surgical treatment, for 23 years. At the last visit, the patient complained of low-back pain and marked discrepancy in the lower limbs. A clinic-radiographic evaluation showed a right knee with two separate femoral condyles that articulated with the proximal tibia, a hyporadioactive patella, and a limitation in knee flexion at 95°. The patient presented lower-limb dysmetria, measuring 17 cm, resulting in pelvic obliquity and dextroconvex scoliosis. The patient received a 16 cm orthoprosthesis that improved the gait pattern and resolved the complaint of low-back pain.

Keywords
- dysmetria
- femur
- limb deformities, congenital
- scoliosis

Resumo

A duplicação do fêmur é raríssima, e os poucos casos descritos são de duplicações parcial, proximal ou distal. Segundo a nossa revisão de literatura, esse é o primeiro relato de duplicação total. O paciente foi acompanhado, sem tratamento cirúrgico, por 23 anos. Na última visita, queixava-se de dor lombar marcada discrepância dos membros inferiores. A avaliação clínico-radiográfica mostrava um joelho direito com dois côndilos femorais separados que se articulavam com a tíbia proximal e uma patela hipoplásica, e limitação da flexão do joelho em 95°. O paciente apresentava dismetria dos membros inferiores medida em 17 cm, o que resultava em obliquidade pélvica e escoliose dextroconvexa. O paciente recebeu uma ortoprótese de 16 cm que trouxe melhora do padrão de marcha e resolução da queixa de lombalgia.

Palavras-chave
- deformidades congênitas dos membros
- dismetria
- escoliose
- fêmur

Work carried out at the Department of Orthopedics, Rede Sarah de Hospitais de Reabilitação, Brasília, Federal District, Brazil.

received
December 21, 2020
accepted
May 14, 2021

DOI https://doi.org/10.1055/s-0041-1735139.
ISSN 0102-3616.

© 2021. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Introduction

Congenital short femur is the most common femoral deformity. Some authors have described rare cases of distal femoral bifurcation, which is characteristic of the Gollop-Wolfgang complex, a rare genetic syndrome usually associated with deformities of the ipsilateral limb, such as tibial aplasia, hypoplasia, or congenital talipes equinovarus, most commonly known as clubfoot.[1–4] There was also a case of proximal femoral duplication reported in 2009; however, total femoral duplications have never been described in the literature.

Case Report

A patient was evaluated At the Orthopedics Department of Rede Sarah de Hospitais de Reabilitação, in Brasília, the Federal District of Brazil, at 35 days of life due to an abnormal esthetic appearance and shortening of the right lower limb. He was the second child of a healthy mother, the result of an uncomplicated pregnancy, born at term and without identifiable risk factors for congenital anomalies. There were no known relatives with deformity in the limbs or relevant genetic history. The right limb was 3 cm shorter and slightly thinner, and the reduction in length was concentrated in the femur, while the tibias and feet were symmetrical and without deformities (►**Fig. 1**). The hips and knees presented regular and symmetrical range of motion on the contralateral side. There were no findings in the renal, cardiovascular, gastrointestinal and nervous systems; and no upper-limb malformations were observed. The boy had a normal global neuropsychomotor development, and began walking at 14 months.

At 1 year of age, a radiograph showed total duplication of the femur. In the proximal region, the medial femur articulated in the hip without abnormalities, despite a certain valgus of the femoral neck (►**Fig. 2**), and the lateral femur was at the level of the greater trochanter. The proximal epiphysis of the right tibia was hypoplasic and tilted towards the medial femur. The fibula showed no obvious deformities. A radiographic evaluation of the spine showed no deviations or congenital anomalies.

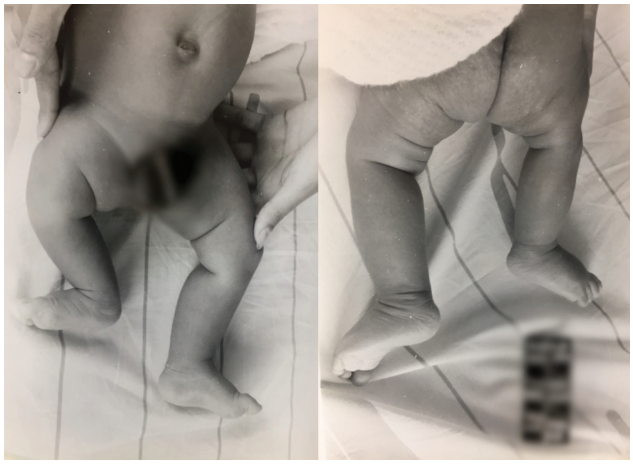


Fig. 1 Patient at 35 days of life, presenting discrepancy between the limbs, with the right limb being the shortest.

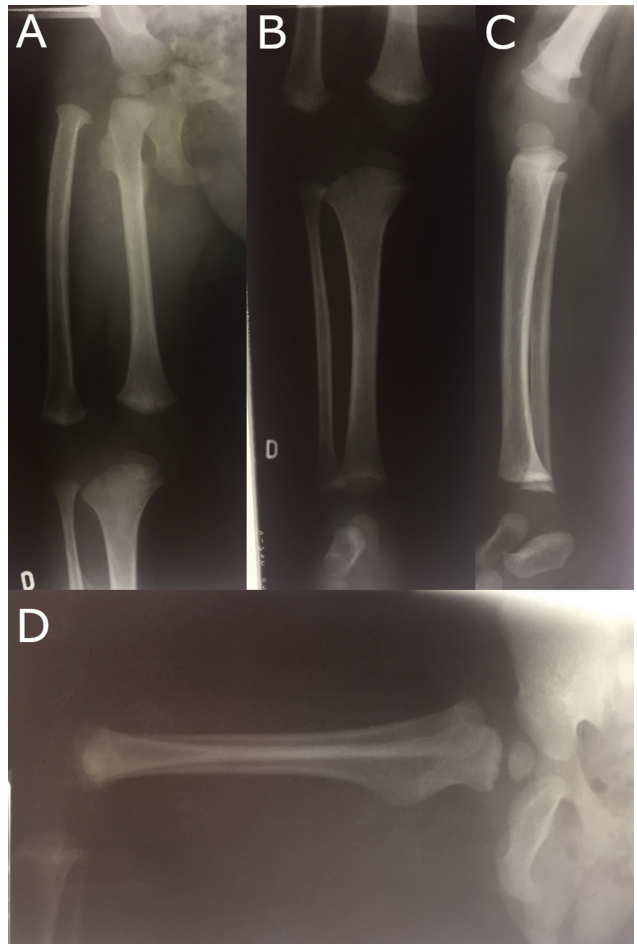


Fig. 2 Radiograph at 1 year of age. (**A**) Right hip and right femur in anteroposterior (AP) view. (**B**) Distal femur and tibia in AP view. (**C**) Distal femur and tibia in profile view. (**D**) Right hip and femur in profile view.

The next consultation took place at the age of 3; at that time, the discrepancy in the lower limbs had increased to 6 cm (►**Fig. 3**). There was a loss in the range of knee flexion



Fig. 3 Clinical images of the patient at 3 years of age, showing 6 cm of discrepancy in the length of the legs.



Fig. 4 Clinical images of the patient at 23 years of age, showing 17 cm of discrepancy in the length of the legs.

on the right side, which was between 0° and 70°. While walking, the patient kept his right foot in equine position (reducible) and his left knee semi-flexed to compensate for the discrepancy.

Radiographs showed the presence of distal epiphysis in the medial femur, and the proximal epiphysis of the tibia kept its development concentrated on the medial side. Using the multiplier method to predict length at 3 years of age, the expected discrepancy would be of 13.4 cm in skeletal maturity. The patient adapted well to a shoe compensation of 5 cm. After this visit, the patient did not return for the next 20 years.

In August 2016, at the age of 23, the patient sought new care. His main concern was the discrepancy in the lower limbs and sporadic low-back pain. He did not use any compensation, and external rotation of the limb was observed at the expense of the hip/femur, and, during gait, he kept his left knee semi-flexed and the right foot in an equine position. In addition, there was evident scoliosis with convexity on the right and pelvic obliquity (►**Fig. 4**). On the right, the flexion-extension motion of the knee ranged from 0° to 95°, and the motion of hip ranged from -20° to 45°, compared to -30° to 90° on the left side.

A radiograph showed a femoral neck valgus to the right with a normal hip joint, one knee with two separate femoral condyles that articulated with the proximal tibia, and a hypoplasic patella (►**Fig. 5**). The talar dome presented a spherical configuration that articulated with a concave surface in the tibia, forming a ball-and-socket ankle. The radiographic measurements in orthostatism were of 67 cm (femur: 33 cm; tibia: 34 cm) on the right side, and of 84 cm (femur: 46 cm; tibia 38 cm) on the left side, revealing a discrepancy of 17 cm, similar to the clinical measure.



Fig. 5 Radiograph in AP view of the lower limbs at 23 years of age. The image shows right-hand valgus femoral neck with normal hip joint, one knee with two separate femoral condyles articulating with the proximal tibia, and a hypolabic patella. The talar dome has a spherical aspect articulating with a concave surface on the tibia, forming a ball-and-socket ankle. The right lower limb measures 67 cm (femur: 33 cm; tibia 34 cm), and left limb, 84 cm (femur: 46 cm; tibia 38 cm).

A magnetic resonance imaging (MRI) scan showed femoral condyles with irregular surface, and thin cartilage in the posterolateral part of the lateral condyle and in the anteromedial part of the medial condyle. There are meniscal contours, predominantly in the anterior part of the lateral and posterior compartments of the medial compartment. A low signal structure is identified in intra-articular topography with an oblique path, inserted in the medial face of the lateral femoral condyle and in the posterior tibial plateau.

After receiving a 16-cm orthoprosthesis, there was resolution of the complaint of low-back pain.

Discussion

The present is the first report in the literature of a case of total duplication of the femur leading to the formation of a peculiar knee. In the images, one can observe the evolution of the condition from the first days after birth until adulthood. Despite the clinical repercussions of the great dysmetria, the patient presented good overall muscle development, and works as an assistant mason, an occupation with a high physical demand. After the use of the orthoprosthesis for three months, the patient reported complete improvement in low-back pain, and was completely asymptomatic at that time. Because of the anatomical structure of the knee, the authors did not consider any surgical approach, as a possible bone elongation could result in significant functional worsening. The treatment with an orthoprosthesis proved to be effective in restoring the patient's quality of life.

There have been few reports of distal femur bifurcation since Erlich's first description in 1889. In general, it occurs associated with other deformities of the ipsilateral limb, such as tibial aplasia, foot hypoplasia, and congenital talipes equinovarus, and it is characteristic of the Gollop-Wolfgang complex.[1–4] It may also be associated with upper-limb malformations.[5]

There are some theories about the etiology of isolated femoral bifurcation, and it is likely to be heterogeneous, as postulated by Bodurtha et al.[6] Embryological neuropathy can lead to a wide variety of abnormalities, depending on the nerves involved and their innervation. The growth of an organ or part of it is related to its nervous supply, due to its co-stimulating function of growth.

Ogden[3] reported a case of femoral bifurcation and ipsilateral tibial hemimelia. He proposed that femoral bifurcation resulted from the division of the mesoderm of the embryonic bud that originates the limb, resulting in an independent development of each of these halves. This division can be produced mechanically by the pressure of amniotic bands, leading to total or partial duplication of the limb.

Osuji et al.[7] reported a patient presenting proximal duplication of the femur who underwent excision of one of the heads and neck of the femur associated with a defeat osteotomy, Salter-type pelvic osteotomy, and adductor tenotomy due to the remaining 70° anteversion of the femoral head. Compared to the present case, complete excision of the femur was not an option, as the lateral part formed the lateral condyle of the femur, and the medial part, the head and neck of the femur.

As this patient was not submitted to surgical intervention, it is possible to observe the natural history of this unusual malformation over 23 years.

Ethical Statements

The present study was approved by the Ethics Committee of the Associação das Pioneiras Sociais (under CAAE process number: 34092620.0.0000.0022).

Financial Support

The authors declare that there was no financial support from public, commercial, or non-profit sources.

Conflict of Interests

The authors have no conflict of interests to declare.

References

1 Wolfgang GL. Complex congenital anomalies of the lower extremities: femoral bifurcation, tibial hemimelia, and diastasis of the ankle. Case report and review of the literature. J Bone Joint Surg Am 1984;66(03):453–458
2 Kotakemori K, Ito J. Femoral bifurcation with tibial aplasia. A case report and review of the literatures. Clin Orthop Relat Res 1978;(135):26–28
3 Ogden JA. Ipsilateral femoral bifurcation and tibial hemimelia. A case report. J Bone Joint Surg Am 1976;58(05):712–713
4 Dhanakodi N, Tripathy SK. Gollop-Wolfgang syndrome. Indian J Med Res 2014;139(06):963–964
5 Gollop TR, Lucchesi E, Martins RMM, Nione AS. Familial occurrence of bifid femur and monodactylous ectrodactyly. Am J Med Genet 1980;7(03):319–322
6 Bodurtha J, Coutinho M, Benator R, Nogi J, Sholley M, Nance WE. Femoral duplication: a case report. Am J Med Genet 1989;33(02):165–169
7 Osuji CK, Chafik D, Moseley CF. Unilateral proximal bifurcation of the femur. J Pediatr Orthop 2009;29(07):695–697

Smartphones: A New Source of Pain in the Wrist and Hand in the 21st Century – Letter Regarding the Study by Gonçalves et al.

Smartphones: *Uma nova fonte de dor no punho e na mão no século XXI – Carta sobre o estudo de Gonçalves et al.*

Sitanshu Barik[1] Vishal Kumar[2] Vikash Raj[3]

[1] All India Institute of Medical Sciences, Nagpur, India
[2] Postgraduate Institute of Medical Education and Research (PGIMER), Chandigarh, India
[3] All India Institute of Medical Sciences, Deoghar, India

Address for correspondence Sitanshu Barik, Department of Orthopedics, All India Institute of Medical Sciences (AIIMS), Devipur, Deoghar, 814112, India (e-mail: sitanshubarik@gmail.com).

Rev Bras Ortop 2024;59(5):e805.

Smartphones have become a part and parcel of the daily existence in our lives due to their multifunctional usefulness apart from normal phone features, which includes internet browsing, electronic mail, location services, camera, as well as third-party applications called "apps", which let the user perform a whole gamut of activities.[1] With this premise, the study by Gonçalves et al.[2] was read and analyzed with interest, and it aimed to investigate the long-term use of smartphones as a risk factor for the development of morbidities in the wrist and fingers. The study concluded that there is a significant correlation between the length of smartphone use and discomfort in the wrist and fingers.

The study included 100 subjects with a history of smartphone use for the past 5 years. Considering the prevalence of smartphone use, which is reported to be of approximately 79% of the population in the age group between 18 and 44 years, an adequate sample size in a prospective study like this may have yielded more interesting results with greater validity.[3]

The study used the Boston Carpal Tunnel Questionnaire (BCTQ) to assess the symptoms as well as the functional deficit in the included subjects. This patient-reported outcome measure (PROM) has been criticized since its functional scale does not cover activities related to computers or smartphones.[4] Since the study in question deals with the effects of smartphone use, the application of the BCTQ may have been inappropriate. The use of other validated tools, such as the Modified BCTQ, which contains two additional items related to electronic gadgets and driving, would have provided more valid results.

Studies with an adequate sample size calculated prospectively based on the prevalence rate of smartphone use along with the use of a PROM which encompasses the items related to smartphone use shall help us more in understanding the role of smartphones in the development of pain in the upper limb.

Conflict of Interests

The authors have no conflict of interests to declare.

References

1 Choi JS, Yi B, Park JH, et al. The uses of the smartphone for doctors: an empirical study from samsung medical center. Healthc Inform Res 2011;17(02):131–138
2 Gonçalves AMDS, Carmo VJGD, Araújo LMC, Pereira TMM. Use of Smartphones as a Risk Factor for the Development of Morbidities in the Wrist and Fingers. Rev Bras Ortop 2023;58(03):457–462
3 Mustafaoglu R, Yasaci Z, Zirek E, Griffiths MD, Ozdincler AR. The relationship between smartphone addiction and musculoskeletal pain prevalence among young population: a cross-sectional study. Korean J Pain 2021;34(01):72–81
4 Miedany Y. PROMs for Carpal Tunnel Syndrome. In: Miedany Y, ed. Patient Reported Outcome Measures in Rheumatic Diseases [Internet]. Cham: Springer International Publishing; 2016:329–355 [cited 2023 Sep 17]. Available from: Doi: 10.1007/978-3-319-32851-5_13

received
September 23, 2023
accepted
March 18, 2024

DOI https://doi.org/10.1055/s-0044-1787764.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

Letter to the Editor Regarding: "Padilha VH, et al. Lumbopelvic Muscle Mobility and Resistance and Their Association with Musculoskeletal Pain in Ballet Dancers. Rev Bras Ortop (São Paulo). 2023;58(3):410–416"

Carta ao editor referente a "Padilha VH, et al. Mobilidade e resistência muscular lombopélvica e associação com dor musculoesquelética em bailarinas. Rev Bras Ortop (São Paulo). 2023;58(3):410–416"

André Pontes-Silva[1]

[1] Postgraduate Program in Physical Therapy, Department of Physical Therapy, Universidade Federal de São Carlos, São Carlos, SP, Brazil

Rev Bras Ortop 2024;59(5):e806–e808.

Address for correspondence André Pontes-Silva, Programa de Pós-Graduação em Fisioterapia (PPGFT), Departamento de Fisioterapia (DFisio), Universidade Federal de São Carlos (UFSCar), Rodovia Washington Luís, Km 235, CEP 13565-905, São Carlos, SP, Brazil (e-mail: contato.andrepsilva@gmail.com).

In a study recently published in *Revista Brasileira de Ortopedia*, Padilha et al.[1] analyzed ankle and lumbopelvic muscle mobility, resistance, and factors associated with musculoskeletal pain in young ballet dancers. The main complaints reported by the ballet dancers were low back pain and lower extremity pain. Those with low back pain presented significantly lower lumbar mobility ($p = 0.05$) and lower ankle mobility bilaterally ($p \leq 0.05$).[1] The authors are to be congratulated for the article; however, an important gap regarding evaluation needs to be discussed so that we can move forward scientifically.

Padilha et al.[1] used the Leg Lateral Reach Test (LLRT)[2] to assess the thoraco-lumbo-pelvic rotation range of dancers. They placed the participants in the supine position with their arms at their sides to perform hip flexion with unilateral knee extension (only the side being evaluated) and thoraco-lumbo-pelvic rotation range with the shoulders maintaining contact with the floor.[1] The goal of the test is to reach a previously marked measuring tape perpendicular to the popliteal fossa on the side that is contralateral to the one being tested (right and left sides).[2]

Although the LLRT is reliable (intraclass correlation coefficient, ICC ≥ 0.889) and inexpensive,[3] it is a new and extremely-limited test. It was developed by Kim et al.[2] (2017) for healthy subjects and adapted by Pontes-Silva et al.[3] (2021) for patients with chronic low back pain. To date, only these three studies[1–3] have used the LLRT, and none of them has established a cut-off point to diagnose adequate/inadequate thoraco-lumbo-pelvic rotation range, making it just another test whose evaluation generates data that cannot define a prognosis.[1–3]

The study by Padilha et al.,[1] for example, showed that patients presented rotational mobility to the right with a mean distance of 69.8($\pm$5.47) cm and, to the left, of 80.7 ($\pm$31.56) cm. However, the lack of a cutoff point to diagnose thoraco-lumbo-pelvic rotation hypomobility using the LLRT makes it impossible to state that these values (69.8 cm or 80.7 cm) indicate adequate or inadequate thoraco-lumbo-pelvic rotation range.

Therefore, further research should be conducted to assess whether the LLRT has a cutoff point in healthy individuals to diagnose thoraco-lumbo-pelvic rotation hypomobility in patients with low back pain. Finally, two questions remain unanswered: what is the cutoff point to diagnose thoraco-

received
December 31, 2023
accepted
March 18, 2024

DOI https://doi.org/10.1055/s-0044-1787771.
ISSN 0102-3616.

© 2024. The Author(s).
This is an open access article published by Thieme under the terms of the Creative Commons Attribution 4.0 International License, permitting copying and reproduction so long as the original work is given appropriate credit (https://creativecommons.org/licenses/by/4.0/).

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

lumbo-pelvic rotation hypomobility using the LLRT? And what is the variation in the sensitivity and specificity of the LLRT using a receiver operating characteristic (ROC) curve?

Financial Support
The author declares that he has received no financial support from agencies in the public, private or non-profit sectors to write the present article.

Conflict of Interests
The author has no conflict of interests to declare.

References

1 Padilha VH, Lara S, Graup S, Teixeira LP, Silva LDS, Maciel ET. Lumbopelvic Muscle Mobility and Resistance and their Association with Musculoskeletal Pain in Ballet Dancers. Rev Bras Ortop 2023;58(03):410–416
2 Kim S-H, Kwon O-Y, Park K-N, Hwang U-J. Leg lateral reach test: The reliability and correlation with thoraco-lumbo-pelvic rotation range. J Sci Med Sport 2017;20(01):2–5
3 Pontes-Silva A, Avila MA, de Araujo ADS, et al. Assessment of the Reliability of the Leg Lateral Reach Test to Measure Thoraco-Lumbo-Pelvic Rotation in Individuals With Chronic Low Back Pain. J Manipulative Physiol Ther 2021;44(07):566–572

Revista Brasileira de Ortopedia

Author Instructions

Thank you for contributing to *Revista Brasileira de Ortopedia*. Please read the instructions carefully and observe all the directions given. Failure to do so may result in unnecessary delays in publishing your article (You may find the Portuguese version of the author instructions at the end of this file).

APC Type	***Article Processing Charge* (APC)**
Regular	None (Society Funded)

Find out more about Open Access at Thieme at http://open.thieme.com

SUBMISSION CHECKLIST
All manuscripts must be submitted at the following link:
http://www.editorialmanager.com/rbo

☐ AUTHOR INFORMATION
- All authors: full name, department, affiliation
- Corresponding author: full name, degrees, department, affiliation, mailing address, telephone and fax number, e-mail address

☐ MANUSCRIPT FILE
- Must be digital - hard copy submissions are not accepted

☐ ABSTRACT AND KEYWORDS
- See the section Article Types for word limit

☐ REFERENCES
- Cited sequentially in AMA

☐ FIGURES AND TABLES
- Cited sequentially in the main document, must be saved separately from the main document

☐ ART FILES
- Must be saved separately from the main document

☐ PERMISSIONS
- Required if you plan to reproduce content from a published source or include a photograph of a patient
- Patient permission form forms available at www.thieme.com/journal-authors

CONTENTS

Peer Reviewing Process 3
MANUSCRIPT FORMAT **3-6**
Article Types 3
General Guidelines 3
Files/Information Checklist 3
Language 4
Title Page 4
Abstract and Keywords 4
Main Document 4
Acknowledgments 5
Formatting of Funding Sources 5
Conflict of Interest Statement 5
Informed Consent 5
Conflicts arising from papers authored by Editorial Board Members 6
References 6
Figure Captions 6
Tables 6
Videos 6
Supplementary Material 6

DIGITAL ARTWORK PREPARATION **6-7**
General Guidelines 6
Black and White Art 7
Color Art 7
Art Labels 7

SUBMISSION PROCEDURE **7**
Article Processing Charge (APC) and Open Access 7
Submission Procedure 7
Revision Procedure 7

PRODUCTION PROCEDURE **7**
Page Proofs 7

POLICY STATEMENTS **8-9**
Privacy Statement 8
Preprint Server Statement 8
Ethics standards 8
Authorization Letter 8
Conflict of Interest Statement (if any): 8
Informed Consent 8
Copyright Statement 8
Definition of Authorship 8
Contributors 9
Changes to authorship 9

EDITORIAL CONTACTS **9**

The Revista Brasileira de Ortopedia (RBO) is the official publication of the Brazilian Society of Orthopedics and Traumatology (Sociedade Brasileira de Ortopedia e Traumatologia, SBOT) dedicated to the publication of scientific articles that contribute to the dissemination of scientific knowledge and advances that contribute positively to the practice, research, teaching, and updating of orthopedics and traumatology and related areas. The RBO aims to provide an opportunity for the exchange of information between healthcare professionals, researchers, and educators, promoting the advancement of orthopedic science and improved patient care. It is published bimonthly in February, April, June, August, October and December, and has been published regularly since its first edition in 1965. The journal is dedicated to orthopedists who are linked to the SBOT, healthcare professionals who are dedicated to similar activities and orthopedists in other countries.

Peer Reviewing Process

The journal follows a double-blind peer-review process where neither author and reviewer does not get to know the identity of each other.

At least two reviewers are randomly appointed from their area of expertise, under the coordination of the Editor-in-Chief. The decision is taken based on the comparative reviews that the manuscript receives during the review process.

MANUSCRIPT FORMAT

Article Types

The following graph shows what types of articles are accepted for publication, and what requirement they may have.

Article Type	Abstract Limit	Keywords Limit	Title Limit	Illustrations	Reference
Original Article (Up to 2,500 words)	Up to 250 words	Up to 6	N/A	16 (between figures, tables and graphs)	Up to 30 References
Update Articles (Up to 4,000 words)	Up to 250 words	Up to 6	N/A	5 (between tabels and figures)	Up to 40 References
Review Articles (Up to 4,000 words)	Up to 250 words	Up to 6	N/A	5 (between figures, tables and graphs)	Up to 40 References
Systematic Review Protocol (Up to 2,500 words)	Up to 250 words	Up to 6	N/A	N/A	Up to 20 References
Technical Notes (Up to 1,500 words)	Up to 250 words	Up to 6	N/A	7 (between figures and tables)	Up to 10 References
Letters to the Editor (Up to 500 words	N/A	N/A	N/A	2 Figures	Up to 4 References
Editorial (Up to 500 words)	N/A	N/A	N/A	N/A	N/A

- **Original Article**: It describes prospective or retrospective experimental research or clinical investigations, which may be randomized or double blind. It should have a Title, Structured Abstract (Objective, Methods, Results, and Conclusion), keywords, introduction, materials and methods, results, discussion, conclusions and references. Can have maximum of 6 authors. Maximum of 2,500 words, 30 references, 16 illustrations (between figures, tables and graphs).
- **Update Articles**: Written by a specialist at the invitation of the Editor-in-Chief to review topics that present technological and diagnostic advances, innovative surgical techniques, new therapeutic approaches, and imaging techniques, ensuring that practices are based on the best available evidence. The article will be subjected to the peer-review process. They should have Title, Unstructured abstract keywords, and references. Maximum of 4,000 words, 60 references, 5 illustrations (including tables and figures).
- **Review Articles**: These have the purpose of examining the published bibliography on a given subject, in order to make a critical assessment on a certain specific topic and present the important conclusions based on this literature. They should have Title, an unstructured (with the except of Systematic Review and Meta-analysis) abstract, keywords, and references. Maximum of 4,000 words, 40 references, 5 illustrations (between figures, tables and graphs).
- **Systematic Review Protocol:** The protocol can be published in article format. Must contain the strategies methodologies for carrying out the systematic review and must contain at least the following information: a search strategy to identify articles of interest, eligibility criteria, data extracted, the variables of interest, data analysis, and forms to explore heterogeneities. The essential items inherent in performing a systematic review may be seen at the link: https://tinyurl.com/systematicr. RBO suggests that all researchers register the protocol of their systematic reviews in Prospero (https://www.crd.york.ac.uk/prospero/) or PRISMA (http://www.prismastatement.org/). The protocol will be evaluated by the journal's editorial board and submitted to the peer-review process.
- **Technical Note:** It is intended for the dissemination of a diagnostic method or experimental surgical technique, new surgical instruments, orthopedic implants, etc. It is important that the technique presented be well tested (appropriate follow-up time) and that it can promote a solution to a problem that still does not have well-established techniques in the medical literature. It must have: Title, Abstract (unstructured), Keywords, Explanatory Introduction, Description of Method, Material or Technique,

Final Comments and References. Maximum of 1,500 words, 10 references, 7 illustrations (between figures and tables).

- **Letters to the Editor:** These have the aim of commenting on or discussing studies published in the journal or reporting on original research that is in progress. They will be published at the editors' discretion, with the respective reply, when appropriate.
- **Editorial**: These are written on invitation from the Editor-in-Chief, presenting comments on important studies in this journal, describing important published research or presenting communications from the editors that are of interest to the specialty.

General Guidelines

- You must submit a digital copy of your manuscript. Hard copy submissions are not accepted.
- Keep the format of your manuscript simple and clear. We will set your manuscript according to our style—do not try to "design" the document.
- The manuscript, including the title page, abstract and keywords, text, references, figure captions, and tables should be typewritten, double-spaced in 12-point font with 1-inch margins all around and saved as one file.
- Each figure should be saved as its own separate file. Do not insert figures within the manuscript file. This requires special handling by Thieme's Production Department.
- Keep abbreviations to a minimum and be sure to explain all of them the first time they are used in the text.
- The manuscripts should be written in consistent British or American English.
- The authors should use Système International (SI) measurements. For clarity, nonmetric equivalents may be included in parentheses following the SI measurements.
- Use generic names for drugs. You may cite proprietary names in parentheses along with the name and location of the manufacturer.
- Credit suppliers and manufacturers of equipment, drugs, and other brand-name material mentioned in the manuscript within parentheses, giving the company name and primary location.

Files/Information Checklist:

- One of the authors can be designated as the corresponding author. The e-mail address and full postal address should be included in the title page. For more details, please see below the section of Title Page.
- Manuscript:
  - Include Keywords
  - All relevant Figures and their Figure captions/legends
  - All Tables (including titles, description, footnotes)
  - Ensure all figure and table citations in the text match the files provided
  - Indicate clearly if color should be used for any figures in print Graphical Abstracts / Highlights files (wherever applicable)
  - Supplemental files (wherever applicable)
- Further considerations
  - Manuscript has been 'spell checked' and 'grammar checked'
  - All references mentioned in the Reference List are cited in the text, and vice versa
  - Permission has been obtained for use of copyrighted material from other sources (including the Internet)
  - A competing interests statement is provided, even if the authors have no competing interests to declare
  - Journal policies detailed in this guide have been reviewed
  - Referee suggestions and contact details provided, based on journal requirements

Language

Articles can be written in Portuguese or English.

Title Page

- This journal adheres to a double-blinded peer-review policy. The title page should **not** be included in the main document and should be provided as a separate document.
- Article Title: Concise and informative. Titles are often used in information-retrieval systems. Avoid abbreviations and formulae where possible.
- Authorship: A maximum of 6 authors, except to the multicenter studies where the number of authors may be greater, as follows:

- Two or three institutions, a maximum of 4 authors per institution;
- More than four institutions, a maximum of 3 authors per institution.
- Under no circumstances, the number of authors can be greater than 20.

- Indicate each author's affiliation separately. If there is more than one institutional affiliation, only indicate the most relevant. Please clearly indicate the first and last name of each author with the correct spelling. List all affiliations to the respective authors, including city and country. Provide the ORCID (https://orcid.org/) email for each author. Indicate all affiliations with a lower-case superscript letter immediately after the author's name and in front of the appropriate address. Provide the full postal address of each affiliation, including the city, state and country name and, if available, the e-mail address of each author. Author affiliations should be presented in increasing hierarchical order (e.g. Harvard University, Harvard Business School, Boston, USA) and should be written as established in its own language (e.g. Universit Paris-Sorbonne; Harvard University, Universidade de So Paulo).
- Corresponding Author: Clearly indicate who will handle correspondence at all stages of refereeing and publication, also post-

publication. Ensure that the e-mail address is given and that contact details are kept up to date by the corresponding author.

Abstract and Keywords

See the section Article Types for word limits.

The abstract should briefly outline the content of the article and any conclusions it may reach. The keywords should be words a reader would be likely to use in searching for the content of the article.

A structured abstract, by means of appropriate headings, should provide the context or background for the research and should state its purpose, basic procedures (selection of study subjects or laboratory animals, observational and analytical methods), main findings (giving specific effect sizes and their statistical significance, if possible), and principal conclusions. It should emphasize new and important aspects of the study or observations.

The abstracts should be a maximum of 250 words and structured in the following format: Purpose: One or two sentences that simply state purpose with no background information. Methods: Provide details about the methods of the study, including data analysis. Results: Present most important findings of the study. Please provide numbers (means with standard deviations or medians with ranges) to support your findings, and results of significance tests, e.g. p-values. Conclusions: One or two sentences that state only what your study identified and actually demonstrated. Please do not include comments or information not supported by the data of your study. Level of Evidence (for human studies) or Clinical relevance (basic science in-vitro or in-vivo study: why is this study important from a clinical standpoint?).

Immediately after the abstract, provide a maximum of 6 keywords in alphabetical order and separated by semicolon, to represent the content of the article. The descriptors or keywords should be based on the Health Science Descriptors (Descritores em Cincias da Sade, DECS), which are available at the electronic address http://www.decs.bvs.br; or on the Medical Subject Headings (MeSH), from www.nlm.nih.gov/mesh/ MBrowser.html.

Main Document

- This journal uses **double-blind peer-review**, which means the identities of the authors are concealed from the reviewers, and vice versa. To facilitate this, please include the following separately:
  - Title page (with author details): This should include the title, professional qualification, academic title and affiliation of each author, acknowledgements and any Declaration of Interest statement, and a complete address for the corresponding author including an e-mail address.
  - Blinded manuscript (no author details): The main body of the paper (including the references, figures, tables and any acknowledgements) should not include any identifying information, such as the authors' names or affiliations.
- Articles including humans or animals must present the opinion with the approval provided by the specific committee in the submission and cited in the text.
- Use generic names of drugs or devices. If a particular brand was used in a study, insert the brand name along with the name and location of the manufacturer in parentheses after the generic name when the drug or device is first mentioned in the text.
- Quantities and units should be expressed in accordance with the recommendations of the International System of Units (SI), 8th edition 2006 (www.bipm.orgutilscommonpdfsi_brochure_8_en.pdf).
- When abbreviations are used, give the full term followed by the abbreviation in parentheses the first time it is mentioned in the text, such as inferior gleno-humeral ligament (IGHL).
- Please clearly distinguish the hierarchy of headings within the manuscript by using capital letters, underline, italic, and bold styles as necessary.
- As needed, use italic, superscripts, subscripts, and boldface, but otherwise do not use multiple fonts and font sizes.
- Do not insert page or section breaks except where noted in the Author Instructions.
- Use hard returns (the Enter key) only at the end of a paragraph, not at the end of a line. Allow lines of text to break automatically in your word-processing software. Do not justify your text.
- Use only one space, not two, after periods.
- Create tables using the Table function in Microsoft Word.

Acknowledgments

Present acknowledgments at the end of the article before the references and do not, therefore, include them on the title page, as a footnote to the title or otherwise. List here those individuals who provided help during the research (e.g., providing language help, writing assistance or proof reading the article, etc.).

Formatting of Funding Sources

List funding sources in this standard way to facilitate compliance to funder's requirements:

Funding: This work was supported by the National Institutes of Health [grant numbers xxxx, yyyy]; the Bill & Melinda Gates Foundation, Seattle, WA [grant number zzzz]; and the United States Institutes of Peace [grant number aaaa].

It is not necessary to include detailed descriptions on the program or type of grants and awards. When funding is from a block grant or other resources available to a university, college, or other research institution, submit the name of the institute or organization that provided the funding.

If no funding has been provided for the research, please include the following sentence:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interest Statement

All authors (including corresponding and co-authors associated with the manuscript) must make a formal statement at the time of submission indicating any potential conflict of interest that might constitute an embarrassment to any of the authors if it were not to be declared and were to emerge after publication. Such conflicts might include, but are not limited to, shareholding in

or receipt of a grant or consultancy fee from a company whose product features in the submitted manuscript or which manufactures a competing product. Should the article be accepted for publication, this information will be published with the paper.

Please click http://www.icmje.org/conflicts-of-interest to download a Conflict of Interest form. The disclosure information is important in article processing. If the provided forms are incomplete or missing, it can cause delays in publishing of article.

Informed Consent

The journal adheres to the principles set forth in the "http://www.wma.net/en/30publications/10policies/b3/"Helsinki Declaration and holds that all reported research conducted with human participants should be conducted in accordance with such principles. Reports describing data obtained from research conducted in human participants must contain a statement in the Methods section indicating approval by the Institutional Review Board (IRB). The authors should also indicate whether or not individual consent for the study was obtained, or whether it was waived.

Conflicts arising from papers authored by Editorial Board Members

The journal evaluates any submissions from the members of the editorial board purely on merit of the clinical content presented as it does for any other article coming from authors globally. All the articles including articles from Editorial Board members are evaluated via double-blind peer review process, which will ensure that the information of author(s) is not revealed to the reviewers. In doing so, the journal ensures there are no conflict of interests or preferences and selection of articles is purely on its clinical content merit, thus ensuring best ethical standards and practices of peer-review are maintained.

Videos

Revista Brasileira de Ortopedia (RBO) encourages video submissions to complement its articles. Professional quality is expected and can be obtained by using easily available equipment without the need of a professional team.

All videos must have a slide with title, authors and possible conflict of interests. The nature and purpose of the video must be clearly stated, and it must have clear and understandable narration. All videos will be submitted to a peer-review.

The same ethics standards used in Revista Brasileira de Ortopedia for studies with human and animals are valid for the video archives to be submitted. Avoid incluiding institucional industry or any other type of marketing information or displaying a logo. Just as figures, videos must be cited in the manuscript (for example, "Video 1").

The following formats are acceptable: *.avi, *.mov, and *.mp4

Instructions:

- The length of the video cannot exceed 4 minutes;
- Sent only one video per article and not a multipart video;
- The video archive cannot exceed 150 MB;
- Narration is mandatory and can be made in Portuguese or English;
- The videos must be attached to the submission system, choosing *Dataset* the option in the *file upload menu.*

Supplementary Material

Supplementary material such as applications, images and podcasts can be published with your article to enhance it. The submitted material is published just as provided. Please send your supplementary material along with the article and provide a concise description for each item. If you wish to change the supplementary material, please provide the updated file.

Figure Captions

- Figures include photographs or radiographs, drawings, graphs, bar charts, flow charts, and pathways, but NOT lists or tables.
- Figures must be cited sequentially in the text. Number all figures (and corresponding figure captions) sequentially in the order they are cited in the text.
- Figure captions should be written after the reference list. Insert a page break between the end of references and the start of figure captions.
- Figure captions should include a description of the figure and/or each lettered part (A, B, etc.) and of any portions of the figure highlighted by arrows, arrowheads, asterisks, etc.
- For a figure borrowed or adapted from another publication (used with permission), add a credit line in parentheses at the end of each figure legend. This credit line should be a complete bibliographic listing of the source publication (as a reference), or other credit line as supplied by the copyright holder. For example (Reprinted with permission from Calfee DR, Wispelwey B. Brain abscess. Semin Neurol 2000;20:357.)

Tables

- Data given in tables should be commented on but not repeated in the text. Be sure that lists or columns of related data are composed in a word-processing program like the rest of the text.
- Do not intersperse tables in the text. Tables should appear after the figure captions. Insert a page break between the end of the figure captions and the start of the tables.
- Tables must be double-spaced and numbered in the same sequence they are cited in the text. A short descriptive title should be provided for each table.
- If a table contains artwork, supply the artwork separately as a digital file.
- For tables borrowed or adapted from another publication (used with permission), add a credit line as the first footnote beneath each table. This credit line should be a complete bibliographical listing of the source publication (as a reference), or other credit line as supplied by the copyright holder. For example, "Reprinted with permission from Calfee DR, Wispelwey B. Brain abscess. Semin Neurol 2000;20:357." ("Data from . . ." or "Adapted from . . ." may also be used, as appropriate.)
- Other footnotes for tables should be indicated in the table using superscript letters in alphabetical order.
- Any abbreviations used in the table should be explained at the end of the table in a footnote.

References

References must be as recent as possible and relevant to the available literature. It is essencial that they are complete and thoroughly checked. If the reference provided is incomplete, good search options are National Library of Medicine: www.nlm.nih.gov; Books in Print: www.booksinprint.com; Pub-Med: www.ncbi.nlm.nih.gov/PubMed/; or the publishers website.

- Must be listed in AMA style, using the Index Medical journal title abbreviation.
- Must come at the end of the text. Open a line before listing references.
- Must be cited sequencially in the text in numerical order (not alphabetical).
- Cite all authors up to the sixth author. If there are more than 6 authors, cite the first 3 followed by et al.
- Must follow the style as shown in the following examples:

1. Citing a journal article:

Borges JLP, Milani C, Kuwajima SS, Laredo Filho J. Tratamento da luxação congênita de quadril com suspensório de Pavlik e monitorização ultra-sonográfica. Rev Bras Ortop 2002;37(1/2):5–12

2. Citing a chapter in a book:

Johnson KA. Posterior tibial tendon. In: Baxter D. The foot and ankle in sport. St Louis: Mosby; 1995. p. 43–51

3. Citing a book:

Baxter D. The foot and ankle in sport. St Louis: Mosby; 1995

4. Citing a thesis:

Laredo Filho J. Contribuição ao estudo clínico-estatístico e genealógico-estatístico do pé torto congênito equinovaro [thesis]. São Paulo: Universidade Federal de São Paulo colocar virgula Escola Paulista de Medicina; 1968

5. Citing a government publication:

Food and Drug Administration. Jin Bu Huan Herbal Tablets. Rockville, MD: National Press Office; April 15,

1994. Talk Paper T94-22

6. Citing na online article:

Lino Junior W, Belangero WD. Efeito do Hólmio YAG laser (Ho: YAG) sobre o tendão patelar de ratos após 12 e 24 semanas de seguimento. Acta Ortop Bras [periodical on the Internet] 2005 [cited 2005, Aug 27];13(2):[about 5 p.] Available from: http://www.scielo.br/ scielo

7. Citing a symposium article:

Eisenberg J. Market forces and physician workforce reform: why they may not work. Paper presented at: Annual Meeting of the Association of American Medical Colleges; October 28, 1995; Washington, DC

DIGITAL ARTWORK PREPARATION

General Guidelines

- It is best to use Adobe Photoshop to create and save images, and Adobe Illustrator for line art and labels.
- Do not submit art created in Microsoft Excel, Word, or PowerPoint. These files cannot be used by the typesetter.
- Save each figure in a separate file.
- Do not compress files.
- All black-and-white and color artwork should be at a resolution of 300 dpi (dots per inch) in TIFF format. Line art should be 1,200 dpi in EPS or TIFF format. Contact the Production Editor at Thieme if you are unsure of the final size.
- It is preferable for figures to be cropped to their final size (approximately 3½ inches for a single column and up to 7 inches for a double column), or larger, and in the correct orientation. If art is submitted smaller and then has to be enlarged, its resolution (dpi) and clarity will decrease.

  Note: Lower resolutions (less than 300 dpi) and JPEG format (.jpg extension) for grayscale and color artwork are strongly discouraged due to the poor quality they yield in printing, which requires 300 dpi resolution for sharp, clear, detailed images. JPEG format, by definition, is a lower resolution (compressed) format designed for quick upload on computer screens.

Black-and-White Art

- Black-and-white artwork can be halftone (or grayscale) photographs, radiographs, drawings, line art, graphs, and flowcharts. Thieme will only accept digital artwork.
- If possible, do not send color art for conversion to black-and-white. Do the conversion yourself so that you can check the results and confirm in advance that no critical details are lost or obscured by the change to black-and-white.
- For best results, line art should be black on a white background. Lines and type should be clean and evenly dark. Avoid screens or cross-hatching, as they can darken or be uneven in printing and lead to unacceptable printing quality.

Color Art

- All color artwork should be saved in CMYK, not RGB.

Art Labels

- Arrows, asterisks, and arrowheads (or other markers) should be white in dark or black areas and black in light or white areas, and large in size. If not, these highlighting marks may become difficult to see when figures are reduced in size during the typesetting process.
- Use 1-point (or thicker) rules and leader lines.
- Capitalize the first word of each label and all proper nouns. Consider using all capitals if you need a higher level of labels.
- Where there are alternate terms or spellings for a named structure, use the most common one and make sure it is consistent with what is used in the text.

- Avoid using multiple fonts and font sizes for the labels; use only one or two sizes of a serif font.

SUBMISSION PROCEDURE

Article Processing Charge (APC) & Open Access

This is a subsidized Open Access journal: all the articles after publishing online, will be immediately and permanently made free for everyone to read and download on Thieme-connect platform. The Brazilian Society of Orthopaedics and Traumatology (Sociedade Brasileira de Ortopedia e Traumatologia SBOT) pays for the publishing costs incurred by the journal. Authors do not have to pay any Article Processing Charge or Open Access Publication Fee. All peer- reviewed articles are published as open access in this journal. Permitted third party (re)use is defined by the following Creative Commons user licenses: *CC BY (Creative Commons – Attribution 4.0 Internacional – CC BY 4.0)*

This license allows users to distribute, remix, adapt, and build upon the material in any medium or format, as long as attribution is given to the creator. The license allows commercial use.

Submission Procedure

- Consult the checklist on the first page of this document to ensure that you are ready to submit your manuscript.
- Manuscripts must be submitted electronically at the following link: http://www.editorialmanager.com/rbo
- Always review your manuscript before submitting it. You may stop a submission at any phase and save it to submit later. After submission, you will receive a confirmation email. You can also check the status of your manuscript by logging in to the submission system. The system converts your article files to a single PDF file used in the peer-review process. Editable files are required to typeset your article for final publication. All correspondence, including notification of the Editor's decision and requests for revision, is sent by e-mail. The Editor in Chief will inform you via email once a decision has been made.

Revision Procedure

The journal follows a double-blind peer-review process where neither author and reviewer does not get to know the identity of each other. At least two reviewers randomly selected based on their knowledge and experience under the supervision of the Editor-in-Chief on each manuscript. The decision is taken based on the comparative reviews that the manuscript receives during the review process.

- If the editor and reviewers conclude that your article needs revision, you will have to make the changes via a word-processing program and resubmit it electronically.
- Log In to the submission system and find your article, which will be marked for revision.
- The best way to make revisions to your manuscript is by enabling the Track Changes mode in Microsoft Word, which will automatically highlight and mark up revised text. Please submit both a marked up copy and a clean copy of your revised manuscript to the submission system.
- Your original files will still be available after you upload your revised manuscript, so you should delete any redundant files before completing the submission.
- You will also be provided space in which to respond to the reviewers' and editors' comments. Please be as specific as possible in your response.

PRODUCTION PROCEDURE

Page Proofs

Page proofs will be sent to you via email. The proofs will be in a PDF file format, which should be opened using Acrobat Reader software. You will receive further instructions with your proofs. Take this opportunity to check the typeset text for typographic and related errors. Elective alterations are difficult to accommodate owing to the associated time and expense of introducing them. Therefore, please be sure that when you submit your manuscript, it is accurate, complete, and final.

POLICY STATEMENTS

Privacy Statement

The names and email addresses entered in this journal site will be used exclusively for the stated purposes of this journal and will not be made available for any other purpose or to any other party.

Preprint Server Statement

RBO encourages the submission of manuscripts that have been deposited in an initial draft version in preprint repositories such as Research Square, arXiv, and medRxiv. Drafts of short conference abstracts or degree theses posted on the website of the degree-granting institution, and draft manuscripts deposited on authors' or institutional websites are also welcome. All other prior publication is forbidden.

During submission, authors should:

(1) note use of the preprint repository in the cover letter;

(2) state what adjustments and/or updates the draft has undergone between deposition and submission;

(3) cite the preprint, including the DOI, as a reference in the manuscript.

After submission to the journal, and until a final decision has been made, authors are discouraged from depositing versions of their manuscript as preprints. Upon publication authors should add a link from the preprint to the published article. Twelve months after publication, authors can update the preprint with the accepted manuscript.

Ethics standards

No data or image identifying a patient can be used without formal consent (patient permissionforms are available at: www.thieme.com/journal-authors); studies using human beings or animal trials must follow ethical standards from the International Committee of Medical Journals Editors – ICMJE, as well as approval of original institution's Ethics Committee; conflicts of interest must have a ICMJE form filled in by all authors (available at: http://icmje.org/); commercial marks should be avoided; authors are the sole responsible for opinions and concepts in the published articles, as well as for the reference accuracy. You may find the full Ethical Review Committee Statement here: https://cdn0.scrvt.com/9ca5761af4a1cf7bf49dd51537e8f4d1/0cd6b9200990aeae/c93e0c087bf4/Ethical_Review_Committee_Statement_form.pdf

Authorization Letter

The corresponding author should send a letter authorizing publication, signed by all coauthors, ensuring the uniqueness of the publication, ie, the article should not be posted on other news outlets, not be available online. Articles already published in other media should say when and where they were accepted for publication.

Conflict of Interest Statement (if any):

All authors (including corresponding and coauthors associated with the manuscript) must make a formal statement at the time of submission indicating any potential conflict of interest that might constitute an embarrassment to any of the authors if it were not to be declared and were to emerge after publication. Such conflicts might include, but are not limited to, shareholding in or receipt of a grant or consultancy fee from a company whose product features in the submitted manuscript or which manufactures a competing product. Should the article be accepted for publication, this information will be published with the paper.

Types of conflicts include: Consulting, Royalties, Research Support, Institutional Support, Ownership, Stock/Options, Speakers Bureau, and Fellowship Support. Any commercial entity whose products are described, reviewed, evaluated, or compared in the manuscript, except for those disclosed in the Acknowledgments section, are potential conflicts. This journal follows the guidelines of the International Committee of Medical Journal Editors and an ICMJE disclosure of potential conflicts of interest (COI) form must be submitted for each author at the time of manuscript submission. Forms must be submitted even if there is no confl ict of interest. It is the responsibility of the corresponding author to ensure that all authors adhere to this policy prior to submission.

A conflict of interest statement must also be included in the manuscript after any "Acknowledgements" and "Funding" sections and should summarize all a spects of any conflicts of interest included on the ICMJE form. If there is no conflict of interest, authors must include 'Conflict of Interest: none declared'. Please click http://www.icmje.org/conflictsofinterest to download a Conflict of Interest form. The disclosure information is important in article processing. If the provided forms are incomplete or missing, it can cause delays in publishing of article.

Informed Consent

The journal adheres to the principles set forth in the Helsinki Declaration and holds that all reported research conducted with human participants should be conducted in accordance with such principles. Reports describing data obtained from research conducted in human participants must contain a statement in the Methods section indicating approval by the Institutional Review Board (IRB). The authors should also indicate whether or not individual consent for the study was obtained, or whether it was waived.

Conflicts arising from papers authored by Editorial Board Members

The journal evaluates any submissions from the members of the editorial board purely on merit of the clinical content presented as it does for any other article coming from authors globally.

All the articles including articles from Editorial Board members are evaluated via double-blind peer review process, which will ensure that the information of author(s) is not revealed to the reviewers. In doing so, the journal ensures there are no conflict of interests or preferences and selection of articles is purely on its clinical content merit, thus ensuring best ethical standards and practices of peer-review are maintained.

Copyright Statement

The Contribution shall be published and made open access under the terms of a CC BY License (Creative Commons -- Attribution 4.0 International -- CC BY 4.0). This license means that anyone may freely use, adapt, redistribute and reproduce the material in any medium or format, even commercially, provided that the Contributor(s) and the Contribution as the source are acknowledged, a link to the Open Access License is provided and any modifications of the material are indicated. For more Information on our Open Access Program please visit https://open.thieme.com. Without prejudice to the terms and conditions of this Open Access License to Publish Agreement, you as the Contributor or, if applicable your employer, will retain all proprietary Intellectual Property rights in the Contribution, as well as in any process, procedure or article of manufacture described therein. By executing this Open Access License to Publish Agreement, the Contributor, and if applicable, the Contributor's employer, grants to the Publisher on a non-exclusive basis all rights necessary with regard to the editorial process and publishing service, in connection with the reproduction and distribution of the Contribution in the Journal and all subsequent versions and making it available to the public. Your work will be credited as © The Author(s). The Publisher is entitled, but not obliged, to use the aforesaid rights and may adapt the Contribution for these uses. The Publisher will take your and your co-authors' legitimate interests into account in this respect.

Definition of Authorship

Authorship credit should be based on criteria established by the International Committee of Medical Journal Editors. Each

author should have made the following contributions towards the completion of the manuscript:

1. Substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data
2. Drafting the article or revising it critically for important intellectual content
3. Final approval of the version to be published

Contributors

Each author is required to declare his or her individual contribution to the article: all authors must have materially participated in the research and/or article preparation, so roles for all authors should be described. The statement that all authors have approved the final article should be true and included in the disclosure.

Changes to authorship

Authors are expected to consider carefully the list and order of authors **before** submitting their manuscript and provide the definitive list of authors at the time of the original submission. Any addition, deletion or rearrangement of author names in the authorship list should be made only **before** the manuscript has been accepted and only if approved by the journal Editor. To request such a change, the Editor must receive the following from the **corresponding author**: (a) the reason for the change in author list and (b) written confirmation (e-mail, letter) from all authors that they agree with the addition, removal or rearrangement. In the case of addition or removal of authors, this includes confirmation from the author being added or removed.

Only in exceptional circumstances will the Editor consider the addition, deletion or rearrangement of authors **after** the manuscripthas been accepted. While the Editor considers the request, publication of the manuscript will be suspended. If the manuscript has already been published in an online issue, any requests approved by the Editor will result in a corrigendum.

EDITORIAL CONTACTS

Please contact the Editors or Thieme Publishers with any questions.

Editor in Chief

Prof. Dr. Geraldo da Rocha Motta Filho
Sociedade Brasileira de Ortopedia e Traumatologia
Alameda Lorena, 427 - 14º. Andar - Jd. Paulista, SP, Brazil
rbo@sbot.org.br
T: +55 11 2137 5400

Thieme Publishers

Acquisitions Editor

Ana Bluhm

Production Coordinator

Paula Di Sessa Vavlis
paula.disessa@thieme.com.br

Junior Production Coordinator

Tamiris Moreira Rudolf
tamiris.rudolf@thieme.com.br

Journals Intern

Caroline Bianchi Ávila
carol.avila@thieme.com.br

Momentos *que a vida inspira* voltam com

Nusira®
cloridrato de tramadol
+ diclofenaco sódico



Combinação que permite o tratamento da agudização da dor crônica.[1] Efetivo também na dor aguda inflamatória.[2]

Tratamento Multimodal[3]

Combinação segura[2]

Tempo médio para início da ação em 15 min[2]

Menor dose e melhor eficácia[3]



APRESENTAÇÕES EXCLUSIVAS COM 30 COMPRIMIDOS

Efeito sustentado[3]

Menor efeito adverso[3]

Alívio significativo *versus* monoterapia[3]

Menor consumo de analgésicos de resgate[3]

NUSIRA®
cloridrato de tramadol + diclofenaco sódico

USO ORAL
USO ADULTO

Contraindicações: Hipersensibilidade ao diclofenaco ou ao tramadol.
Interações Medicamentosas: Inibidores da recaptação de serotonina (ISRS).

Utilize o código abaixo para acessar a bula de Nusira® na íntegra.

Referências bibliográficas: 1. Warner et al. FASEB J. 2004:18790-804. **2.** Bula do produto Nusira®. **3.** Desjardins, P., Alvarado, F., Gil, M., González, M. & Guajardo, R. Efficacy and Safety of Two Fixed-Dose Combinations of Tramadol Hydrochloride and Diclofenac Sodium in Postoperative Dental Pain. Pain Med. 21, 2447–2457 (2020).

FA-292-24-MAIO/2024. USO EXCLUSIVO PARA A CLASSE MÉDICA.

Adium