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Updates in the Treatment of Knee Osteoarthritis

Atualizações no tratamento da osteoartrite de joelho

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Abstract

Knee osteoarthritis (OA) is an inflammatory and degenerative condition resulting in articular cartilage destruction and functional loss. Its prevalence has grown considerably due to increased life expectancy and obesity, and its diagnosis relies on evaluation, medical examination, and confirmation by supplementary radiographic images. Knee OA is multifactorial and influenced by several local, systemic, and external aspects. In addition, its progress and therapeutic responses highly depend on the characteristics of each subject. The initial recommendation is drug treatment and alternative therapies to improve quality of life. However, if these treatments are unsuccessful, one must consider surgical treatment. Surgical options include arthroscopies, osteotomies, and partial and total arthroplasties, while non-surgical treatments include medications and alternative therapies such as infiltrations, acupuncture, and physical exercise. It is worth highlighting that biomarkers can be a significant strategy for early disease detection, assessment of disease activity, prediction of prognosis, and monitoring a better response to therapy. Nevertheless, this topic must be the focus of further research to confirm its findings.

Keywords

- arthroscopy
- articular cartilage
- biomarkers
- intra-articular infiltrations
- knee
- osteoarthritis
- physical exercise

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Resumo

A osteoartrite (OA) do joelho é uma doença inflamatória e degenerativa que ocasiona a destruição da cartilagem articular e leva à perda de funções. Sua prevalência vem crescendo consideravelmente devido ao aumento da expectativa de vida e da obesidade, e o diagnóstico pode ser feito por meio de avaliação e exames médicos, e é confirmado em imagens radiográficas complementares. Uma condição multifatorial, a OA do joelho pode ser influenciada por diversos aspectos locais, sistêmicos e externos; além disso, a sua evolução e as respostas aos tratamentos dependem muito das características de cada indivíduo. Inicialmente, recomenda-se proceder a um tratamento medicamentoso e a terapias alternativas que melhorem a qualidade de vida do paciente; mas, a partir do momento em que se verifica que tais terapias não estão proporcionando resultados satisfatórios, um tratamento cirúrgico deve ser considerado. Entre os tratamentos cirúrgicos, as artroscopias, as osteotomias e as artroplastias parciais e totais são destacadas; os métodos não cirúrgicos incluem o uso de medicamentos e de terapias alternativas, como infiltrações, acupuntura e prática de exercícios físicos. Vale ressaltar ainda que a utilização de biomarcadores pode ser uma importante estratégia para detectar precocemente a doença, avaliar sua atividade, prever um prognóstico e monitorar uma melhor resposta à terapia; porém, esse tema ainda deve ser foco de mais estudos para que os seus resultados sejam comprovados.

Palavras-chave

- artroscopia
- biomarcadores
- cartilagem articular
- exercício físico
- joelho
- infiltrações intra-articulares
- osteoartrite

Introduction

Osteoarthritis (OA) causes cartilage degradation, bone remodeling, osteophyte formation, and synovial inflammation, resulting in pain, stiffness, edema, and loss of joint function. It is a significant cause of disability among adults and older subjects.[1,2] Populational aging and the progressively higher prevalence of obesity are increasing the incidence of this disease.[2]

The most common knee disease, OA may result in repeated joint effusion and functional limitation.[3] A slow and steady understanding of the pathophysiology of knee OA has been witnessed in recent decades. However, gaps regarding its pathogenesis remain, negatively impacting drug development and innovation. The lack of new medications and modifying drugs for knee OA treatment highlights the need for lifestyle changes to delay surgical intervention.[4] Furthermore, medical societies recommend low-impact physical activity, and surgical interventions may have conflicting outcomes.[5–7]

Additionally, the use of biological therapies has been increasing as alternatives to OA treatment, particularly intra-articular (IA) infiltrations. Hyaluronic acid (HA) is widely known as a safe conservative treatment for OA in the knee and other joints.[8] It provides pain relief, stimulates synovial fluid production, and cushions and lubricates joint surfaces.[9]

A growing body of scientific literature supports the use of IA infiltrations with HA for knee OA over placebo and other therapies. Acharya et al.[10] analyzed the effectiveness of IA with HA regarding pain, functional capacity, and quality of life in patients with early primary knee OA. These authors[10] reported short-term beneficial effects (up to one year), observing a decreasing trend in pain intensity and a progressive improvement in physical functioning and health-related quality of life after a single intervention.

Knee OA is multifactorial and influenced by several local, systemic, and external aspects. In addition, its progress and therapeutic responses highly depend on the characteristics of each subject. To better understand this condition, the present study aimed to gather information about its pathophysiology, clinical diagnosis, and updates on its treatment.

Pathophysiology of Knee Osteoarthritis

Osteoarthritis results from complex biological processes affecting cartilage, bone, ligaments, synovium, meniscus, periarticular fat, and muscles. It usually presents with joint space narrowing (JSN) due to articular cartilage loss, meniscal degeneration, and bone changes, including subchondral bone sclerosis and osteophytes.[11,12]

The biomechanical environment can influence OA development. Varus alignment shifts the load medially, increasing the risk of knee OA in the medial compartment, while valgus alignment shifts the load laterally, triggering OA in the lateral compartment. Additionally, previous knee trauma increases the risk of OA by 3.86 times.[13]

Mechanical overload often accounts for starting the process of cartilage damage, which later evolves into inflammation, causing joint degradation. The primary precursors of this inflammation process include interleukin-1 (IL-1) and tumor necrosis factor (TNF). These molecules maximize the expression of metalloproteinases and nitric oxide, the main catabolic agents synthesized by chondrocytes in response to injury.[14] Therefore, OA is an inflammatory disease of the entire synovial joint, comprising the mechanical and

structural degeneration of the articular cartilage and triggering functional changes in the entire joint.[4]

The development of OA is slow, and the pain can be progressive;[12] OA is a major cause of pain and disability, directly affecting quality of life.[2] It may result from several factors, including age, body weight disorders, knee joint overload, prolonged hyperflexion, and axis deviations.[3]

According to Primorac et al.,[15] the prevalence of knee OA is higher in adults aged $\geq$ 60 years, representing one of the most significant causes of disability among elderly subjects. In addition, the risk is higher in obese people (body mass index [BMI] $\geq$ 30 kg/m^2) than in non-obese people (19.7% versus 10.9% respectively).

Clinical Diagnosis and Classification Systems

The diagnosis is initially clinical, based on symptoms of pain, stiffness, and functional limitations, as well as a thorough physical examination with crepitus, pain, restricted mobility, joint sensitivity, and bone enlargement observation.[2] Weight-bearing knee radiographs help confirm the diagnosis and enable the classification of knee OA and the observation of structural damage. In addition, they improve specificity when osteophytes or JSN are present.[16]

Magnetic resonance imaging (MRI) reveals the effects of knee OA on the cartilage, meniscus, synovial membrane, and subchondral bone. Moreover, a tool developed by Cho et al.[17] uses infrared immunoliposomes against type-II collagen antibodies for early OA diagnosis and treatment.

Classifications are critical in knee surgery since effective classification systems can guide prognostic estimates. The recent publication by Pires et al.[18], "Classifications and flowcharts in knee surgery," is a Brazilian reference study that combines several classifications, flowcharts, and questionnaires to aid in the diagnosis and decision-making by specialists.

Following the classifications for degenerative lesions,[18] the most common method for radiographic definition is the Kellgren-Lawrence classification system. The overall joint score classifies OA as follows: grade 0 represents no pathological findings; grade 1 indicates potential JSN and edge osteophytes; grade 2 indicates potential JSN and definitive osteophytes; grade 3 establishes the presence of JSN, multiple osteophytes, some subchondral sclerosis, and potential bone contour deformity; and grade 4 denotes notable JSN, severe subchondral sclerosis, definitive bone contour deformity, and the presence of large osteophytes.[19]

Clinical Examination and Imaging

About 40% of the population aged over 65 years has symptomatic knee OA. Early detection and intervention are paramount to reduce morbidity and disability, resulting in better self-reliance. Radiography is the first investigation of choice for OA patients presenting with knee pain. Community-based studies[19] have shown that 40% to 80% of subjects with OA and radiographic knee changes are symptomatic, and that severe radiographic findings are associated with reports of pain that is more intense. However, there is a high degree of discordance between clinical and radiographic findings, and radiological OA classification is inaccurate in the early stages. The multifactorial origin of pain may explain this discrepancy between pain and radiographic findings.[19]

The discrepancy between the physical and imaging examinations, especially concerning symptoms, can be explained by the propensity of some OA patients to develop sensitized central nociceptive circuits that increase pain during various states of aggression to peripheral tissues.[20,21] This abnormality, known as central sensitization, is a maladaptive nociceptive process involving complex neuroplastic changes amplifying pain at multiple levels of the neuraxis.[20] Since central sensitization correlates with the activation of neural circuits implicated in the descending facilitation of pain and, as such, is a risk factor for the development and maintenance of chronic pain, it is essential to identify which patients present abnormal responses to relevant painful stimuli.

Biomarkers

An accurate and reliable biomarker must present specificity for a given condition and reflect the actual activity of the disease, monitor the changes achieved with therapy, and predict the prognosis.[20] Thus, most biochemical markers of OA characterize cartilage renewal. The most commonly investigated markers include the following: for extracellular matrix (ECM) degradation – urinary C-telopeptide fragments of type-II collagen (uCTX-II), Coll2–1, C2C, C2M, Coll2–1NO2, cartilage oligomeric matrix protein (COMP), aggrecan epitopes (ARGS, TEGE, FFGV), fibulin-3 epitopes (Fib3–1, Fib3–2, Fib3–3) etc.; and, for ECM synthesis, PIIANP, PIIBNP, CPII, CS846 etc.[21] The uCTX-II) is one of the best-known biochemical markers of OA, achieving a superior predictive profile compared to others.

According to the literature, several conditions can affect biomarker levels. Some evidence suggests that physical activity, hormonal levels, medications, and the sex of the patient may result in biomarker level fluctuations. Tanishi et al.[22] observed that uCTX-II levels differed significantly between men and women and in premenopausal and postmenopausal women.

Due to its ability to distinguish between healthy subjects and OA patients, another potential biochemical marker widely reported in the literature is COMP,[23] which also has some potential prognostic capabilities. Although some studies have reported conflicting results, a meta-analysis[23] showed that these biochemical markers (that is, COMP and CTX-II) may be effective to diagnose OA, assess prognosis progression, and differentiate between healthy subjects and those with OA.

The emergence of these biomarkers is relatively recent, and the best strategies for their application remain under study, in terms of technology and medical research, with the goal of developing reliable detection methods.

Treatments

The first-line treatment for knee OA does not involve surgical interventions, and management may be multimodal. However,

if these therapies are unsuccessful, one must consider surgical treatment. Although OA has no cure, several surgical and non-surgical treatment options are available to help manage pain and maintain the health of the affected patients.[12]

The following section will discuss the most widespread treatments according to their current level of recommendation.

Materials and Methods

Search Strategy

A bibliographical survey was performed in PubMed, MEDLINE, and Embase for studies published until February 20, 2023. The descriptors included *Updates*; *Knee Osteoarthrosis*, and *Treatment*, and the filters included *Randomized Controlled Trial*, *Randomized Clinical Trial*, *Meta-Analysis*, *Systematic Reviews*, and *Cohort*.

Eligibility and Selection Criteria

The retrieved studies met the following inclusion criteria:

- Studies related to the proposed topic;
- Studies with level of evidence of I to III;
- Articles in English, Spanish, and Portuguese;
- Research carried out on humans;
- Articles available in full versions.

The exclusion criterium was the following:

- Studies with a low level of evidence, such as a simple case reports.

Results

Identification of Studies and Characteristics

Following the search strategy, we found 41 studies with the aforementioned descriptors. These studies underwent a new assessment regarding their design, relevance, study type filters, and inclusion criteria. This assessment resulted in eight studies available in full and included according to category and type of treatment.

Surgical Treatments

Arthroscopy

Arthroscopy removes debris and crystals released in the joint cavity affected by OA, regularizing the joint surface.[24] A literature survey retrieved 26 systematic reviews and meta-analyses describing the results of 6,418 patients with a mean age of 47 ± 19 years (►**Figs. 1** and **2**).

Arthroscopic surgery for degenerative knee disease has been the focus of several recently published randomized clinical trials (RCTs), high-quality systematic reviews, and meta-analyses. Although pioneering studies have demonstrated that minimally-invasive arthroscopy had promising results, their strength was insufficient for a recommendation. Current clinical studies comparing arthroscopic joint debridement with placebo surgery or conservative treatment have demonstrated that arthroscopy is no longer effective and has no recommendation.[10–17,25]

A recent systematic review[11] published in the *British Medical Journal* strongly recommended against arthroscopy in patients with degenerative knee disease, emphasizing the importance of fully utilizing appropriate conservative treatment options. In particular, the recommendations directed clinicians to maximize exercise therapy, as the results presented in RCTs demonstrate that arthroscopic surgeries are not superior to complete physiotherapy protocols.[11] Another systematic review of eight RCTs evaluating arthroscopic surgery in degenerative meniscal injuries found moderate evidence suggesting no clinical benefit of arthroscopic meniscal debridement for degenerative meniscal tears compared to non-surgical or sham treatments in middle-aged OA patients.[10,26–28]

In a prospective cohort, Navarro et al.[29] aimed to ascertain whether knee arthroscopy to treat meniscal damage by OA

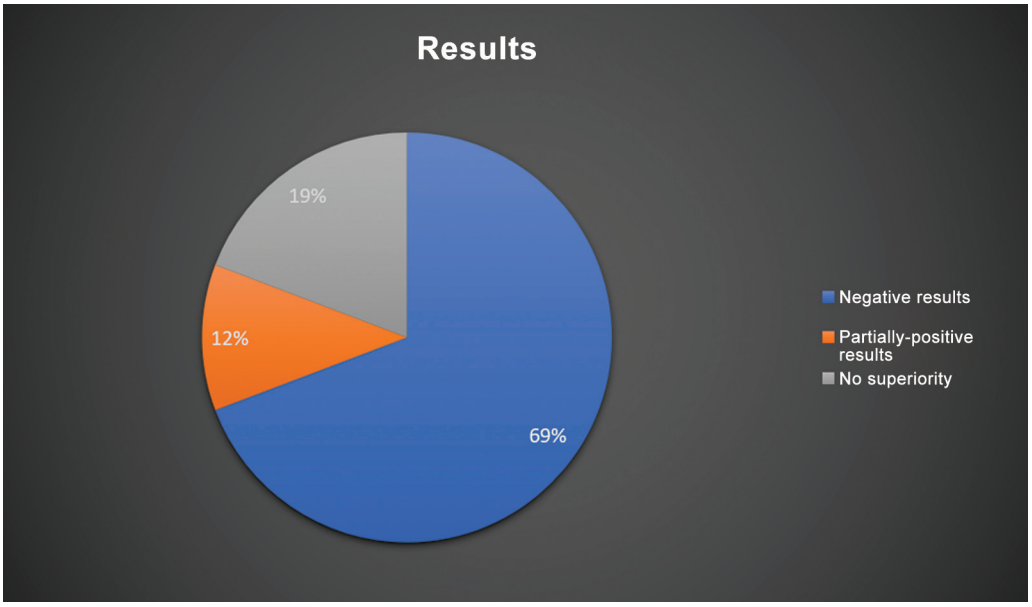


Fig. 1 Graphical representation of the outcomes of studies assessing arthroscopy for the treatment of knee degenerative disease.

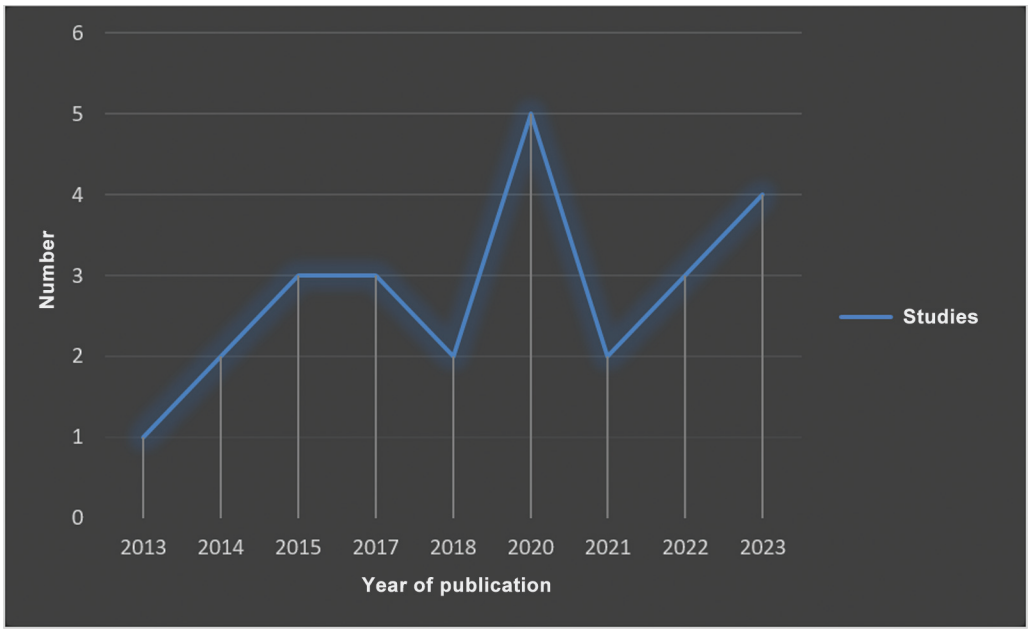


Fig. 2 Temporal description of the literature included by year of publication.

delayed knee replacement compared with physiotherapy alone. The main findings were that the cumulative incidence of knee replacement was modest but significantly higher for subjects undergoing arthroscopy than physical therapy alone (risk ratio: 1.30; 95% confidence interval: 1. 17–1.44; $p < 0.001$). The authors[29] concluded that, for patients with meniscal damage complicated by OA, those who underwent arthroscopy were 30% more likely to have partial or total knee replacement surgery at any point during follow-up compared with those undergoing physical therapy alone.

Indications

For all these reasons, many researchers limit the indications for arthroscopy. The technique still presents advantages in the early stages of OA, in which movement limitation is mechanical, and there are free articular bodies. However, physical therapy must accompany arthroscopy.[26]

For Zhao et al.,[27] arthroscopy presents no advantages over the several surgical options due to the weak and scarce evidence supporting its application. Likewise, recent studies suggest that arthroscopy may not be beneficial for patients with chronic degenerative meniscal tears, emphasizing the importance of conservative follow-up for the management of knee OA.[28]

The small and inconsequential benefit observed in interventions including arthroscopy for the degenerated knee is time-limited and absent within one to two years after surgery. Knee arthroscopy is associated with harm. Together, these findings do not support arthroscopic surgery for middle-aged or elderly patients with knee pain with or without signs of OA.

Arthroplasty

Arthroplasty is a surgical option to treat patients with extreme cases of knee joint degeneration; it can be total (total knee replacement, TKR) or unicompartmental (partial knee replacement, PKR), depending on the degree of OA.[30]

In the literature survey, we found 22 systematic reviews and meta-analyses describing the outcomes of 14,095 patients with a mean age of 58 ± 21 years (►**Figs. 3** and **4**).

For OA limited to a single compartment, PKR or unloading osteotomy may be an option. Their recommendation includes young, active patients because of the risks and limited durability of TKR. In contrast, TKR is a common, safe method in elderly patients with advanced knee OA and the gold-standard surgical treatment for advanced cases.[30]

An RCT[31] demonstrated that TKR is superior to non-surgical treatment alone in relieving pain in patients with moderate to severe knee OA and in improving function and quality of life after one year. However, both groups presented clinically relevant improvements, and patients undergoing TKR had more severe side effects. Furthermore, resection of the interpatellar fat pad during TKR is the subject of ongoing debate, with no clear consensus.[31]

Indications

The indication for TKR includes patients with advanced joint degeneration process and subjects older than 60 years. It is also the gold-standard treatment in this last group of patients. The indication for PKR includes young, active patients due to the risks and limited durability of TKR.

Osteotomy

High tibial osteotomy (HTO) has been used for over sixty years as a clinical exercise. This technique, performed around the knee, aims to maintain a regular anatomical structure, achieve better functional recovery of the knee joint, attenuate joint softness, reduce the cartilage degeneration rate, and

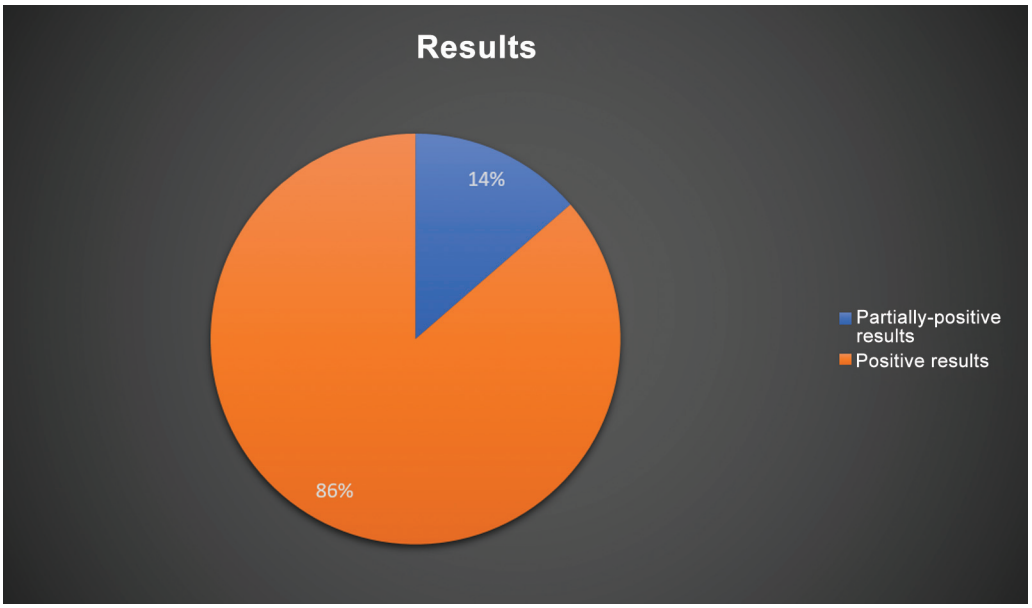


Fig. 3 Graphical representation of the outcomes of studies assessing (total or partial) arthroplasty for the treatment of knee degenerative disease.

prevent or postpone joint replacement.[32] This technique relies on a controlled osteotomy, transferring the weight-bearing axis from the degenerate compartment to the healthy compartment to realign the lower limb.[33] As a result, this procedure interferes little with soft tissues and often has no harmful effects on the stability and mobility of the knee joint.[34]

In the literature survey, we found 19 systematic reviews and meta-analyses describing the outcomes of 8,412 patients with a mean age of 51 ± 7 years (►**Figs. 5** and **6**).

High tibial osteotomy comprises two main techniques: closing-wedge HTO (CWHTO) and opening-wedge OTA (OWHTO).[34] These procedures may occur proximal or distal to the knee joint. In general, if knee OA is in the medial compartment, HTO is most commonly performed by operating on the upper tibia. In OA affecting the lateral compartment, HTO is usually performed on the lower femur. However, one must always measure the distal lateral femoral angles and the medial proximal tibial angle to optimize the correct osteotomy location and whether it will be an addition

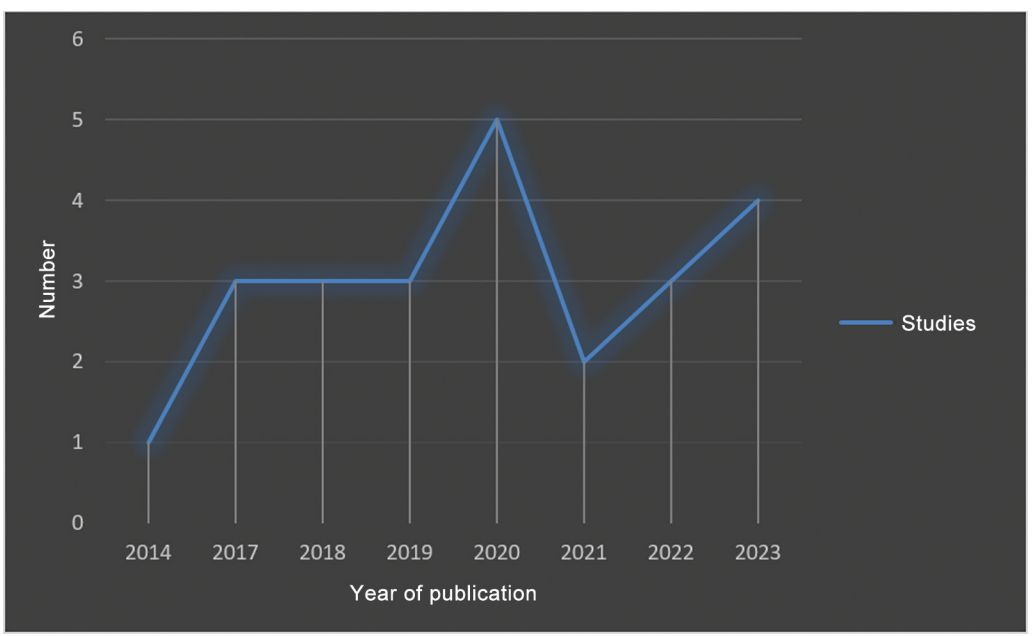


Fig. 4 Temporal description of the literature included by year of publication.

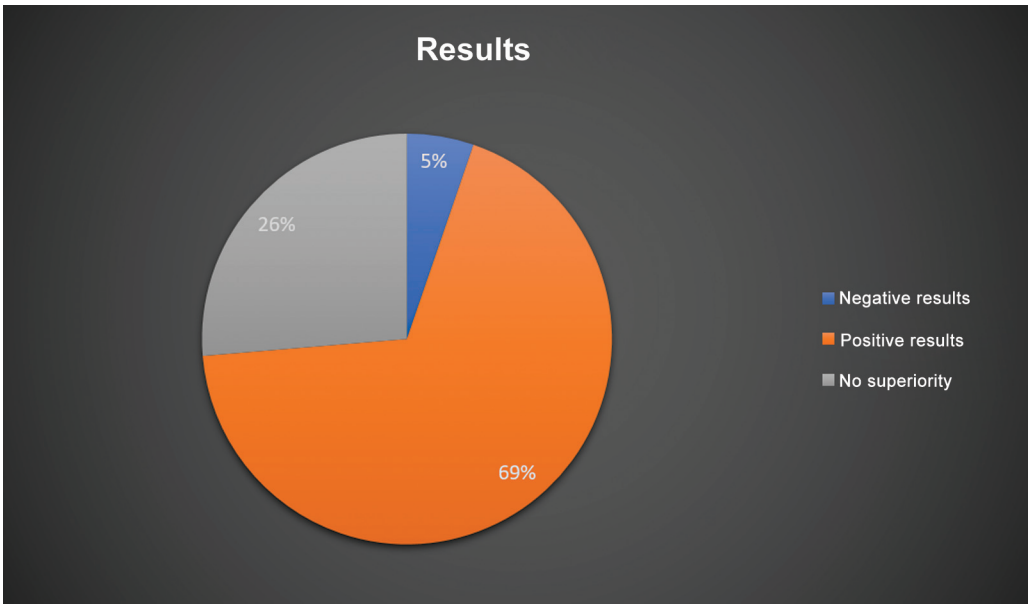


Fig. 5 Graphical representation of the outcomes of studies assessing osteotomy for the treatment of knee degenerative disease.

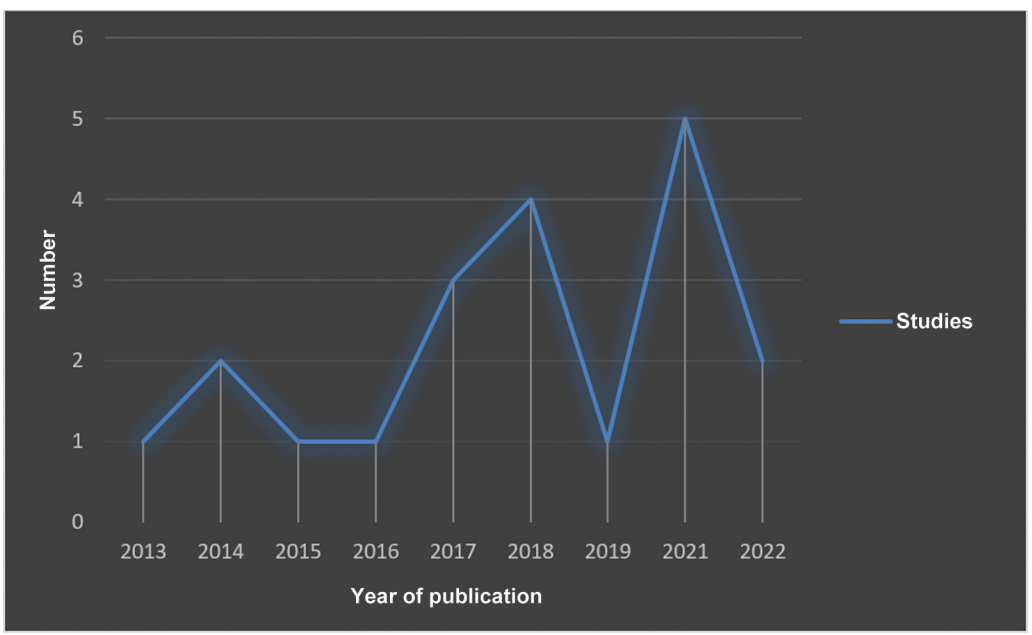


Fig. 6 Temporal description of the literature included by year of publication.

or subtraction following the principles described by Paley and Tetsworth.[35]

The indication for HTO includes young, active subjects, often under the age 50. Several factors may influence HTO outcomes.[36] Valeiy Evgenievich et al.[37] demonstrated a greater efficiency of HTO in the second stage of knee OA than in the third stage. These authors also noted that age and correction angle do not affect the outcome, but high BMI is associated with worse results and complications. The literature heterogeneously reports its imprecision, including lower functional outcomes, OA progression, and conversion to arthroplasty.

Lastly, HTO is an autonomous treatment, but the process of limb alignment intrinsically relates to the joint and stabilizing knee structures. Therefore, one must consider combining HTO with other osteotomies and arthroplasties. In addition, it may be a treatment strategy in procedures aiming to stabilize the knee and restore the cartilage.

Indications

High tibial osteotomy is suitable for young patients, especially those with OA and partially preserved cartilage. For knee biomechanics correction, the highest efficacy of HTO

occurs in patients with second-stage knee OA compared to the third stage.

Proximal fibular osteotomy (PFO) is more suitable for patients with many complications and low surgical tolerance, as it can reduce operative time, intraoperative bleeding, hospitalization time, and postoperative complications, with some advantages.

Non-surgical Treatments

Pharmacological Therapies

Pharmacological therapy for OA is purely symptomatic and, in most cases, successfully assures the maintenance of the patient's mobility. It may include paracetamol, topical or oral non-steroidal anti-inflammatory drugs (NSAIDs), or intra-articular corticosteroids. Although paracetamol is a drug of considerable efficacy, safety, and low cost, the Osteoarthritis Research Society International (OARSI) guidelines recommend its administration in conservative doses and periods because of the increased risk of gastrointestinal and liver disorders.[38]

In parallel, NSAIDs are the first-line pharmacological treatment for OA, with evidence proven by placebo-controlled trials. Topical NSAIDs often result in less gastrointestinal toxicity than oral NSAIDs. However, one must discuss alternatives to NSAIDs for patients who are susceptible or present risk factors for the adverse effects of the medication. It is worth highlighting that drugs should complement, not replace, the non-pharmacological treatment.

Indications

Patients with symptomatic OA.

Intra-articular Infiltrations

Biological therapies have been increasingly sought after as alternatives for OA treatment. Intra-articular infiltrations stand out as treatments approved by the Food and Drug Administration (FDA) and the European Medicines Agency (EMA).[39] These infiltrations enable the administration of a concentrated drug dosage and its distribution locally and throughout the joint. Thus, these drugs can access places that it would not with oral intake. Furthermore, IA infiltrations offer much better bioavailability and limit the systemic drug passage, reducing the risk of side effects.[39,40]

Indications

Intra-articular infiltrations are an adjuvant therapy for OA treatment, especially in patients already under chronic systemic treatment, such as elderly subjects.

Hyaluronic Acid (HA)

A natural substance found in the synovial fluid surrounding joints, HA is a polysaccharide from the glycosaminoglycan family that smoothly reduces attrition during movement, cushioning the shock between loads. Subjects with OA present lower HA levels. Therefore, exogenous HA infiltrations can help restore the elastic and viscous properties of the synovial fluid, minimizing pain and improving function.[12] Hyaluronic acid also increases shock absorption, provides synovial fluid lubrication, and acts on joint nociceptive response with reflex quadriceps muscle inhibition. The anti-inflammatory, analgesic, and chondroprotective action of HA results from the modulation of intra- and extracellular inflammation cascades. In addition to being safe and effective in treating pain due to patellar chondropathy, it improves mobility and slows down the degenerative process.[8]

Russu et al.[41] investigated the treatment of knee OA with HA derivative infiltrations and observed satisfactory outcomes six months after the procedure, showing therapeutic efficiency in treating moderate to severe knee OA. In contrast, HA application alone yielded less significant outcomes concerning pain in patients under treatment when compared to HA combined with platelet-rich plasma (PRP).[42]

However, some authors mention the occurrence of allergic side effects related to the product's origin. Pain and swelling after injection may result from the high molecular weight and different pharmaceutical formulations of HA. The other major challenge of HA treatment is the need for multiple injections to obtain the desired efficacy. As such, multiple injections could result in more cost, pain, and potential infection. Therefore, updates and innovations in single-dose high molecular weight medications have gained prominence in the therapeutic arsenal, with good outcomes in the joint functional status.

Indications

Infiltration of HA is an adjuvant therapy for OA treatment, mainly regarding symptoms and function, but its evidence still lacks scientific strength.

Platelet-Rich Plasma (PRP)

A blood-derived product with a high platelet concentration in a small plasma volume, PRP plays a role in the release of several growth factors (insulin-like growth factor 1 [IGF-1], platelet-derived growth factor [PDGF], epidermal growth factor [EGF], vascular epidermal growth factor [VEGF], and transforming growth factor-β [TGF-β]). All of these molecules act in the initial phase of healing and tissue regeneration. The type of growth factors in PRP and their levels vary in each subject. Moreover, its mechanism is not fully understood, and it is difficult to determine the effects of each type of factor.[43] The use of PRP in studies has already demonstrated considerable and complex biological activities, such as cell proliferation, anti-apoptotic activity, cartilage regeneration, collagen synthesis, and angiogenesis maximization.[43]

Saita et al.[44] studied 517 patients receiving 3 PRP injections and analyzed the outcomes per the severity of knee OA. The authors state that the therapy is approximately 60% effective depending on the severity of the disease. Furthermore, this efficacy is independent of age, gender, body weight, or platelet count.[44,45] Knop et al.,[46] based on RCTs, reported that PRP significantly improves joint pain and function when compared with HA, including sustained response for up to two years in milder knee OA cases.

Furthermore, it is worth highlighting that the Brazilian Federal Council of Medicine (Conselho Federal de Medicinas,

CFM, in Portuguese), in its Resolution no. 2,128/2015, considers PRP an experimental procedure and only allows its use in clinical trials within the protocols of the Brazilian Research Ethics Committee/Research Ethics National Committee (Comitês de Ética em Pesquisa/Comissão Nacional de Ética em Pesquisa CEP/CONEP, in Portuguese) system. Likewise, the Brazilian National Health Regulatory Agency (Agência Nacional de Vigilância Sanitária, ANVISA, in Portuguese), in Technical Note no. 12/2015, ratified the experimental use of PRP as a product with no proven therapeutic utility, requiring more scientific evidence for clinical use.

Indications

Platelet-rich plasma is an adjuvant therapy for OA treatment, mainly concerning pain; it significantly improves pain and joint function compared to HA, including sustained response for up to two years in milder cases of knee OA.

Stem Cells

Stem-cell therapy emerges as a milestone in regenerative medicine for knee OA treatment, and its potential is deemed high.[47] Mesenchymal stromal/stem cells (MSCs), such as bone marrow, adipose tissue, and synovium stem cells, aid in damaged cartilage regeneration and are reportedly safe.[48]

In a trial,[49] nine patients diagnosed with knee OA received a single injection of adipose-derived mesenchymal stem cells (AD-MSCs) at a concentration of $0.5–1.0 \times 10^7$ cells. The follow-up period was of 18 months. The results showed significant improvement in all aspects evaluated in the initial six months, being sustained up to the end of the treatment.[49] An RCT by Chen et al.[50] assessed the safety and efficacy of allogeneic adipose-derived stem cells (ADSCs; ELIXCYTE, UnicoCell Biomed Co., Ltd., Taipei, Taiwan) infiltration for knee OA treatment. Patients either received one dose of HA or three doses of ELIXCYTE. ELIXCYTE was more effective than HA, providing an early pain reduction and functional improvements.[50]

Although studies have shown that MSCs yield promising results in improving patients' clinical and structural conditions, there is still limited evidence, a lack of procedural standardization, and no long-term advantages.

Indications

Mesenchymal stem cells are adjuvant therapy for OA treatment, mainly for pain.

Prolotherapy with dextrose

The fundamental principle of dextrose prolotherapy is the injection of small volumes of an irritating solution into areas of painful attachments (ligaments, tendons, and adjacent joint spaces) at several treatment sessions. The mechanism of action remains unclear. However, hypotheses suggest that prolotherapy stimulates local healing of chronically-damaged extra- and intra-articular tissue, but with no definitive evidence. The literature[51] reports that prolotherapy injections may be appropriate to treat the multifactorial cause of OA-related knee pain.

Indications

Dextrose prolotherapy is an adjuvant method for OA treatment, mainly concerning pain, but there is no current evidence about it.

Genicular Nerve Block

In the literature survey, we retrieved seven randomized studies and one systematic review.

Genicular nerve block (GNB) is a therapeutic alternative aimed at blocking the three sensory nerves of the knee: the lateral and medial superior genicular nerve and the medial inferior genicular nerve. The block hinders the transmission of pain to the central nervous system and results in functional improvement.[52] Ultrasound can guide GNB, enabling direct visualization of the structures and real-time control of the anesthetic application.[53] Thus, the block is performed more efficiently, generating lower latency, dependence on anatomical information, and lower use of the anesthetic solution, in addition to providing greater safety.[54]

A study[54] analyzed four elderly patients with advanced knee OA, presenting limited movement and chronic pain, who underwent ultrasound-guided GNB. The outcomes were satisfactory, with a significant improvement in pain and functional capacity and no complications.[54] A twelve-week analysis[55] compared the efficiency of IA block therapy and GNB. Both techniques resulted in satisfactory outcomes, minimizing pain, improving nighttime sleep quality, and facilitating the performance of daily activities. However, the study reports that GNB represents a safer, minimally-invasive, and highly-efficient alternative.[55]

Indications

There is reasonable evidence to at least target the superior medial genicular nerve, the inferior medial genicular nerve, and the inferior medial genicular nerve using local anesthetics, corticosteroids, or alcohol to reduce pain and improve knee function in patients with chronic knee OA under ultrasound guidance. The procedure is safe, but more research is needed to determine the ideal interventional approach.

Acupuncture

Acupuncture is a well-known technique to treat several conditions by inserting fine needles in specific anatomical points.[56] Studies on acupuncture to minimize knee OA pain and provide functional rehabilitation have been increasing, demonstrating that this therapy acts to mitigate symptoms due to the activation of various chemical elements that present bioactivity through peripheral, spinal, and supraspinal mechanisms.[57]

Teixeira et al.[6] evaluated the treatment of two patients with knee OA through one weekly, thirty-minute acupuncture session (for six weeks) at four local points. The researchers[6] reported pain minimization and increased range and mobility of the knee joint flexion, demonstrating that the technique is efficient as an alternative or complementary treatment for OA, even in a short period. In general,

acupuncture can improve the subjective perception of the quality of life of patients with OA, enabling a better performance of daily activities. Nevertheless, one must consider factors such as the number and duration of acupuncture sessions, the patient's health status, and the time of prevalence of the disease.

Indications

Acupuncture plays a role in OA treatment, especially concerning pain.

Physical Exercises

Clinical guidelines for knee OA management suggest that patients should receive a core set of non-pharmacological interventions, including education, weight loss, and low-impact exercise (strengthening, cardiovascular exercise, and/or mind-body exercises, such as yoga or tai chi).[58] A recent systematic review[59] evaluated different RCTs on the effectiveness of land-based physical activities for patients with knee OA. In these studies, patients with this joint condition either underwent exercises or did not perform exercises or receive any treatment. The authors[59] found that the group performing land-based physical activities consistently presented reduced pain and improved their physical shape and quality of life.

Indications

Current research[60] indicates that aerobic activity for 150 minutes a week at moderate intensity, moderate/vigorous physical activity, or muscle strengthening exercises 2 days a week bring many benefits to subjects with preexisting knee OA.

Miscellaneous Interventions

Another therapeutic resource is the lateral wedge insole. Recent research[61] concluded that a customized external orthosis (fixed below the sole) resulted in a higher improvement in pain and functional status than a control orthosis. Likewise, varus or valgus correction orthoses (altering biomechanics) and shifting the load to the least compromised compartment are alternatives to gain function and improve pain.

Final Considerations

Knee OA is a highly prevalent and disabling disease. In the past few years, we gained significant information about the cause and pathogenesis of OA, leading to a new era in OA therapy. However, management should not be generalized and requires adaptation according to each subject, enabling the establishment of the ideal intervention for each case.

Changing lifestyles, practicing physical exercise, and acupuncture, among others, are minimally-invasive methods for initial treatment, leaving surgical procedures as alternatives for cases in which these methods do not provide satisfactory responses. Therefore, the search for disease-modifying drugs for OA treatment has become a priority in orthopedics. Hyaluronic acid is safe and effective in treating OA-related pain in the knee and other joints, confirming that it may have some disease-modifying properties.

In conclusion, further studies on this topic are required to achieve better scientific knowledge and then understand and fill the remaining gaps.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Arthroscopy-assisted Procedures in Hand and Wrist Surgery: An Update. Where Are We So Far?

Procedimentos assistidos por artroscopia no punho e na mão: Atualização. Onde nós estamos?

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Abstract

Wrist and hand arthroscopy, despite being an old tool, has gained popularity and advanced in assisting in the treatment of various injuries and conditions in the region in recent years. Dorsal, volar, ulnar, and radial accessory portals are used to reach all points of the carpal and hand joints. The minimal tissue damage, lesser injury to the capsule and its mechanoreceptors, the assessment of injuries associated with the reason for surgery, and aesthetically more favorable scars have attracted many doctors and their patients. As a result, there has been an increase in publications and diversifications of arthroscopic techniques. The aim of this update article is to present the advances and the evidence available in the literature to assist readers in their decision on which technique to use in the treatment of wrist and hand conditions.

Keywords
- arthroscopy
- pseudarthrosis
- scaphoid bone
- synovial cyst
- wrist

Resumo

A artroscopia de punho e mão, apesar de ser uma ferramenta antiga, tem ganhado popularidade e avançado no auxílio do tratamento das mais diversas lesões e doenças da região nos últimos anos. Utilizam-se portais acessórios dorsais, volares, ulnares e radiais para se alcançar todos os pontos das articulações do carpo e da mão. O menor dano tecidual, a menor lesão da cápsula e de seus mecanoceptores, a avaliação de lesões associadas ao motivo da cirurgia e as cicatrizes esteticamente mais favoráveis têm atraído muitos médicos e seus pacientes. Com isso, houve um aumento das publicações e diversificações de técnicas artroscópicas. O objetivo deste artigo de atualização é mostrar os avanços e o que temos de evidência na literatura para apoiar os leitores na sua decisão sobre qual técnica utilizar nos tratamentos das doenças do punho e da mão.

Palavras-chave
- artroscopia
- cisto sinovial
- osso escafoide
- pseudartrose
- punho

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Introduction

Arthroscopy has become an indispensable tool in the arsenal of the contemporary hand surgeon. Most procedures can be performed arthroscopically or hybridly, allowing the use of smaller incisions and less damage to healthy tissues, a fundamental step towards early postoperative recovery and better functional results.

Through good anatomical knowledge and classic open procedures, the surgeon was able to introduce the arthroscope (about 3mm in diameter) into their daily routine, replacing larger incisions with small portals. The main portals used are the dorsal ones. In the radiocarpal joint the 3-4 (between the 3rd and 4th extensor compartments) and the 6R, radial to the extensor carpi ulnaris. In the midcarpal joint, the radial midcarpal (MCR) and ulnar midcarpal (UMC), both 1cm distal to the radiocarpals, radial and ulnar to the 4th extensor compartment. They were developed to cover most procedures, becoming routine and sufficient for the surgeon at the beginning of their learning curve. Assistance in joint reduction of fractures of the distal end of the radius and scaphoid and synovial cysts are great examples of this (►**Fig. 1**).

However, technical improvement and the emergence of more complex procedures have made it necessary to develop new techniques and new portals, with specific portals for each pathology, specific portals for certain joints and with greater exploration of volar portals.[1–3]

The objective of this work is to point out how far we have come with arthroscopy to treat diseases and injuries that affect the wrists and hands.

To make reading easier, we will divide the article by the pathologies treated.

Dorsal Synovial Cysts

The first technical description of arthroscopic resection of synovial cysts by Osterman and Raphael[4] demonstrated that dorsal cysts could be safely treated using this tool, generating similar recurrence rates and with lower rates of stiffness, postoperative pain and aesthetically unsatisfactory scarring. Later authors corroborated Osterman's results and described his variations of the technique. The most widespread are Kim's,[5] or radiocarpal technique, in which the cyst is approached through portals 3-4 and 4-5 (or 6R) and a capsulectomy is performed over the entire region of the cyst, and Mathoulin and Gras's,[6] or transcyst, in which the UMC and RMC portals are used. The shaver often passes through the cyst when creating the RMC portal, hence the name "transcyst". The original technique includes reconstruction of the dorsal capsulo-scapholigamentary septum, better known by its acronym in DCSS. The authors of this article do not recommend this reconstruction method for cysts not associated with scapholunate ligament instability. In the case of instability, there are several options for repairing or reconstructing the ligament. It is worth noting

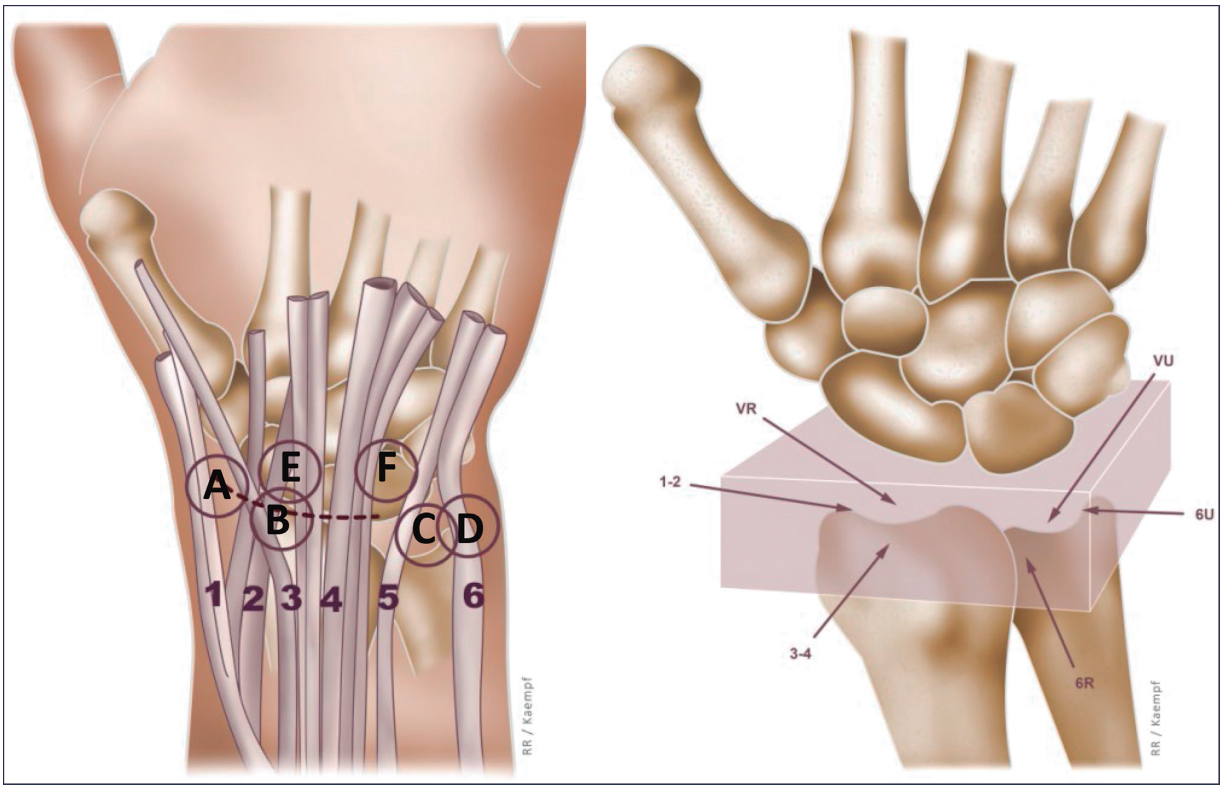


Fig. 1 Wrist arthroscopy portals. A: portals 1-2, B: portals 3-4, C: portal 6R, D: portal 6U, E: radial mid-carpal portal (RMC), F: ulnar mid-carpal portal (UMC). VR: volar radial, VU: volar ulnar.

that complete resection of the cyst is not necessary. The important thing is to create a "window" in the cyst wall to drain its contents.

The recurrence rate varies widely in the literature, suggesting the likelihood of bias in some studies, with the real incidence of lesion recurrence being unclear. A study pointed out some factors that may be associated with this, such as dominant side, female sex and young patients.[5] The location or not of the pedicle was not associated with an increase in recurrences, corroborating our clinical observation and that of other authors that this is not an obligatory step for the quality of the procedure. In fact, one study found that the vast majority of dorsal cysts present as a diffuse cystic mass and capsular redundancy, without the visualization of a classic pedicle image.[7] We also agree with this observation in our practice. Another important fact is that the presence of underlying pathologies does not seem to worsen postoperative results in terms of pain, function and cyst recurrence, as long as they are treated simultaneously in the same procedure.[8] This could be considered an advantage of treating cysts arthroscopically, in order to identify and treat these injuries, mostly injuries of the triangular fibrocartilage complex (TFCC) and injuries of the intrinsic ligaments of the first row. Some lesion associated with the dorsal synovial cyst is found in approximately 50% of patients undergoing arthroscopy for resection of the lesion. Most of these patients would remain undiagnosed if the resection was performed open.[8]

As can be inferred, a significant portion of the studies places a great emphasis on the outcome of "recurrence" when discussing synovial cysts treated through arthroscopy. The use of methylene blue was introduced to facilitate the localization of the lesion and its pedicle.[9] There is no overwhelming evidence that its use is superior, requiring comparative work. In any case, the authors have good experience with both techniques, and the use of intraoperative dyeing is at the discretion of the surgeon.

Volar Synovial Cysts

With the spread of arthroscopic treatment of dorsal cysts and the improvement of techniques, associated with the good functional and aesthetic results obtained, its use expanded to include volar cysts. Ho et al.[10] were the first to publish a series of arthroscopic treatment of volar cysts originating predominantly in the radiocarpal joint, showing good results. This represented a break with the paradigm that the presence of noble volar structures would prevent the procedure from being performed properly, with a greater risk of complications and recurrence. In fact, the procedure proved to be safer than the open technique in some studies,[11] except in cases of midcarpal joint cysts. Injury to noble structures in the open approach, especially the radial artery, tends to be more extensive. Other series have also demonstrated good satisfaction rates with arthroscopic treatment and a low rate of complications, such as recurrence.[12,13] A caveat presented in these series is the radiocarpal origin of the cyst, with mediocarpal cysts excluded from the casuistry. One justification provided by these authors is that, in addition to the greater instrumentation difficulty due to limited space, mediocarpal cysts are more superficial and farther from volar neurovascular structures, reducing the advantage of arthroscopic treatment and suggesting an open technique.

More recently, the same group that pioneered arthroscopic treatment of volar cysts published the technique and a small series of scaphotrapeziotrapezoid joint (STT) cysts, demonstrating that the method is feasible and safe with good results.[14] They used specific STT portals for lesion excision, further expanding the use of arthroscopy, now for mediocarpal cysts.

Another tool that has proven useful as an adjuvant in the treatment of cysts is ultrasound.[5] Its use is justified both by the greater ease in locating the lesion and by the protection of adjacent healthy structures, such as tendons, nerves and vessels. This same group, with the expansion of its series, observed that the aid of ultrasound is more useful for volar cysts than for dorsal cysts, with no recurrence of volar cysts in their series of more than 40 patients treated.[15]

Scaphotrapezoidal joint (STT)

Osteoarthritis of the STT joint (OA-STT) has a high incidence in the population, reaching more than 80% of individuals over 80 years of age in cadaveric studies.[16] Even in symptomatic cases, with pain at the base of the thumb and weakness of the pinch, making daily activities difficult, such as opening a bottle, other conditions usually coexist that justify the symptoms, such as trapeziometacarpal arthrosis and scapholunate injury/carpal instability.[17] Arthroscopy has become an important tool in the management of OA-STT as it allows, in the same procedure, the diagnosis and staging of the injury, the diagnosis of possible associated injuries and definitive treatment, which is difficult to achieve with open techniques, in which only the target joint will be addressed.

The treatment rationale should be guided by the presence of isolated OA-STT or concomitant carpometacarpal arthrosis (peritrapezial arthrosis) or carpal instability (DISI).[18] For cases of isolated OA-STT, some procedures can be performed with arthroscopic assistance, such as simple synovectomy, resection of the distal pole of the scaphoid, STT arthrodesis, capsular or tendon interposition arthroplasty and interposition arthroplasty with silicone implant or pyrocarbon.[19]

STT is traditionally approached through the RMC portal for visualization, with the creation of the STT dorsal ulnar portal (STT-U) "from the outside in", introducing an ulnar needle to the extensor pollicis longus (EPL), in line with the edge radial of the second metacarpal. More recently, new portals have been added, allowing access to all portions of the joint. Perez Carro et al.[20] introduced the radial dorsal portal of the STT (STT-R), made immediately radial to the abductor pollicis longus (APL) tendon. Baré et al.[21] described in the same year a palmar portal of the STT (STT-P) easily created by palpating the ALP, the scaphoid tubercle, the radial styloid and the base of the first metacarpal.

Regarding treatment, Ashwood et al.[22] demonstrated good short-term postoperative symptomatic relief with

simple arthroscopic synovectomy, offering low morbidity in cases of isolated OA-STT, and can be a good tool before proceeding to more invasive treatments, similar to what has been performed on the knee for decades. Iida et al.[23] studied the impact of arthroscopic resection of the distal pole of the scaphoid and found good results, as long as the resection did not exceed 3 mm and there was no associated carpal instability (DISI). Luchetti et al.[24] found similar results, adding that the technique does not contraindicate cases of associated trapeziometacarpal arthrosis, as long as it is treated concomitantly. Mathoulin and Darin[25] had already published their series using this same technique, with the exception that, in the long term, an impingement phenomenon could occur at the joint level, justifying the addition of pyrocarbon implants to maintain physiological carpal height. This may also be advantageous in the case of concomitant DISI, where simple resection may worsen long-term instability, justifying some interposition.[18]

STT arthroscopy can also be performed in combination with the trapeziometacarpal (TMC) joint approach, adding to the main procedure (trapeziectomy, hemitrapeziectomy with or without interposition) partial resection of the trapezoid and/or the distal pole of the scaphoid in cases of combined TMC-STT osteoarthritis, improving postoperative results in terms of mobility and pain.[18,19]

STT arthrodesis, despite being widespread, does not appear to be a satisfactory solution, associated with a long period of immobilization, severe loss of range of motion and high rates of complications, such as non-union.[18]

Rhizarthrosis

The concepts of open procedures were brought into arthroscopy to offer options with greater preservation of the soft tissue envelope in trapeziometacarpal osteoarthritis. The most commonly used traditional techniques, despite showing good results in the literature, require significant capsuloligamentary violation and bone manipulation, with potential postoperative impacts in terms of pain and time to functional recovery. The lack of consistent evidence of superiority among traditional techniques (simple trapeziectomy, trapeziectomy with interposition, trapeziectomy with suspensionplasty) also leaves room for considering more tissue-preserving procedures. Arthroscopic hemitrapeziectomy is an example of this, allowing the resection of the contact surface between the metacarpal and the trapezium without violating the capsuloligamentary envelope.[26] The addition of interpositions, synthetic or biological material, such as tendons and fascia, has also been widely tested, being an alternative, however without consistent evidence of superiority to simple resection in controlled and randomized studies.[27] Studies with fat grafting as an alternative to interpositions have also been published, proclaiming a possible chondral regenerative effect induced by adipose stem cells.[28] More recently, techniques combining partial trapezius resection with button suspensionplasty have had the advantage of preventing metacarpal sinking in a proximal direction.[29] Arthrodesis, attractive to patients who require greater clamping force, also proved to be feasible through arthroscopy.[30] Even arthroscopic synovectomy without trapezius resection appears to offer good results in the short and medium term.[31] A meta-analysis demonstrated that arthroscopy-assisted techniques are a good alternative when conservative treatment fails, with less morbidity.[32]

Kienböck's disease

In order to determine the treatment for Kienböck Disease, in addition to the Litchmann classification, the Bain and Begg classification is used,[33] which is based on the number and location of "non-functional" joints of the lunate and its surroundings, diagnosed by arthroscopy. A nonfunctional joint is one that has extensive fibrillation, cracks, localized or extensive joint damage, and a floating joint surface. When diagnosing bad joints, partial wrist arthrodeses can be planned and openwork and fixation performed for these fusions.

Fracture and Intra-articular Osteotomy of the Distal Radius Region

Arthroscopy is a tool to assist or check joint reduction in the distal region of the radius. Saab et al.,[34] in their meta-analysis published in 2019, came to the conclusion that the use of arthroscopy helped in the diagnosis and simultaneous treatment of ligament injuries associated with fractures of the distal region of the radius, such as injury to the scapholunate ligament (SLL) or the triangular fibrocartilage complex (TFCC). However, there is no evidence in the literature that proves that arthroscopy guarantees a better reduction of joint fragments or better functional results.

In the authors' opinion, arthroscopy, for selected cases, brings many benefits, not only in the diagnosis of associated injuries, but also in the reduction of joint fragments and the certainty that the implants are outside the joint and that the fragments are stable enough for mobilization precocious.

To perform wrist arthroscopy in patients with fractures of the distal region of the radius, dry arthroscopy is recommended.[35] Not using the solution will avoid compartment syndrome, tissue infiltration and the presence of floating synovium, for example.

The recommended technique consists of performing metaphyseal reduction and positioning the locked plate and, only after this step, the wrist is placed under traction to perform the reduction or check the reduction of joint fractures and definitive fixation with screws.[36] For partial joint fractures, we can place the patient under traction and perform reduction and fixation with the aid of arthroscopy and fluoroscopy. Comminuted intra-articular fractures also benefit from arthroscopic assistance in reduction.[37] One should not forget to keep the optics in the 6R portal: over the head of the ulna, the camera does not interfere with the reduction and visualization of the dorsal fragments.[36]

Viciously consolidated radius fractures bring significant harm to patients. Arthroscopy assists in assessing the viability of articular cartilage, determining locations for osteotomies,

and allows for precise bone cuts. Similar to fractures, metaphyseal reduction should be performed without arthroscopy, positioning the plate, initiating the plan for articular osteotomies. Only after that, the patient is placed under traction, and the intra-articular osteotomy is completed.[38]

Scaphoid Fracture and Pseudoarthrosis

The role of arthroscopy in the treatment of scaphoid fractures and non-unions is progressively increasing. Slade et al.[39] published a series of 234 scaphoid fractures and non-unions treated with the aid of arthroscopy and fixed with an antegrade percutaneous method, with excellent consolidation results, reaching 99% in acute injuries, without the use of bone graft. Slutsky and Trevare[40] corroborated these results, pointing out the main objectives of arthroscopy: checking the quality of the reduction, checking the stability of the fixation with probe manipulation of the fragments and checking the position of the implants, confirming the absence of extrusion into the joint. It also pointed out its usefulness in the diagnosis of associated injuries, such as ligament injuries (transscaphoperilunar fracture-dislocation). These injuries were successfully treated arthroscopically in some series, and could replace open techniques, which until recently were the gold standard.[41] The possibility of grafting and approaching the ligament components by arthroscopy offers a more biological solution to the traditional open approach. Caloia et al.[42] found previously undiagnosed associated injuries in 15 of the 24 cases of scaphoid fractures treated arthroscopically, favoring the use of the tool. Geissler[43] also contributed to the topic, recommending percutaneous fixation associated with arthroscopy in athletes with scaphoid fractures as an alternative to conservative treatment, even in non-displaced fractures. Due to the prolonged period until consolidation, this method would favor the maintenance of function and an earlier return to sporting activities. In this article, the author also detailed his fixation method, which allows arthroscopic localization of the screw entry point, without the need for multiple fluoroscopy and without the need for hyperflexion of the wrist.

The good results in acute scaphoid fractures and fracture-dislocations have led to many studies on non-unions. Several authors have already demonstrated that arthroscopic treatment of these injuries is not only feasible, but also presents similar or superior results to traditional techniques, when well indicated. Cognet et al.[44] published a series of 23 treated patients, with a consolidation rate of 100%. They highlighted that the arthroscopic view facilitates the removal of all devitalized tissue and that positioning in traction helps to reestablish the normal realignment of the bone (►**Fig. 2**). Ecker et al.[45] exposed the good results even for cases of pseudoarthrosis of the proximal pole, with high union rates. Initially, pseudarthroses with large humpback deformity and great instability were excluded from arthroscopic treatment series, however it is known that even these injuries can be treated with the aid of arthroscopy, with good results. Kim et al.[46] emphasize that, even though there is limited potential for restoring the normal length of the scaphoid in unstable pseudarthrosis, the functional results are satisfactory, possibly due to less aggression to healthy tissues and restricted vascular violation in relation to open techniques. The same applies to the early stages of SNAC, which currently does not represent a contraindication. Regarding the possibility of dispensing with the use of a graft, studies indicate that, in cases of stable pseudarthrosis and without carpal collapse / DISI, fixation without the use of a graft is sufficient to achieve union.[47]

The scope of arthroscopy in the treatment of acute and chronic scaphoid injuries has been shown to be broad, with advantages over traditional techniques in terms of allowing the identification and treatment of associated pathologies, such as intrinsic ligament injuries, in allowing the optimal positioning of implants in the percutaneous fixations, aiding in debridement and reduction of fragments under direct visualization and greater preservation of the soft tissue envelope, favoring consolidation and good functional results.

Scapholunate Ligament (SLL) Injury

The treatment of scapholunate ligament injuries is one of the greatest challenges in hand surgery. Many of these injuries go unnoticed in the acute phase, when repair is possible. Lack of adequate treatment leads to a pattern of carpal osteoarthritis known as scapholunate advanced collapse (SLAC).[48]

In order to choose the best treatment for the patient, Garcia-Elias et al.[49] formulated 5 questions regarding important parameters for these injuries and described a 6-stage classification for them.

There are a myriad of possible treatments, which aim to restore the normal relationship between the scaphoid and lunate, recovering mobility, strength and function of the wrist in each of these stages. None proved to be absolutely superior to the others.

In this context, arthroscopy-assisted techniques for repair, reconstruction or salvage techniques have emerged and are emerging, with the idea of being less invasive, causing less morbidity and providing better results than conventional techniques.

For stage I, when the dorsal LES is intact, also known as pre-dynamic injury, percutaneous or arthroscopy-assisted fixation is indicated, with or without ligamentoplasty and dorsal capsulodesis.[50]

For stage II, when there is rupture of the dorsal and volar SLL, ligamentoplasty and dorsal [50] e and volar[36] capsulodesis, can be performed, with scapholunate fixation with Kirschner wires or scapholunate screw (RASL) assisted by arthroscopy.

In stages III (complete, irreparable SLL injury) and IV (stage III with reducible scaphoid rotation), different types of reconstruction of the scapholunate ligament can be performed. The classic techniques are dorsal capsulodesis or Brunelli reconstruction or Brunelli modified by Garcia-Elias. The techniques that are currently gaining more followers are those that perform 360º repair, such as that of Corella et al.[51]

For stages V (irreducible scaphoid rotation) and VI (arthrosis secondary to SLL injury), partial and total arthrodesis of the wrist and resection of the proximal row of the

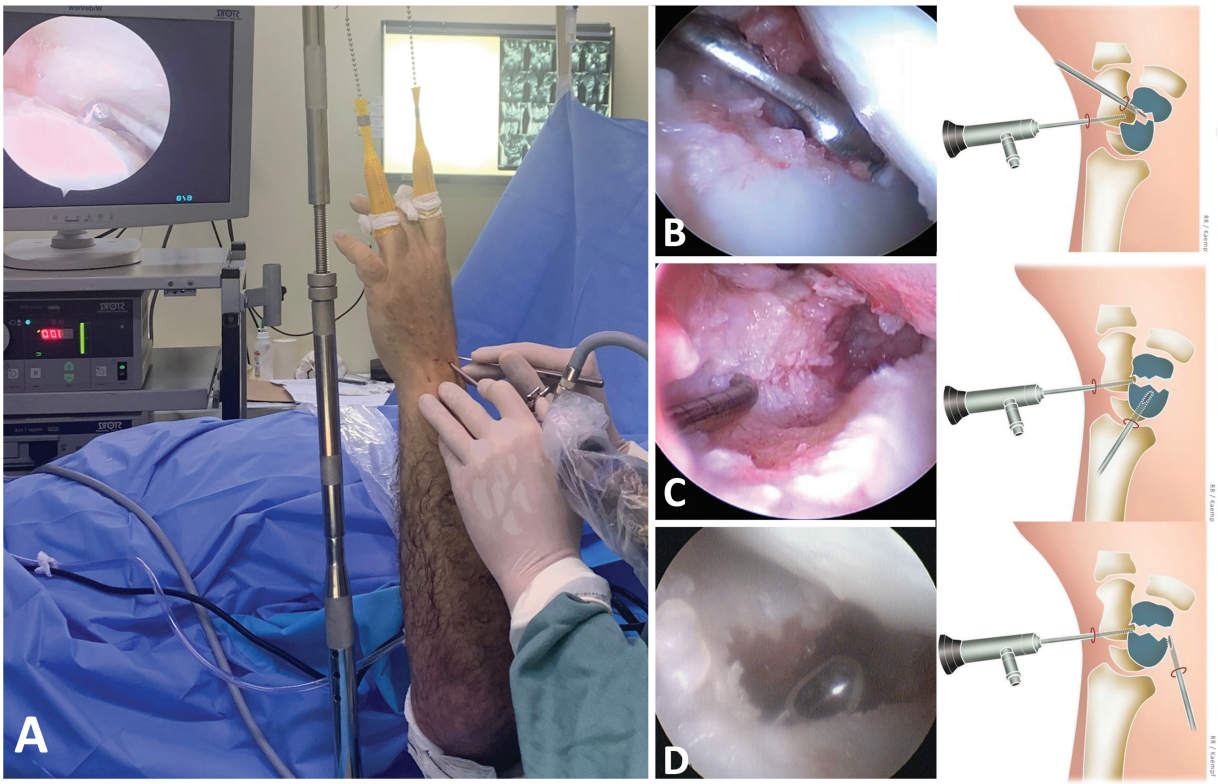


Fig. 2 Wrist arthroscopy for scaphoid non-union treatment. A: patient positioning. B: Scrapping of the scaphoid non-union with a curette through the radial mid-carpal portal. C: Scrapping and positioning through the radiocarpal portal. D: Scrapping through the volar aspect of the scaphoid.

carpal bones are indicated. There are several authors in the literature who demonstrate that it is feasible to perform these procedures assisted by arthroscopy. There is still no evidence, however, that minimally invasive procedures are advantageous over traditional techniques.

Perilunar Carpal Dislocation and Perilunar Carpal Fracture-Dislocation

Since wrist arthroscopy can assist in the reduction and fixation of radius and scaphoid fractures, as well as in the repair of carpal ligaments, it has become an option for aiding in the reduction and treatment of carpal fracture-dislocations. Although there is a study in the literature demonstrating the superiority of arthroscopic assistance,[52] we will need more articles to ensure that this is the best technique. However, we advise caution in indicating arthroscopy for these injuries, as extensive capsular damage and significant instability pose significant technical challenges in the arthroscopic procedure.

Injury of the Triangular Fibrocartilage Complex (TFCC)

This is one of the most indisputable indications for wrist arthroscopy today. Since Palmer's classic article,[53] which classified traumatic and degenerative TFCC injuries, much has been studied about the anatomy and functions of this ligament complex. Those who have experienced open surgery for ulnar disinsertion of the TFCC have often had difficulty both in identifying the correct tissue and in defining the site for reinsertion of the TFCC.

Performing TFCC debridement and evaluating chondropathy of the lunate, triquetrum and head of the ulna via an open approach seems a distant reality. The tissue damage would be very large and the assessment incomplete.

The 2008 article by Anderson et al.[54] demonstrated no significant differences in patient function and mobility between arthroscopic and open TFCC repair. However, only the latter performed foveal reinsertion of the ligament. In 2009, Atzei[1] published his work on arthroscopic foveal reinsertion of the TFCC, which gained popularity and gained recognition around the world. In this same article, he proposed a TFCC classification for ulnar peripheral traumatic injuries (Palmer Class 1B) (►**Fig. 3**).

This classification allowed an algorithm to be designed for the treatment of peripheral ulnar TFCC injuries and their sequelae. Injuries without foveal disinsertion can be repaired with peripheral stitches between the capsule and the TFCC, injuries with proximal avulsion must be reinserted into the fovea, irreparable injuries must be reconstructed and arthroplasties and arthrodeses (Sauvè-Kapandji) can be performed for patients with injuries cartilaginous.

Since 2009, several other authors have launched techniques for foveal TFCC reinsertion via arthroscopic[55,56] and open methods.[57]

Arthroscopic techniques for TFCC reconstruction with tendon grafts have begun to emerge. The open technique of Adams and Berger[58] is the gold standard for reconstruction of the ligament complex. However, there are several

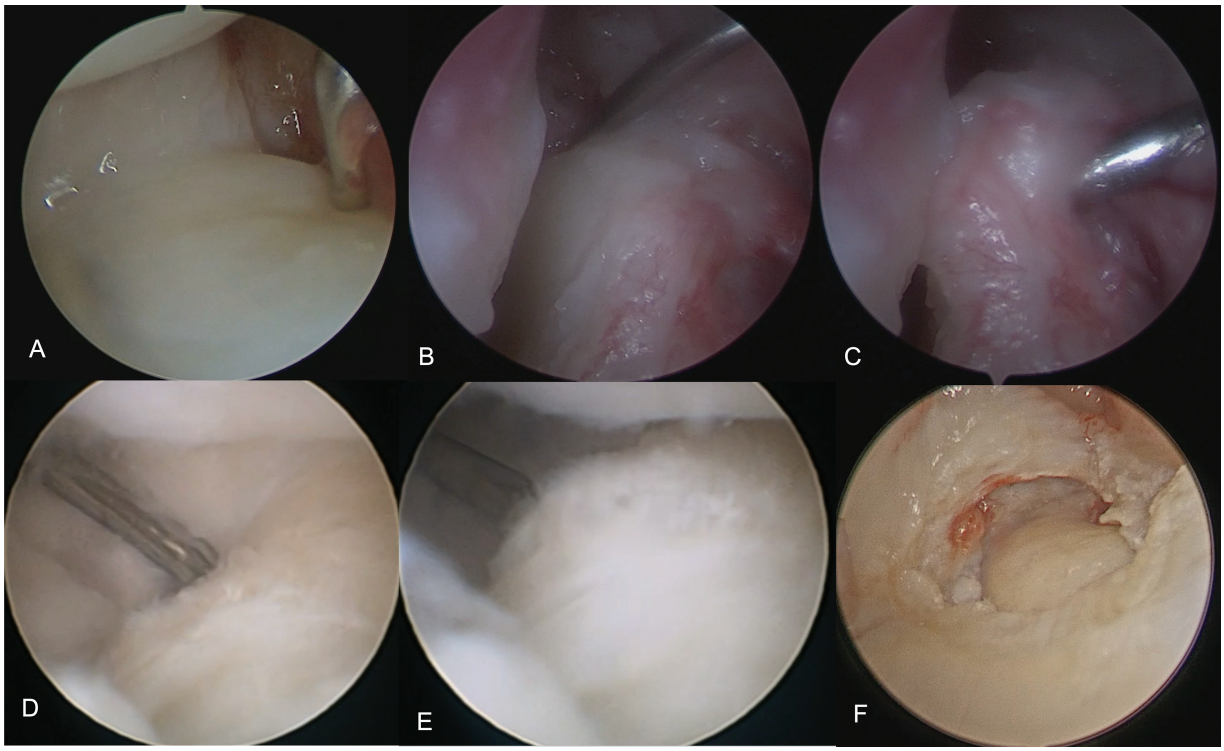


Fig. 3 Types of triangular fibrocartilage complex (TFCC) injuries. A: Distal detachment of the TFCC, class 1. B: Proximal and distal detachment of the TFCC, class 2. C: Positive "hook" test for the injury shown in figure B (class 2). D: TFCC class 4 injury with friable edges. E: The same patient as shown in figure B, with significant instability of the remaining TFCC. F: Massive irreparable TFCC class 4 injury.

techniques gaining popularity for arthroscopic reconstruction.[59–61] We believe that, over time, anatomical techniques with less joint and mechanoreceptor damage will replace open techniques.

Obviously, the distal radio-ulnar joint must be observed in all its complexity and not just the TFCC to make decisions regarding the treatment to be implemented.[62]

Discussion

Arthroscopy in the wrist and hand joints has developed very rapidly in recent years. The European Wrist Arthroscopy Society has greatly contributed to this leap in knowledge and practice, as it brought together different schools in Europe and the world around the topic.

For several procedures, we believe we are better off with the help of arthroscopy than without it. However, we must remember that arthroscopy is a method, a tool to get where we want and not the purpose of the treatment.

Conclusion

Wrist and hand arthroscopy provides assistance in the diagnosis and treatment of the vast majority of injuries and conditions that affect the region.

Ethics Committee

For this paper, we did not request an appraisal from the ethics committee because it is a technique widely used and widespread in the literature.

Our modification of the original technique did not provide any additional incisions or injuries.

Authors' Contributions:

All authors contributed equally to the study, participating in all stages of conception, writing, review and editing. All approved the final version of the manuscript.

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Conflict of Interests

The authors declare no conflict of interest.

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Results of the Surgical Approach of Idiopathic Scoliosis in Adolescents and Postoperative Quality of Life: Systematic Literature Review

Resultados da abordagem cirúrgica da escoliose idiopática em adolescentes e qualidade de vida pós-operatória: Revisão sistemática de literatura

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Abstract

Adolescent idiopathic scoliosis is considered the most severe and common spinal deformity, affecting children and adolescents still in the neuropsychomotor development phase before they reach skeletal maturity.

This study aimed to evaluate the surgical approach to adolescent idiopathic scoliosis (AIS), considering the results associated with the reduction of pathological curvature, pulmonary function, and repercussions on the quality of life of adolescents undergoing such treatment.

Systematic literature review, with a quantitative and qualitative approach to the data collected, structured according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), carried out in the databases linked to the Medical Literature Analysis and Retrieval System Online (MEDLINE) and Latin American and Caribbean Health Sciences Literature (LILACS). The total sample of the studies was 638 adolescents with AIS, with a mean age of 14.93 years $\pm$ 1.24. The mean correction of the main pathological curvature in the studies was 55.06% $\pm$ 12.24.

In all of the selected studies using posterior spinal fusion to correct AIS, there was a significant reduction in pathological curvatures ($>$ 49%), and the recurrence of curvature in none of the studies exceeded a pathological gain of more than 5%. As for lung function, the studies showed significant increases in forced expiratory volume

Keywords

- adolescent
- orthopedic surgery
- scoliosis

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in 1 second (FEV1) and forced vital capacity (FVC) in patients with severe AIS, and no pulmonary function losses were reported after surgery to correct AIS.

Resumo

A escoliose idiopática do adolescente (EIA) é considerada a deformidade vertebral de maior gravidade e ocorrência, que acomete crianças e adolescentes ainda na fase de desenvolvimento neuropsicomotor, antes de atingirem a maturidade esquelética.

Este estudo teve como objetivo avaliar a abordagem cirúrgica da EIA, considerando resultados associados à redução de curvatura patológica, função pulmonar e repercussões na qualidade de vida dos adolescentes submetidos a tal tratamento.

Revisão Sistemática de literatura, com abordagem quanti-qualitativa dos dados coletados, cuja estruturação se deu conforme as orientações de *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) realizada nas bases de dados vinculadas à *Medical Literature Analysis and Retrieval System Online* (MEDLINE) e Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS). A amostra total dos estudos foi de 638 adolescentes com EIA, com uma idade média de 14,93 anos $\pm$ 1,24.

A correção média da curvatura patológica principal nos estudos foi de 55,06% $\pm$ 12,24. Em todos os estudos selecionados com fusão espinhal posterior para correção da EIA verificou-se redução significativa das curvaturas patológicas ($>$ 49%), sendo que a reincidência de curvatura em nenhum dos estudos superou um ganho patológico superior a 5%. Quanto à função pulmonar, os estudos apontaram ganhos significativos de volume expiratório forçado em 1 segundo (VEF1) e capacidade vital forçada (CVF) em pacientes com EIA grave. Além disso, não foram relatados prejuízos de função pulmonar após intervenção cirúrgica para correção da EIA.

Palavras-chave

- adolescente
- cirurgia ortopédica
- escoliose

Introduction

Adolescent idiopathic scoliosis (AIS) is considered the most severe and common spinal deformity that affects children and adolescents during the neuropsychomotor development phase before they reach skeletal maturity, causing significant alterations in the sagittal curvatures of the spine.[1]

This is a three-dimensional spine deformity in which there is a process of lateral inclination and axial rotation of the vertebral bodies at an angle of more than 10 degrees, measured according to the Cobb method.[2] To measure the Cobb angle (CA), two-dimensional or three-dimensional X-rays (X/2D or 3D) are taken in the sagittal and anteroposterior profiles. The CA is then calculated from perpendicular lines from the projection of a tangent line at the top of the vertebra, indicating the beginning of the curvature of the spine, and another tangent line at the base of the vertebra, indicating the end of the curvature of the spine.[3]

Various studies indicate that the prevalence of AIS varies between 0.35 and 5.2%.[4,5] In a study conducted in São Paulo, Brazil, the overall prevalence of AIS in adolescents was 1.5%, considering a total sample of 2,562 adolescents aged between 10 and 14. There was also a higher prevalence in females (2.2%) than males (0.5%).[6]

Curvatures usually progress in up to ⅔of patients before they reach skeletal maturity, and angles greater than 50° are associated with various pathophysiological repercussions.[7] The literature reports high levels of disability, intense pain, and significant cardiovascular impairment.[8] However, recent data shows that idiopathic scoliosis has significant variability in the type of curvature, location, and etiopathogenesis, which can lead to different clinical outcomes and functional limitations.[9]

The risk factors for progression of the curvature include age under 12, premenarcheal girls with CA curves $\geq$ 20°, as well as the presence of double and thoracic curves, and Risser grade 0 or 1.[10]

The approach to AIS cases aims to reduce or stop the progression of the curvature during puberty and prevent cardiorespiratory dysfunctions and vertebral pain syndromes. Among the available alternatives are orthotics, therapeutic exercise protocols, and a surgical approach. Surgical correction is indicated in patients with skeletal immaturity and curves with CA $\geq$ 50°, although some individual peculiarities may lead to a surgical approach in patients with CA between 40 and 50° or even individuals who already have skeletal maturity and CA $\geq$ 50°.[11,12]

The surgical approach to AIS aims to prevent the progression of the curvature and achieve permanent correction of the deformity. The surgical treatment aims to maintain the spine's stability in the sagittal and coronal planes, preserving as many mobile segments as possible.[13,14] The present study aimed to evaluate the surgical approach to AIS, considering the results associated with curvature reduction, pulmonary

function, and repercussions on the quality of life of adolescents undergoing this treatment.

Materials and Methods

A systematic literature review, with a quantitative and qualitative approach to the data collected, was structured according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[12] guidelines. A checklist was then drawn up to analyze the results. A four-stage flow diagram was used to analyze the data in detail.

The search for studies that met the established criteria took place in March 2023 in databases linked to the *Medical Literature Analysis and Retrieval System Online* (MEDLINE) and Latin American and Caribbean Literature in Health Sciences (LILACS), using the SPICE strategy[13] to identify the relevant studies:

- *Setting*: Patients with AIS
- *Perspective*: Individuals with arthrogryposis and clubfoot;
- *Intervention*: Surgical correction;
- *Comparison*: Reduction in pathological curvature, improvement in pain, improvement in quality of life and lung function;
- *Evaluation*: Rate or occurrence of pathological curvature recurrence or lung function worsening.

The medical subject heading MeSH terms were used in combination, according to the following structure:

- *Scoliosis* AND *Adolescent* AND *Orthopedic* Procedures

Subsequently, the studies were sorted according to their subject matter, restricting them to studies that dealt with the surgical correction of adolescent idiopathic scoliosis.

Inclusion and Exclusion Criteria

Studies that met the following criteria were included: (1) studies with humans, age group < 18 years; (2) patients diagnosed with AIS; (3) studies addressing patients treated with surgical correction; (4) studies published between 2018 and 2023, and (5) original studies, preferably randomized ones.

Studies with the following criteria were excluded: (1) experimental studies using animal models; (2) non-original studies - literature reviews; (3) opinion studies; (4) studies that addressed other approaches to managing AIS without a surgical approach; (5) studies published more than 5 years ago, and (6) studies that did not meet the other inclusion criteria mentioned above.

The studies were searched and selected by two reviewers who independently analyzed them. Initially, using the MeSH terms mentioned above and Boolean operators, studies published in the last 5 years (2018-2023) were selected, followed by an analysis of titles and abstracts. This stage excluded studies using animal models, opinion articles, studies not considering the surgical approach to AIS, and literature reviews.

Once this stage had been completed, the full texts of the articles were retrieved for analysis of the other inclusion and exclusion criteria. Duplicate citations and studies not corresponding to the proposed review parameters were also excluded. Possible disagreements were resolved by discussion with a third reviewer, and inclusion was decided after consensus with the two primary reviewers.

Epidemiological and demographic data were extracted using a Microsoft Excel (Microsoft Corp., Redmond, WA, USA) spreadsheet, including parameters such as the number of patients, the initial and final degree of curvature of the AIS, treatment strategies, recurrences, complications, and the results obtained.

The *systematic* review protocol *was registered in the* International Prospective Register of Systematic Reviews (PROSPERO) under the number ID CRD42023429455 to improve the quality and suitability of the results to the proposed objectives.

Results

After screening according to the PRISMA protocol, 83 studies were initially retrieved, of which 8 were clinical practice guidelines, 7 were systematic reviews, and 21 were opinion studies or narrative reviews. Off-topic studies ($n = 13$) and studies of a conservative approach to AIS ($n = 25$) were also excluded. The following variables were considered for the analysis of 8 studies: techniques used, curvature reduction, improvement or maintenance of lung function, pain reduction or improvement in quality of life (►**Fig. 1**).

The total sample of these studies was 638 adolescents with AIS, with a mean age of 14.93 years $\pm$ 1.24. The average

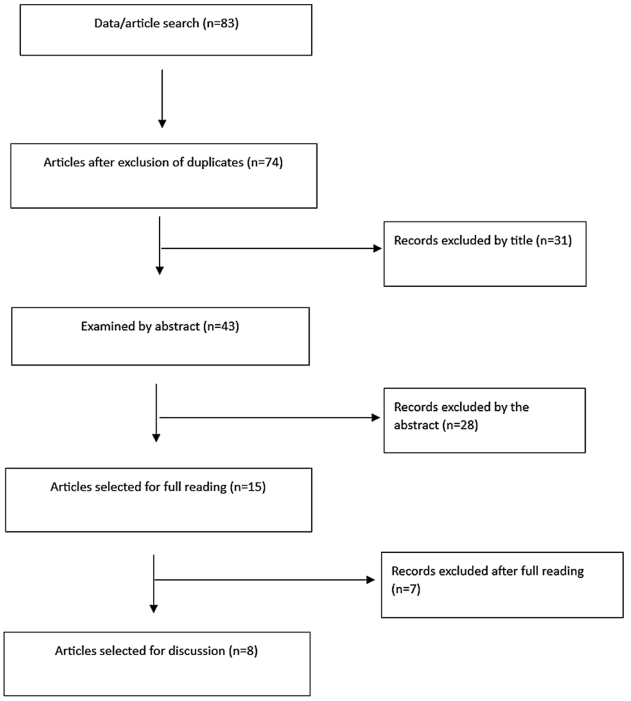


Fig. 1 Screening and selection of studies according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology. **Source:** Elaborated by the authors (2023).

Table 1 Correlation between age at surgery and mean correction of the main pathological curvature in adolescents with adolescent idiopathic scoliosis

Study	Sample	Average age	Mean correction of pathological curvature
Byun et al.[15]	35 patients with thoracic AIS	14.9 years	49.19%
Grabala et al.[18]	195 adolescents with AIS	14.3 years	59%
Zhang et al.[19]	11 adolescents with CA > 130°	13.36 years	40.39%
Altaf et al.[25]	37 adolescents with AIS	14.6 years	33.4%
Santos et al.[16]	41 adolescents with AIS	17.8 years	68%
Sapriza et al.[17]	19 patients with AIS	14 years old	60%
Garcia et al.[20]	278 AIS patients operated on with selective, traditional, and multiple fixations.	15 years	71%
Dittmar-Johnson et al.[21]	22 patients underwent corrective surgery for AIS	15.5 years	59.5%

Abbreviations: AIS, adolescent idiopathic scoliosis; CA, Cobb's angle.
Source: Elaborated by the authors (2023).

correction of the main pathological curvature in the studies was 55.06% ± 12.24 (►**Table 1**).[15–21]

►**Fig. 2** shows the analysis of the mean correction of the pathological curvature using the pre and postoperative CAs.[15–21]

Discussion

Average correction of pathological curvatures

The main objectives of the surgical approach to AIS are to correct the pathological curvatures coronally and sagittally and to prevent their progression. Thus, it is expected that after treatment, there will be correction of the main primary curve and secondary curves while maintaining adequate lumbar lordosis and thoracic kyphosis. The treatment aims to balance fusing as few mobile segments as possible and reducing/correcting the existing deformity. In addition to correcting the deformities, the expected results are to improve and maintain lung function, reduce pain, and improve quality of life.[14]

All the selected studies used posterior spinal fusion techniques for AIS correction. One of the techniques described is posterior spinal fusion with segmental pedicle screw in a lumbar lesion and segmental hook and wiring in a thoracic lesion (hybrid construction) using the ISOLA instrumentation system (DePuy AcroMed, Raynham, MA, USA) without thoracoplasty.[15] Direct vertebral rotation (DVR) techniques associated with type-1 osteotomy have also been reported,[16] Thoracic arthrodesis, thoracolumbar arthrodesis, and lumbar arthrodesis.[17,22,23]

Lung Function after Surgery

Posterior and anterior spinal fusion techniques can correct AIS. Although both types of approach offer correction of pathological curvatures, some studies suggest that the anterior approach with thoracotomy may result in a more significant impairment of lung function. Pulmonary function in the studies was assessed according to the values of forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1).[15,24]

In a 15-year longitudinal study carried out by Byun et al.[15] among patients who did not have preoperative FVC impairment ($n = 35$), no statistically significant differences were found in the mean preoperative (74.0 ± 19.8%) and postoperative (76.4 ± 16.0%) percentages, $p = 0.63$. On the other hand, patients who already had preoperative impairment benefited from the surgical approach.[15]

In a similar approach, including 39 patients with AIS aged between 10 and 21 years, it was observed that after the

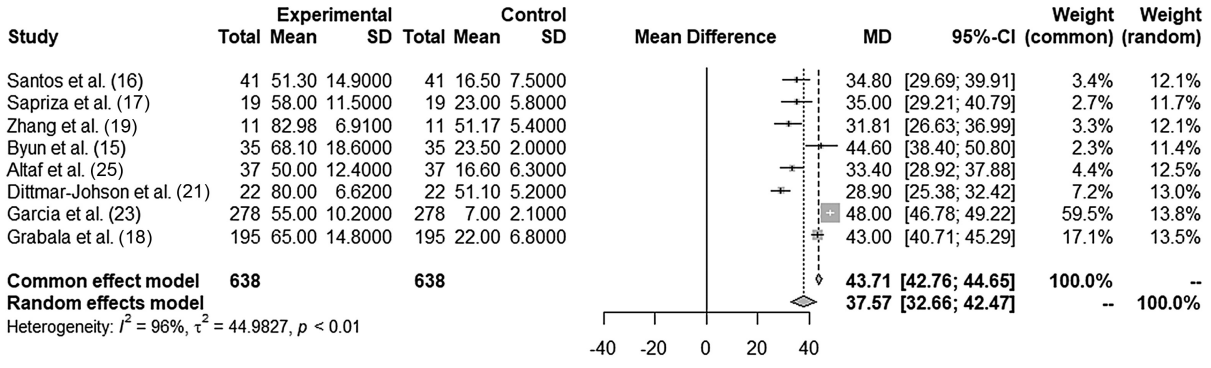


Fig. 2 Mean correction of pathological curvature using the Cobb angle pre-and postoperatively.

restoration of thoracic kyphosis, there was an improvement in FEV1 from 2.74 to 2.98L ($p = 0.005$) and FVC from 3.23 to 3.47L ($p = 0.008$). However, total lung capacity did not change after 5 years of follow-up.[24]

In one of the studies, including 88 patients with severe AIS and 107 with moderate AIS and an average deformity correction of 59%, significant gains in lung function were reported. After 2 years, the severe AIS group observed an improvement in FVC of 69.9% and FEV1 of 81%. In the moderate AIS group, FEV1 improved significantly (76.9%) after 2 years of follow-up.[19]

Concerning the type of vertebral fixation, one of the studies discussed different possibilities for vertebral fixation, considering the degree of AIS correction required. The study refers to treating three groups of patients with AIS who underwent three different fixation approaches: traditional, selective, and multiple. In the first group operated on, the entire length of the structured curvatures was fixed, known as traditional fixation; in the selective fixation group, only the main curve was fixed to preserve vertebral mobility. In the third group, multiple fixation occurred according to the flexibility test, defining the degree of correction required and the vertebrae to be fixed. In the study, the traditional and multiple fixation techniques corrected 75% and 78% of the pathological curvature, respectively, while selective fixation corrected 60%. Considering all the cases, the study showed an average correction of $71\% \pm 7.87$ of the pathological curvatures of the AIS. The study did not address the quality of life or pulmonary function associated with the results obtained.[20]

Sapriza et al.[17] followed 19 patients with AIS who underwent surgical correction by posterior spinal fusion over 9.5 years, with an average of 10 fused intervertebral spaces per patient. The mean preoperative angle was 58 (range 90–42). The mean postoperative angle value before the end of the 1st year was 23, for a correction rate of 60%. The average value of the angle at the end of the follow-up was 26. Therefore, an average correction of 5% was lost at the end of the follow-up. Only 3 cases had a loss of more than 10%. The adolescents considered their quality of life and body appearance improved significantly after the follow-up period. The authors did not analyze pulmonary repercussions in the study.

Santos et al.[16] conducted a cross-sectional observational study with 43 adolescents (mean age 17.8 years) with a CA between 35 and 55° (mean CA $51.5° \pm 13.7°$). A posterior approach was used with classic midline access. After subperiosteal dissection of the muscles, a Schwab type-1 osteotomy was performed. In addition, the most proximal level of arthrodesis and Schwab type-2 osteotomies were performed on the periapical vertebrae according to the subjective assessment of curvature reducibility during the procedure. A 68% correction of the primary thoracic curve was obtained. The study did not report quality of life, pain, or lung function data.

In a study of 195 adolescents with AIS, 88 of whom were classified as severe (AC > 130°) and 107 as moderate AIS, who underwent a posterior approach for surgical correction of the AIS, a mean correction of the deformity after the surgical approach of 59% and a reduction in the number of individuals with pain complaints from 36 to 8% were observed. In patients with severe AIS ($n = 88$), the average curvature was reduced from 131 to 61° and the average thoracic kyphosis from 83 to 35°. Among patients with moderate AIS, the reduction in mean curvature was 60 to 18°, and there was no reduction in thoracic kyphosis in this group.[18]

In a study looking at posterior-only surgical correction with halo-femoral traction, 11 adolescents with AC > 130° were evaluated over a mean follow-up period of 32.18 ± 8.17 months. The mean preoperative coronal CA of the greater curve was $139.01° \pm 5.83°$, and the mean flexibility was $17.21\% \pm 3.33\%$. After the approach, the coronal AC of the greater curvature was reduced to $82.98° \pm 6.91°$, with a correction rate of 40.39%. At the final follow-up, the rate of corrective loss of CA was only 0.72%.[19]

In a study of 37 patients with moderate AIS (AC between 50 and 129°) who underwent thoracoplasty, a mean preoperative curvature of $50.0° \pm 12.4°$ was observed, with a subsequent reduction to $16.6° \pm 6.3°$. The mean correction of deformity was 33.4%, with a mean improvement in FVC of 55.4% and FEV1 of 72%. In the study, the authors used the Scoliosis Research Society (SRS) 22 score to analyze the adolescents' quality of life and found an improvement in the score from 3.8 to 4.3 after surgery.[25]

A study by Dittmar-Johnson et al.[21] included 22 patients undergoing posterior spinal fusion for AIS correction with pathological curves greater than 45°. The average age of the patients was 15.5 years. The SRS 22 questionnaire generated the following mean scores: pain 4.6, function 4.3, self-image 4.41, mental health 4.89, and satisfaction 5.0. Therefore, the surgical intervention was considered to have led to a good quality of life in the five parameters assessed.

The SRS 22 had been used previously in a longitudinal study with a 10-year follow-up of 109 adolescents with AIS treated with a surgical approach. When all patients were included, the mean preoperative CA of the major curves in the frontal plane was 60.8° +/−17.5°. Major curves corrected by 38.7° +/−22.1% on flexion radiographs, postoperatively achieved a correction of 64.0° +/−15.8%. At the last follow-up visit, 10.3° +/−10.8° of loss of correction were recorded on the principal curves in the frontal plane with 50.5° +/−23.1% final correction rate. In addition, the mean postoperative and final kyphosis angles and lumbar lordosis angles were 37.7° +/−7.4°, 37.0° +/−8.4°, 37.5° +/−8.7°, and 36.3° +/−8.5°, respectively. Overall, 4 patients (3.7%) experienced implant failure. Early superficial infection was observed in 3 patients (2.8%). Overall, the mean SRS-22 questionnaire scores for general self-image, function, mental state, pain, and satisfaction with treatment were 3.8 +/−0.7, 3.6 +/−0.7, 4.0 +/−0.8, 3.6 +/−0.8, and 4. 6 +/−0.3, respectively, at the last follow-up visit. Given the results, the authors consider that the surgical approach efficiently corrects deformities in the frontal and sagittal planes and trunk balance, resulting in a better quality of life.[26]

Conclusions

In all the selected studies using posterior spinal fusion to correct AIS, there was a significant reduction in pathological curvatures (> 49%), and in none of the studies did the recurrence of curvature exceeded a pathological gain of

more than 5%. As for pulmonary function, the studies showed significant increases in FEV1 and FVC in patients with severe AIS, and no pulmonary function losses were reported after surgery to correct AIS. Finally, most studies reported improved quality of life and reduced pain after surgery.

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Conflict of Interest
There are no conflicts of interest in this study.

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Epidemiology of Injuries and Their Implications in Jiu-Jitsu Practitioners: An Integrative Systematic Review

Epidemiologia das lesões e suas implicações em praticantes de jiu-jitsu: Uma revisão sistemática integrativa

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Abstract

Objective To investigate the epidemiology of injury types among jiu-jitsu practitioners, as well as the incidence regarding different skill and experience levels, through the question: "What are the characteristics and prevalence of musculoskeletal injuries in Jiu-Jitsu practitioners?".

Methods Since the beginning of the study, in August 2020, we conducted a search on the MEDLINE, LILACS, and SciELO electronic databases. We included cross-sectional studies published between 2018 and 2023 on the epidemiology of the types of injuries among jiu-jitsu practitioners that compared their incidence regarding different levels of ability and experience. Two independent researchers performed the data extraction and assessed the risk of bias.

Results Seven studies were included. The common outcomes involved 2,847 jiu-jitsu practitioners. A high prevalence in the knee joint and chest and rib areas was reported. Considering the difference in experience level among the practitioners, we could observe that most of the individuals included were beginners. Among the age groups observed, male practitioners older than 30 years of age were the ones who presented the highest rate of musculoskeletal injury, especially during training sessions.

Conclusion There is a high prevalence of musculoskeletal injuries among jiu-jitsu practitioners. The most affected anatomical segments are the knee joint, the chest, and the rib region, followed by the shoulder joint. The related factors change according

Keywords
- cumulative trauma disorders
- martial arts
- sports
- sports medicine

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to certain variables, being more common during training in male individuals over 30 years of age and beginners in the sport.

Resumo

Objetivo Investigar a epidemiologia dos tipos de lesões entre praticantes de jiu-jitsu e sua incidência em diferentes níveis de habilidade e experiência por meio da questão: "Quais as características e a prevalência das lesões musculoesqueléticas em praticantes de jiu-jitsu?"

Métodos Desde o início do estudo, em agosto de 2020, foram pesquisados os bancos de dados MEDLINE, LILACS e SciELO. Foram incluídos estudos transversais, publicados entre 2018 e 2023, que investigaram a epidemiologia dos tipos de lesões ocorridas entre praticantes de jiu-jitsu e compararam sua incidência em diferentes níveis de habilidade e experiência. Para tanto, dois pesquisadores independentes realizaram a extração dos dados e avaliaram o risco de viés.

Resultados Sete estudos foram incluídos. Os resultados comuns envolveram 2.847 praticantes de jiu-jitsu. Houve uma alta prevalência de lesão na articulação do joelho e nas áreas do tórax e das costelas. Considerando a diferença de nível de experiência entre os praticantes, pôde-se observar que a maioria dos indivíduos incluídos eram iniciantes. Entre as faixas etárias observadas, homens acima de 30 anos de idade foram os que mais apresentaram lesões musculoesqueléticas, principalmente durante os treinos.

Conclusão Houve uma alta prevalência de lesões musculoesqueléticas entre os praticantes de jiu-jitsu. Os segmentos anatômicos mais acometidos foram a articulação do joelho, o tórax e a região das costelas, seguidos da articulação do ombro. Os fatores relacionados mudaram de acordo com algumas variáveis, sendo mais comuns durante o treinamento em indivíduos do sexo masculino com mais de 30 anos e iniciantes na modalidade.

Palavras-chave

- artes marciais
- esportes
- medicina esportiva
- transtornos traumáticos cumulativos

Introduction

The fights in combat sports can result in soft tissue injuries[1] and even structural trauma;[2] these injuries may be severe and require the performance of arthroplasty in certain structures,[3] and they can also lead to an interruption of the fight or withdrawal from the sport.

Jiu-jitsu is recognized as a combat sport in which athletes use "finishing" techniques on the opponent and many times the outcome of such techniques is a joint block, termed "submission hold" by the practitioners.[4] The fight takes place with unexpected, fast, repetitive, and high-overload movements for muscles and joints. The association of these factors with high-volume training can favor the appearance of musculoskeletal and osteoarticular injuries.[5]

In this martial art, the high physical impact and exposure to daily training sessions corroborate the outcomes observed in the literature, with a higher incidence of injuries during training when compared to competitions.[6–9]

Some authors emphasize that the incidence of injury is very similar among martial arts. However, there are few studies associated with injuries arising specifically from the practice of jiu-jitsu.[4,5,10,11] Since injuries are characterized according to severity, treatment time, nature of the injury, and intrinsic characteristics,[4,12] knowledge of the incidence and prevalence of orthopedic injuries, as well as of their characteristics, yields direct benefits for the treatment, prevention, and promotion of strategies for such events. Thus, the objective of the present study was to investigate the epidemiology of injury types among jiu-jitsu practitioners, as well as the incidence at different skill and experience levels, through the question "What are the characteristics and prevalence of musculoskeletal injuries in jiu-jitsu practitioners?". The present systematic review provides a synthesis and evidence for the scientific and clinical communities concerning these conditions and possible healthcare support for jiu-jitsu practitioners.

Materials and Methods

Search Strategy

The present systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[13,14] The study protocol was prepared and registered on the Prospective Register of Systematic Reviews (PROSPERO) under identification CRD42023422767. The search was carried out on the MEDLINE (PubMed), LILACS, and SciELO electronic databases, and the strategy used was the combination and adaptation of Medical Subject Headings (MeSH) of the National Library of Medicine: *jiu-jitsu*, *Brazilian jiu-jitsu*, and *injuries* (►**Table 1**).

Table 1 Search strategies

Search	Query
#1	(*prevalence [MeSH Terms]* OR *prevalence* OR *prevalences* OR *occurrence* OR *frequency* OR *frequencies* OR *incidence* OR *epidemiology* OR *epidemiologic* OR *incidence* OR *incidences*)
#2	(*injuries* OR *injury* OR *sports injuries* OR *sports injury* OR *injuries, sports* OR *injury, sports* OR *injuries, athletic* OR *athletic injury* OR *injury, athletic*)
#3	(*jiujitsu* OR *jiu-jitsu* OR *jujitsu* OR *Brazilian jiujitsu* OR *Brazilian jiu-jitsu*)
#4	(#1 AND #2 AND #3)

The search was carried out from the inception of the study up to May 2023. The lists of bibliographic references were revised to identify other potential studies.

The Population, Intervention, Comparison, Outcomes, Studies (PICOS) strategy was used to formulate the question in the present systematic review, in which P represents the jiu-jitsu practitioners, I and C are not applicable, O is the prevalence of musculoskeletal injuries and the most frequent types among jiu-jitsu practitioners, and S represents the observational studies. No intervention or comparison were performed in the present systematic review.

Study Selection

The studies identified in the search were entered into a standard Excel spreadsheet (Microsoft Corp., Redmond, WA, United States) for the exclusion of duplicates. Two independent researchers (HHPS and SPN) employed the selection strategy based on the contents of the title and abstract. Subsequently, the full texts of the studies were retrieved for eligibility assessment. The inclusion criteria were cross-sectional studies involving jiu-jitsu practitioners and musculoskeletal injuries. Studies published in languages other than English or Portuguese, as well as incomplete texts, were excluded. In case of disagreement between researchers, resolution was achieved through discussions. In the case of persistence of any disagreement, the evaluation of a third researcher (CEG) was requested.

Data Extraction and Assessment of the Risk of Bias

Two independent researchers (HHPS and SPN) performed data extraction and assessed the risk of bias. A predefined form was used for data collection, encompassing the first author, the year of publication, the practitioners' level, age, gender, the number of athletes, the training frequency, the anatomical region of the musculoskeletal injury, and the moment of injury onset. The risk of bias in observational studies of exposure was assessed using the Cochrane Collaboration's Risk of Bias In Non-Randomized Studies – of Exposure (ROBINS-E)[15] tool, which encompasses seven methodological domains: confounding, measurement of the exposure, selection of participants, postexposure interventions, missing data, measurement of outcomes, and selection of the reported result. The score is established as low (-), high (+), and uncertain (?) risk of bias.

Results

Following a systematic literature search, a total of 34 articles were found on the main electronic databases. No studies were selected from the grey literature, since the identified records were already on the other databases. After duplicates were excluded and title and abstract screening was concluded, ten records remained. Subsequently, one record was discarded, and nine studies were considered eligible to be fully assessed. After full-text reading, seven studies[4,7–9,16–18] were finally included for qualitative and quantitative synthesis. An overview of the selection process is shown in ►**Fig. 1**.

Study Characteristics

The cross-sectional studies included in the present systematic review,[4,7–9,16–18] published between 2018 and 2023, totaled 2,847 jiu-jitsu practitioners. ►**Table 2** shows the characteristics of the articles included.

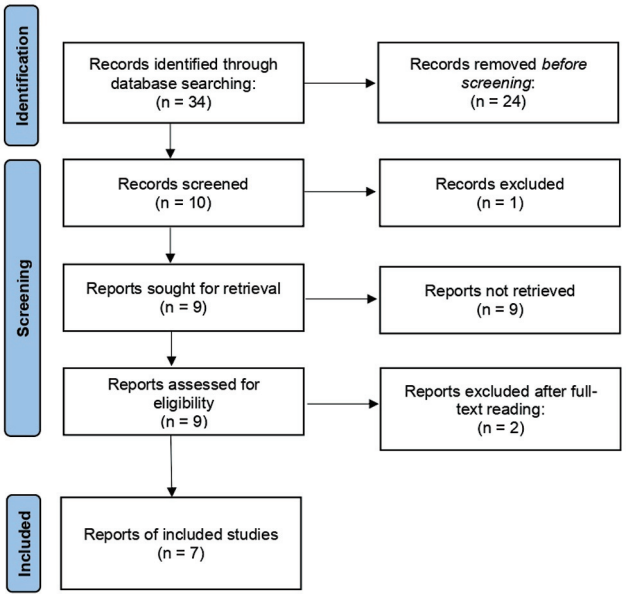


Fig. 1 The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement flow diagram of the study selection process.

Table 2 Characteristics of studies that fulfilled the inclusion criteria

Authors and year of publication		Country	n	Objectives	Data collection
da Silva Junior et al.,[16] 2018		Brazil	108	To verify the regions of the body affected by injuries, the most common site of injury, and the mechanism and severity of injuries in beginners and advanced jiu-jitsu practitioners.	Questionnaire
Lopes et al.,[17] 2018		Brazil	31	To study possible relations between the prevalence of injuries and the functional system of movement of jiu-jitsu fighters.	Questionnaire
Petrisor et al.,[18] 2019		Canada	70	To describe injuries experienced during jiu-jitsu training, both in practice and competition, and to classify the type of injury and explore the characteristics of the participant and the injury associated with the desire to quit jiu-jitsu after the injury.	Questionnaire
Moriarty et al.,[9] 2019		USA	1,287	To determine the six-month incidence rate and related jiu-jitsu pattern injuries and to characterize associations between injuries and experience level, demographic factors, and training variables.	Questionnaire
Nicolini et al.,[4] 2021		Brazil	96	To identify an epidemiological profile of orthopedic injuries present in jiu-jitsu practitioners.	Questionnaire
Hinz et al.,[7] 2021		Germany	1,140	To quantify the incidence of related injuries in jiu-jitsu over three years and to detect common injury patterns and risk factors among jiu-jitsu practitioners.	Questionnaire
Nery et al.,[8] 2023		Brazil	115	To determine the prevalence of musculoskeletal injuries in jiu-jitsu competitors, as well as their profile and characteristics.	Questionnaire

Definition of Musculoskeletal Injury in Sport

Musculoskeletal injuries are common and account for a significant burden to the healthcare system. According to Caine et al.,[19] Hoff and Martin,[20] and Van Mechelen et al.,[21] sports injuries are the collective name to characterize all types of damages related to physical activities. Corroborating the authors' discussion, Timpka et al.[22] define them etiologically as a loss of body functions or deviation of structure caused by the transfer of energy during participation in sport. Therefore, one can distinguish between acute injuries, which occur by interaction with a relatively high force in a short time of stimulus, and chronic injuries, which result from the effect of the force applied in repetition, even in lower intensity, such as overuse. [23,24] Thus, based on this definition, the present systematic review aims to provide understanding about these results reported in the literature.

Injury Epidemiology: Structure, Age, and Timing of Injury

The distribution of the occurrence of musculoskeletal injuries according to the included studies[4,7–9,16–18] shows the high prevalence in the knee joint (22%) and chest and rib regions (22%), with rates close to half of the total cases reported in the present study. Considering the difference in the level of experience among the practitioners, it is possible to observe that most subjects included were white and blue belts, that is, beginners in the sport. The total distribution of the prevalence of injuries and experience of the practitioners can be seen in ►**Fig. 2**.

Considering age groups, participants older than 18 years of age were included, which hampers the analysis of data from younger practitioners. In this regard, according to the data available, it is noticeable that male practitioners older than 30 years of age are more susceptible to experiencing a musculoskeletal injury. Another remarkable characteristic is the high rate of occurrence of injuries during training sessions compared to competitions. The complete data can be seen in ►**Table 3**.

Risk of Bias Assessment

Overall, there was a moderate risk of bias for the studies included[4,7–9,16–18] (►**Fig. 3**). The descriptions of the protocols and methods addressed were not appropriate for a full interpretation of confounders and outcome measurements. Participation, random sequence, and allocation concealment were robustly identified in three studies.[4,8,9] In general, the studies did not add much emphasis to data loss or erroneous exposure, as well as to outcome measurement bias. ►**Fig. 3** presents the assessment of each risk of bias item for the studies included in the present systematic review.

Discussion

The present study is a systematic review of the literature on the prevalence of musculoskeletal injuries in jiu-jitsu practitioners, evaluating the relationship regarding the most affected anatomical segments, age, gender, belt, and time of the injury. Therefore, we could highlight the anatomical

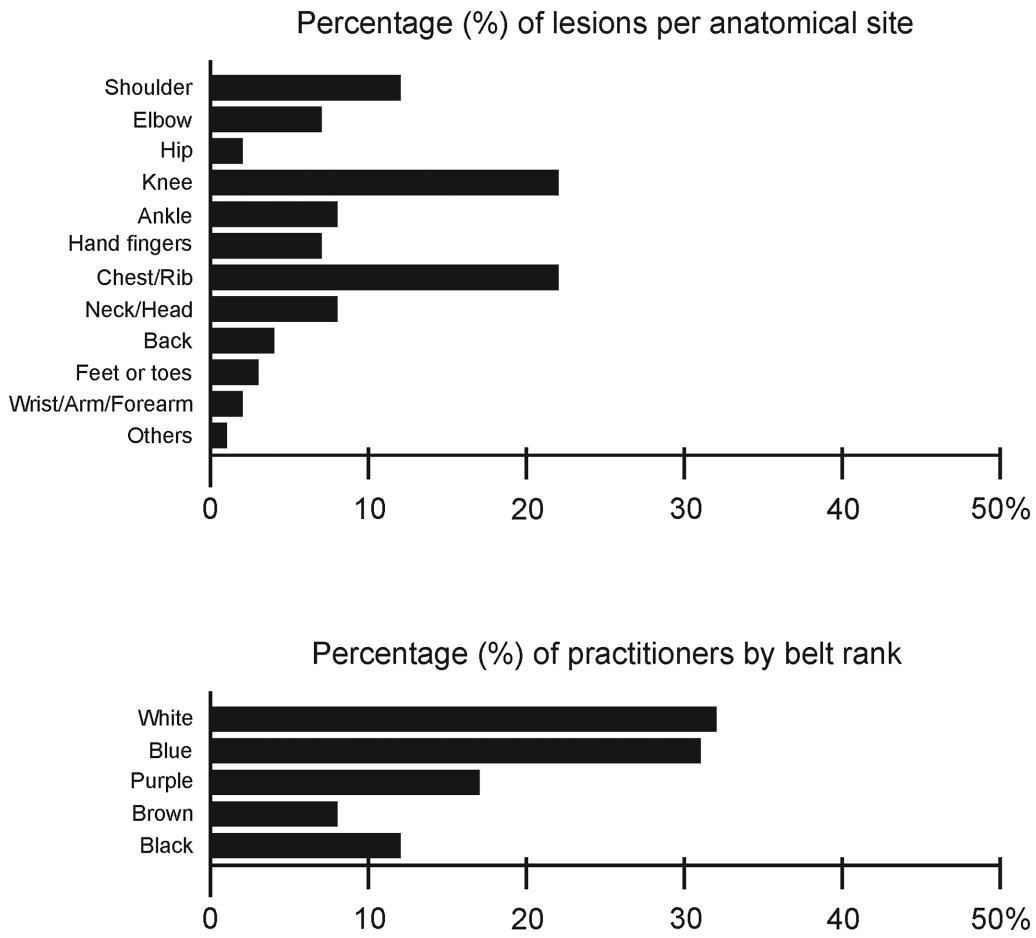


Fig. 2 Epidemiological characteristics of the injuries and level of experience of jiu-jitsu practitioners.

Table 3 Epidemiology of injury characteristics

Study	Age (years)			Frequency of injuries (%)			Time of Injury	
	Mean(±standard deviation)	Inclusion	Highest frequency	Men	Women	Total	Competition	Training
da Silva Junior et al.[16]	28.3(±6.41)	Not reported	Not reported	Not reported	Not reported	100%	0%	100%
Lopes et al.[17]	30.9(±7.3)	Not reported	≥ 30	100%	Not reported	100%	0%	100%
Petrisor et al.[18]	–	> 18	≥ 30	Not reported	Not reported	91.4%	8.6%	100%
Moriarty et al.[9]	29.5(±2.12)	> 18	26 to 35	15.5%	84.5%	59%	2%	98%
Nicolini et al.[4]	27.6(±1.42)	18 to 45	Not reported	86%	84%	84%	16%	100%
Hinz et al.[7]	31.7(±7.9)	Not reported	32.12	89.7	10.2%	48.7%	51.30%	48.70%
Nery et al.[8]	25.8(±4.1)	Not reported	Not reported	Not reported	Not reported	85.2%	41%	59%

regions with a higher incidence of injury that should be the most concerning for jiu-jitsu practitioners and instructors.

It is important to underline that martial arts are based on biomechanical principles that can cause severe damage to practitioners.[5,25] Due to the fighting technique, which exposes practitioners to falls and shocks with a great application of force, orthopedic injuries are very common in the practice of the sport. Approximately 90% of the participating athletes reported the occurrence of at least one injury.[26] However, when examining the incidence of these injuries

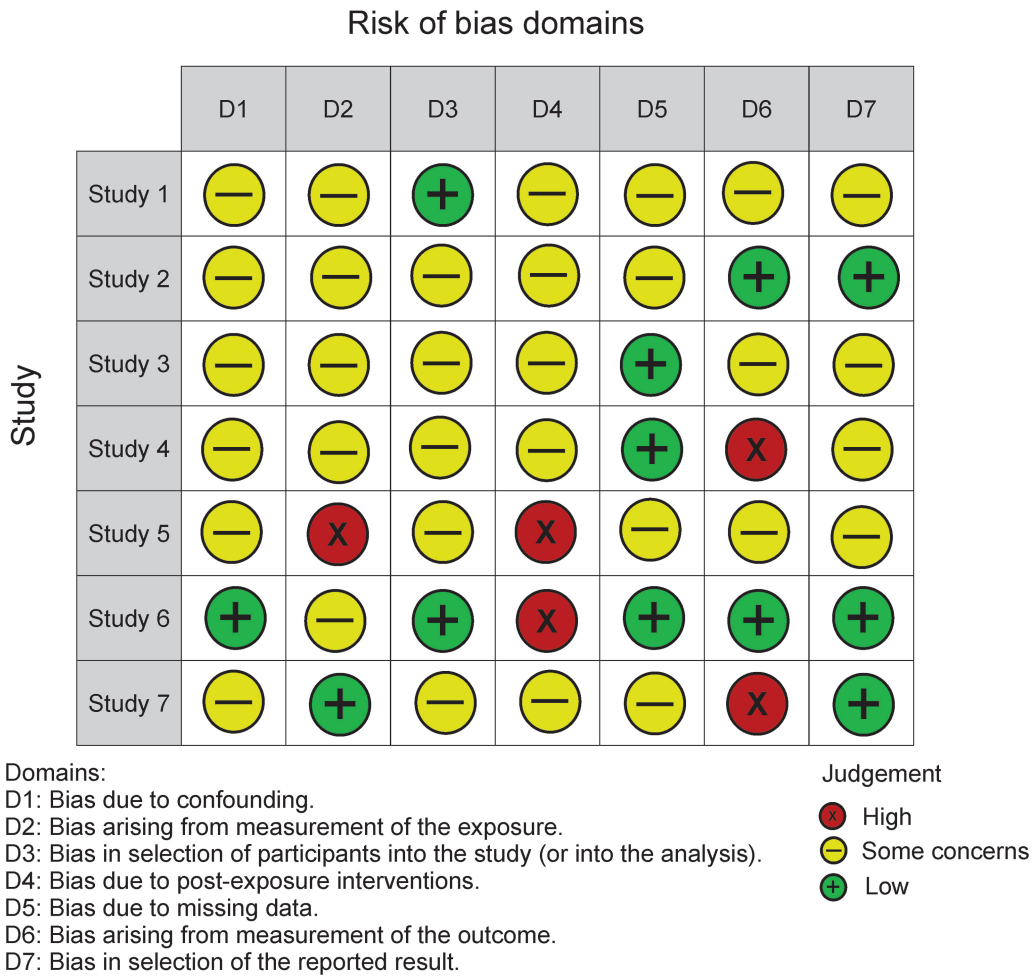


Fig. 3 Summary of authors' review judgments about each risk of bias item for each included study.

according to demographic variables, we were unable to find a consistent factor that had a significant impact on their occurrence.

In the present systematic review, a higher prevalence of injuries to the knee, chest, and ankle was found when compared to other anatomical segments. This situation also applies when we evaluate studies that involved other martial arts, such as judo.[27] Furthermore, as seen in Pocecco et al.,[28] the fingers and hands are the most affected sites of injury in judo, which differs from jiu-jitsu, as it can be seen in the data of the present study. In other modalities, such as mixed martial arts, which allow more acute and incisive contact, such as punching and kicking, the prevalence of injuries is higher in the head and neck. In these modalities, lacerations, abrasions, and contusions are the most frequent, besides conditions such as concussion.

Through our research, we could notice the low number of studies on the subject, which makes it even more difficult to interpret the results. Factors such as the lack of standardization in the classification of athletes as beginners or experienced also hindered inferences about the results. To illustrate this, da Silva Junior et al.[16] considered beginners the athletes who were white or blue belts, while Petrisor et al.[18] considered only white-belt athletes as beginners, while athletes of other belts were considered advanced. It would be interesting if future studies standardized this categorization according to practice time, which seems to be a more reliable metric for future inferences.

Another extremely important factor that should be highlighted in epidemiological studies is the injury mechanisms. Nery et al.[8] subdivide them into two groups: atraumatic and traumatic injuries. Although simple, this division helps to understand the behavior of the injury process in the athlete. As presented by Bittencourt et al.,[29] injuries are composed of a multimodal network with factors, of greater or lesser impact, which are connected. As a result, the precise identification of the mechanisms of injuries and how they occur is of paramount importance for the clinical practice. More accurate studies in this regard are needed, as reported in Hinz et al.[7]

A consensus on the definition of injury in soccer stressed the importance of identifying the time between injury and return to full participation in the sport.[30] In the studies included[4,7–9,16–18] in the present review, only one[7] showed this type of assessment of great importance to also understand the severity of the injury. Only in the studies by Nicolini

et al.[4] and Hinz et al.,[7] the authors pointed out the impact of these injuries through the treatment received after the event.

The present systematic review indicates that future studies should be more categorical in their evaluations for better inference of results. To this end, it is necessary to include variables such as weekly training hours, time of return after the injury, and the mechanism of injury, for the promotion of improvements in class models, coping strategies, and mitigation of the risk of injury.

Conclusion

There is a high prevalence of musculoskeletal injuries among jiu-jitsu practitioners. The most affected anatomical segments are the knee joint, chest, and rib region, followed by the shoulder joint. The related factors change according to certain variables, being more common during training in male
individuals over 30 years of age and beginners in the sport.

Authors' Contributions

Each author contributed individually and significantly to the development of this article: SPS: Conceptualization, formal analysis, methodology, visualization, writing of the original draft, and writing – review and editing. HHPS and SPN: data curation, investigation, methodology, visualization, writing of the original draft, and writing – review, and editing. LCCF: methodology, visualization, writing of the original draft, and writing – review, and editing. CEG: conceptualization, methodology, project administration, supervision, visualization, writing of the original draft, and writing – review, and editing.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Prospective Study of the Assessment of Anxiety Symptoms after Minimally Invasive Lumbar Decompression

Estudo prospectivo da avaliação dos sintomas de ansiedade após descompressão lombar minimamente invasiva

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Summary

Objective To analyze associations between anxiety and postsurgical clinical outcomes in patients who underwent minimally invasive lumbar decompression surgery in addition to comparing symptoms of anxiety and depression before and after surgery.

Methods This prospective cohort study of patients who underwent minimally invasive lumbar decompression surgery. Clinical outcomes were measured before and 6 months after surgery using the Visual Analog Scale (VAS), Global Perceived Effect of Change (GPE), Hospital Anxiety and Depression Scale (HADS), and Oswestry Disability Index (ODI). Based on the presurgical anxiety score, patients were categorized into anxious and non-anxious patients, and the outcomes were compared.

Results The patients of both groups obtained similar results concerning the clinical outcomes evaluated. Preoperative HADS scores decreased significantly 6 months after surgery in both anxiety (8.70 ± 3.48 vs. 5.75 ± 3.91) and depression (6.95 ± 3.54 vs. 5.50 ± 2.99). The VAS scale for the back (-2.8 ± 3.64) and legs (-5.5 ± 3.5) showed a reduction in pain.

Conclusion Minimally invasive lumbar decompression surgery promoted clinical and functional improvement, not being affected by preoperative anxiety symptoms. Mental health indicators showed a significant reduction in symptoms 6 months after surgery.

Keywords
- anxiety
- depression
- estenosis
- minimally invasive surgical procedures
- spine

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Resumo

Objetivo Analisar associações entre ansiedade e desfecho clínico pós-cirúrgico em pacientes que realizaram a cirurgia de descompressão lombar minimamente invasiva, além de comparar sintomas de ansiedade e depressão antes e após a cirurgia.

Métodos Trata-se de um estudo de coorte prospectiva de pacientes que realizaram a cirurgia de descompressão lombar minimamente invasiva. Os desfechos clínicos foram mensurados antes e 6 meses após a cirurgia, utilizando a escala visual analógica de dor (EVA); *Global Perceived Effect of Change* (GPE); *Hospital Anxiety and Depression Scale* (HADS) e o *Oswestry Disability Index* (ODI). A partir do escore de ansiedade pré-cirúrgico, os pacientes foram categorizados em pacientes ansiosos e não ansiosos e os desfechos comparados.

Resultados Os pacientes de ambos os grupos obtiveram resultados similares em relação aos desfechos clínicos avaliados. Os escores HADS pré-operatório diminuíram significantemente 6 meses após a cirurgia, tanto em ansiedade ($8{,}70 \pm 3{,}48$ vs. $5{,}75 \pm 3{,}91$) quanto em depressão ($6{,}95 \pm 3{,}54$ vs. $5{,}50 \pm 2{,}99$). Houve redução da dor na escala EVA das costas ($-2{,}8 \pm 3{,}64$) e das pernas ($-5{,}5 \pm 3{,}5$).

Conclusão A cirurgia de descompressão lombar minimamente invasiva promoveu melhora clínica e funcional, não sendo afetada por sintomas pré-operatórios de ansiedade. Os indicadores de saúde mental evidenciaram redução significativa dos sintomas 6 meses após a cirurgia.

Palavras-chave

- ansiedade
- coluna vertebral
- depressão
- estenose
- procedimentos cirúrgicos minimamente invasivos

Introduction

The main reason for surgery on the spine is lumbar neural compression, which promotes the sensation of paresthesia, pain, loss of sensitivity, and strength in the lower limbs.[1] The most common reasons for lumbar neural compression are spinal canal stenosis and herniated discs. In the failure of conservative treatment or the presence of motor neurological damage, operative treatment should be indicated, with the gold standard being neural decompression. The procedure can be performed openly or microsurgically, with tubular retractors or endoscopy.[2,3] Minimally invasive lumbar decompression is a relatively new technique that represents an alternative to open decompression.[4] The minimally invasive technique demonstrates similar effectiveness to open laminectomy but with lower blood loss, shorter hospital stays, and lower incidence of reoperation.[5,6]

Previous studies have shown an association between symptoms of anxiety, depression, and chronic low back pain.[7] However, the relationship between anxiety symptoms and surgical outcomes in individuals with radiculopathy is not well-established in the literature. Thus, the present study investigates the association between surgical outcomes and the presence of preoperative anxiety symptoms, in addition to the effects of surgery on patients' mental health over time.

The objectives were: Primary - to evaluate the association between anxiety symptoms and clinical and functional outcomes of patients undergoing minimally invasive lumbar decompression. Secondary - compare anxiety symptoms before and after minimally invasive lumbar decompression surgery.

Methodology

This is a prospective cohort study with 44 patients, with follow-up for 6 months after surgery between January 2020 and July 2022. All procedures were performed at the Hospital Israelita Albert Einstein, a private quaternary hospital, a reference in spine surgery, located in the city of São Paulo. The study was approved by the institution's Ethics Committee (CAAE: 94868618.7.0000.0071).

Inclusion criteria: Individuals who had symptoms of lumbar neural compression, radiculopathy or neurogenic lameness, single-level lumbar neural compression, with failure of conservative treatment for at least 6 weeks (or less, in the presence of acute motor damage with a motor force of less than or equal to 3), underwent single-level minimally invasive lumbar decompression.

Exclusion criteria: Open surgeries, placement of implants in the spine, reoperations, complications, or the absence of response to questionnaires after 6 months of surgery.

The collected data was sent and stored in the REDCap software (Vanderbilt University, Nashville, TN, USA[8,9]), at the time before and 6 months after surgery. The preoperative questionnaires were collected shortly after the informed consent form (ICF) was completed.

Operative Technique

The patients were positioned in the genupectoral position without needing bladder probing. The fluoroscopic image in profile incidence confirmed the anatomical level, with the needle positioned at the height of the intervertebral disc.

After placing sterile drapes, a paramedian incision was made, located 1 cm lateral to the midline and 14 mm long, corresponding to the size of the tubular retractor used. After opening the fascia, the musculature was progressively dilated with sequential cannulas until the placement of the 14-mm-diameter closed tube. The tube length varied according to each patient, between 50 and 90 mm deep. The tube was attached to the operating table using a mechanical arm, and from that moment on, the surgery was performed using microscopy (Pentero microscope, Zeiss, Germany). Neural decompression was performed according to the needs of each case. It may include microdiscectomy for cases of a herniated disc, foraminotomy for foraminal stenosis, decompression of lateral recess stenosis, or *over-the-top decompression* for central stenosis. After that, the wound was closed with continuous intradermal suture and simple dressing. Drains were not inserted. Ambulation was authorized on the same day of surgery, and discharge occurred the day after surgery. The surgeries were performed by a senior physician who specialized in minimally invasive spine surgery.

Collected Outcomes

***Visual Analog Pain Scale* (VAS)**:[10] The visual pain scale describes the intensity of the patient's leg and back pain-related pain. The score can range from 0 (non-existent pain) to 10 (pain with extreme intensity)

***Global Perceived Effect of Change* (GPE)** (self-perceived improvement)[11]: Scale designed to quantify patient improvement or deterioration over time, usually to determine the effect of an intervention or to chart the clinical course of a condition.

***Hospital Anxiety and Depression Scale* (HADS)**:[12] The questionnaire consists of 14 questions. Each of its items can be scored from 0 to 3, composing a maximum score of 21 points for each scale.

***Oswestry Disability Index* (ODI)** Version 2.0:[13] This version was adapted for Brazil to measure functional disability in individuals with low back pain. It has 10 scales of 6 points each. The total ODI score ranges from 0 (no disability) to 100 (maximum disability).

Categorization of patients with and without anxiety symptoms

Patients were stratified into two groups depending on the score at the presurgical moment of anxiety (HADS). The chosen cutoff point (≥ 9) in the anxiety score was based on the description of Zigmond and Snaith[14] on the interpretation of results.

Group 1: non-anxious patients. Hospital Anxiety and Depresseion Scale subscale anxiety collected presurgically < 9 points

Group 2: anxious patients. Hospital Anxiety and Depression Scale subscale anxiety collected presurgically ≥ 9 points

Statistical analysis

To evaluate the different associations between the groups, the variations of scores (depression HADS, VAS, GPE) and final scores in the groups were calculated separately. The data were submitted to Shapiro-Wilk normality tests. Subsequently, non-parametric statistical tests were applied to measure the difference in postoperative outcomes between patients' "cases" versus "non-cases" of anxiety. Categorical variables were followed by the percentage that each category occupies and continuous variables by the standard deviation. Nonparametric statistical tests were performed to compare

Table 1 Initial characteristics of the studied population

		Group	
	All	Non-anxious	Anxious
	(n = 44)	(n = 20)	(n = 24)
Gender			
Male (%)	22	12	10
Female (%)	22	8	14
Schooling			
Undergraduate degree	33	17	16
Unfinished undergraduate degree	4	0	4
High school degree	5	2	3
Middle school degree	1	0	1
Technical degree	1	1	0
Age	42.5 ± 10.4	45.6 ± 10.4	39.9 ± 9.76
BMI (Kg/m2)	27.1 ± 3.8	26.8 ± 3.52	27.3 ± 4.09
Height (m)	1.7 ± 0.1	1.71 ± 9.13	1.71 ± 12.1
Weight (Kg)	79.4 ± 14.4	79.3 ± 16	79.6 ± 13.2

Abbreviation: BMI, body mass index.
Age, body mass index (BMI), height, and weight presented with ± standard deviation (±95% confidence interval).

the initial and postoperative scores. The statistical tests applied for continuous variables were Mann-Whitney and, for categorical variables, the Pearson chi-square test. Subsequently, an analysis was performed comparing the evolution of anxious patients with that of non-anxious patients. This comparison was made by evaluating the variation of scores (final score–initial score) and comparing them between the groups.

Results

The sample consisted of 44 patients, 22 males and 22 females, with a mean age of 42.5 years (20–70 years). The mean body mass index (BMI) of the sample was 27.1 kg/m^2. Most of the patients have completed higher education. ►**Table 1** presents the patients' demographic data stratified in relation to the HADS score at the preoperative time, with 20 patients in the non-anxious group and 24 patients in the anxious group. Demographic data, such as BMI, age, height, weight, education, and sex, are similar between groups.

In the comparison between preoperative clinical scores and those 6 months after the procedure, improvement was observed in all scores ($p < 0.05$), regardless of the group. Clinical improvement was observed by the increase in self-perceived improvement (GPE), reduction in leg and back pain scores, and HADS scores for both subscales (depression and anxiety), according to ►**Table 2**.

Six months after surgery, anxious patients maintained statistically worse mental health scores compared to non-anxious patients. However, the score reduction in the 6 months was higher in anxious patients. That is, anxious patients maintained lower mental health scores after surgery compared to non-anxious patients but obtained a more significant reduction in points (-3.96 vs -1.75); this pattern is repeated in depression scores.

Another finding was the different variations of the ODI score between the groups. While the anxious group had a drop of 37.9 points, on average, the non-anxious group had a reduction of 26.1 points. In this sense, the anxious group had a 74% reduction in the average ODI score, and the non-anxious group had 71.5%.

The other scores showed similar variation between the groups. Except for the GPE score, all scores showed more significant variation between preoperative and postoperative moments in the anxious group. Regarding the back VAS score, there was a reduction of 47% in not anxious and 56% in anxious patients. The leg VAS, in turn, had a reduction of 79% in anxious and 72.8% in non-anxious patients.

►**Table 3** presents the evolution of patients without considering the classification of anxiety and depression, showing significant variation in mental health indicators. After 6 months of the procedure, there was a reduction in the HADS scores in both anxiety and depression subscales and in the other scores. The GPE and ODI scores increased in the sample, respectively, demonstrating increased self-perception of improvement and functionality.

A positive correlation was observed between preoperative ODI ($p < 0.001$) and preoperative anxiety (►**Fig. 1A**); that is,

Table 2 Sample data after 6 months of surgery and mean variation

	Preoperative				6 months after surgery			Score variation 6 months	
	Non-anxious	Anxious	p	Non-anxious	Anxious	p	Non-anxious	Anxious
HADS								
Anxiety	5.65 ± 2.06	11.3 ± 2.07	<0.001*	3.9 (±3.42)	7.29 (± 3.66)	0.003	-1.75 (±3.61)	-3.96 (±3.84)
Depression	4.7 ± 2.13	8.83 ± 3.41	<0.001*	4.1 (±1.83)	6.67 (±3.29)	0.003	-0.6 (±2.76)	-2.17 (±3.06)
VAS								
Back	4.6 ± 3.22	5.92 ± 2.7	0.16	2.45 (±3.22)	2.58 (±2.41)	0.562	-2.15 (±3.9)	-3.33 (±3.41)
Legs	6.6 ± 2.89	7.72 ± 2.4	0.44	1.8 (±2.78)	1.62 (±2.24)	0.919	-4.8 (±4.21)	-6.08 (±2.73)
GPE	-0.6 ± 3.55	-0.38 ± 3.51	0.73	2.6 (±2.89)	2.33 (±2.56)	0.457	3.2 (±5.4)	2.71 (±4.36)
ODI	36.5 ± 20.8	52.8 ± 22.9	0.02*	10.4 (±10.4)	13.8 (±10.9)	0.29	-26.1 (±21.4)	-37.9 (±21.9)

Abbreviations: HADS, Hospital Anxiety and Depression Scale; VAS, Visual Analogue Scale; GPE, Global Perceived Effect of Change; ODI, Oswestry Disability Index.
P-value obtained using the Mann-Whitney test.

Table 3 Symptoms and function preoperative and 6 months after surgery

	Preoperative		6 months after surgery		
					p
HADS					
Anxiety	8.7 (±3.48)		5.91 (±4.01)		< 0.001
Depression	6.95 (±3.54)		5.6 (±3.03)		0.005
VAS					
Back	5.32 (±3.03)		2.52 (±2.70)		< 0.001
Legs	7.2 (±2.66)		1.70 (±2.47)		< 0.001
GPE	-0.48 (±3.48)		2.45 (±2.69)		< 0.001
ODI	45.4 (±23.2)		12.2 (±10.70)		< 0.001

Abbreviations: HADS, *Hospital Anxiety and Depression Scale*; VAS, Visual Analogue Scale; GPE, Global Perceived Effect of Change; ODI, Oswestry Disability Index.
P-value obtained by Wilcoxon test.

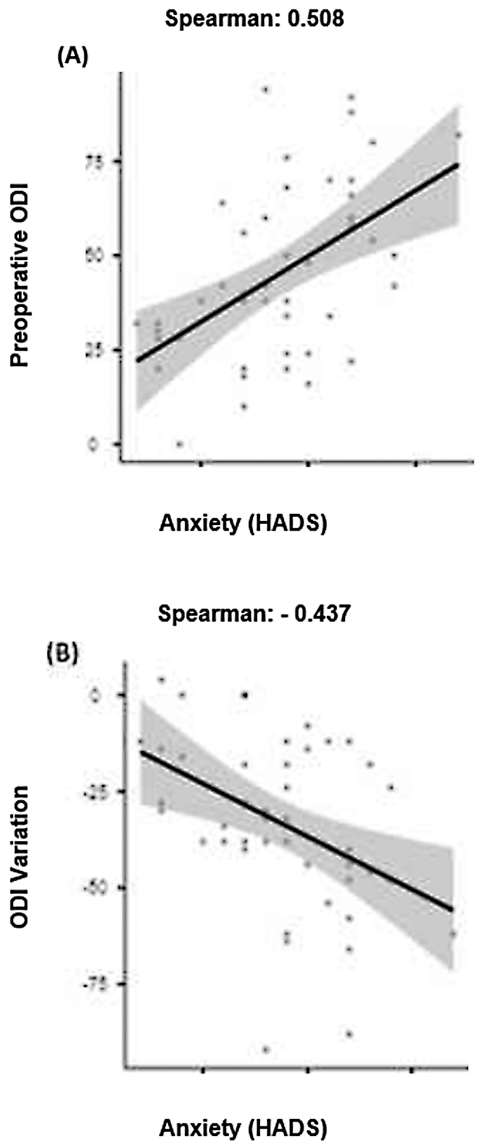


Fig. 1 Anxiety scatter plot x ODI. Spearman rank coefficient.

patients with higher anxiety scores reported greater dysfunction function at the preoperative time. In addition, a negative correlation was observed between preoperative anxiety and ODI score variation, that is, patients with initially higher anxiety scores reported greater functional gain after surgery.

Discussion

Spine surgeries have evolved in recent years, and techniques considered less invasive become increasingly used.[15] In the present study, microtubular and endoscopic surgery was used, which proposes little tissue aggression and an early return to normal preoperative activities.[16] This approach promoted pain improvement, self-perceived improvement, anxiety, and depression symptoms 6 months after surgery.

The age of the patients in this study corresponds to that reported in other studies, with the mean age of patients with neural compression being 35 to 55 years.[17]

Previous studies correlate chronic low back pain with worsening mental health.[18,19] However, the impact of anxiety symptoms on the clinical and functional outcomes of patients with neural compression undergoing minimally invasive lumbar decompression is not well established in the literature. Specific studies on the subject suggest that anxiety symptoms do not modify the prognosis of patients.[20] However, the initial hypothesis of the present study was that anxious patients would have worse clinical and functional outcomes. Contrary to the initial hypothesis, and in agreement with previous studies, it was observed that more anxious patients had similar clinical outcomes to those of non-anxious patients. However, studies on the effects of anxiety on clinical outcomes should continue since it is a comorbidity, and these, in turn, are obstacles in the postoperative treatment of patients.

Regarding the modulation of the anxiety score in patients after surgical treatment, the data obtained suggest that, in individuals adequately selected for neural compression surgery, anxiety symptoms would be caused by pain, not

originate it. Six months after surgery, a significant reduction in anxiety symptoms was observed, accompanied by an improvement in pain and quality of life scores.

The mean variation of the functionality scale during the 6 months was significant (33.2 points), similar to the variation of surgical decompression described in the systematic review by Ma et al.[21] (28.1–34.5).

Concerning the association tables analyzed, the association between dysfunction and preoperative anxiety follows that analyzed in previous studies, which suggests worse anxiety symptoms in patients with more intense lumbar compression symptoms. Simultaneously, the positive correlation between functional gain and preoperative anxiety demonstrates that patients with more anxiety symptoms had more significant benefits from surgery in terms of functionality.

The main limitations of this study are its small sample size, its limitation to a private hospital center, and its potential inability to represent the reality of other services. The use of the HADS questionnaire for anxiety screening can be considered limited due to the lack of face-to-face evaluation by a psychologist. Due to the absence of evaluation of psychiatric comorbidities in patients and their medication use, it was not possible to evaluate possible effects between psychiatric comorbidities, medication use, and the development of anxiety symptoms in patients after surgery. However, the consistency of the data suggests that the presence of neuropathic pain and dysfunction in individuals with lumbar neurological compression promoted the appearance of anxiety symptoms. The factors that corroborate this hypothesis are the initial correlation between dysfunction and anxiety, followed by a decrease in both due to the therapeutic effect of surgery on dysfunction, consequently reducing anxiety.

Conclusions

Minimally invasive lumbar decompression surgery promoted clinical and functional improvement, not being affected by preoperative anxiety symptoms. These, in turn, improved 6 months after surgery.

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

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Prevalence and Risk Factors Associated with Chronic Occupational Low Back Pain among Healthcare Professionals Working at Hospitals: Exploratory Survey Study

Prevalência e fatores de risco associados a dor lombar ocupacional crônica entre profissionais da área da saúde que atuam em nível hospitalar: Estudo survey exploratório

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Abstract

Objective This study aimed to describe the methodological process for developing a questionnaire to identify the prevalence and risk factors for chronic occupational low back pain in healthcare professionals working at hospitals.

Method An exploratory crossectional survey study was carried out in Belo Horizonte, MG, Brazil, and its metropolitan region, in two stages. Initially, the authors prepared a questionnaire based on the Roland Morris disability questionnaire and sent it to a committee of low back pain specialists for validation using the Delphi technique. The second stage consisted of sending the final questionnaire to health professionals working in a hospital environment for at least 2 years and presenting chronic low back pain for at least 3 months.

Results Validation occurred in two rounds of questionnaire adjustments by a panel consisting of physical therapists and physician experts in the field (orthopedists with more than 3 years of experience). Both rounds had 13 participants. The questionnaire initially consisted of 27 items, and, after validation, it had 19 items. The study included 65 subjects, with an average age of 40.91 years old and an average time working at a

Keywords
- back pain
- health professionals
- low back pain
- quality of life
- work capacity evaluation

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hospital of 40 hours per week. The total sample had 76.9% of physicians, 10.8% of physical therapists, and 12.3% of nurses or nursing technicians. Most (52.3%) subjects reported staying in uncomfortable positions affecting the lower back for 5 to 10 hours per day.

Conclusion We developed and validated, using the Delphi technique, a questionnaire on the prevalence and risk factors associated with chronic occupational low back pain among healthcare professionals working at hospitals. This unprecedented tool can benefit the population studied since the questionnaires currently used to evaluate chronic low back pain are not specific for investigating the occupational cause of this condition.

Resumo

Objetivo Este estudo pretende descrever o processo metodológico para a elaboração de um questionário para identificar a prevalência e os fatores de risco associados à dor lombar ocupacional crônica nos profissionais da área da saúde que atuam em nível hospitalar.

Método Foi realizado um estudo transversal exploratório do tipo questionário. O estudo foi realizado na cidade de Belo Horizonte e região metropolitana, em duas etapas. Inicialmente foi elaborado pelos autores um questionário baseado no questionário de deficiências Roland Morris e enviado a um comitê de especialistas em lombalgia para validação do mesmo através da técnica Delphi. A segunda etapa consistiu em enviar o questionário final a profissionais de saúde que atuam em ambiente hospitalar há pelo menos 2 anos e que tenham lombalgia crônica há pelo menos 3 meses.

Resultados A validação foi realizada em duas rodadas de adequações do questionário, com painel composto por fisioterapeutas e médicos especialistas na área (ortopedistas com mais de 3 anos de atuação). Ambas as rodadas contaram com 13 participantes. O questionário foi composto inicialmente por 27 itens e, após validação, 19 itens. O estudo incluiu 65 indivíduos, com idade média de 40,91 anos e tempo médio de atuação em nível hospitalar semanal de 40 horas. A amostra total possuía 76,9% médicos, 10,8% fisioterapeutas e 12,3% enfermeiros ou técnicos de enfermagem. A maioria (52,3%) dos indivíduos relatou manter-se em posições desconfortáveis que afetam a região lombar por 5 a 10 horas por dia.

Conclusão Foi desenvolvido e validado, pela técnica Delphi, um questionário sobre a prevalência e fatores de risco associados a dor lombar ocupacional crônica entre profissionais da área da saúde que atuam em nível hospitalar. Este instrumento inédito pode trazer benefícios para a população estudada, visto que os questionários utilizados atualmente para a avaliação de dor lombar crônica não são específicos para a investigação da causa ocupacional de tal condição.

Palavras-chave
- avaliação da capacidade de trabalho
- dor lombar
- dor nas costas
- profissionais de saúde
- qualidade de vida

Introduction

Low back pain is a common symptom and the major cause of disability in the world.[1] n its occupational variant, the condition appears or worsens due to the subject's work. Occupational low back pain must not be analyzed only as a medical issue but also as a socioeconomic problem as it affects the economically active population and is related to work incapacity.[2] Healthcare professionals working at hospitals need agility and face threats, risk of infections, and increasing demands on medical skills. In this sense, this category must suffer from low back pain resulting from work, and this effect remains unknown.

Simsek et al.[3] demonstrated that the lifetime prevalence of low back pain among healthcare workers was 53%, with an annual one of 39%, and a specific one of 29.5%. Furthermore, the literature identified three large groups of potential risk factors for low back pain: (a) individual factors such as body weight and age; (b) mechanical factors such as heavy physical load, lifting, crooked postures, and vibration; and (c) psychosocial factors such as control and job satisfaction.[4] These psychosocial factors affect physical and

mental performance at work but also influence medical errors.[1]

Few epidemiological studies have analyzed the onset and risk factors for low back pain among healthcare professionals. We found a single study about it, showing its prevalence among nurses in Africa as 70%.[4] The assessment tools for low back pain present high heterogeneity in international epidemiological studies. A systematic review of 165 studies from 54 countries found that the average one-month prevalence of low back pain was 30.8%, with a standard deviation of 12.5%. The deviation for the one-year prevalence was even higher.[5]

Questionnaire use in the medical field is widespread. Although several questionnaires have been developed to assess disability and activity limitations in patients with low back pain,[6] the literature has no specific method for assessing the occupational cause of this condition in healthcare professionals.

For this reason, the present study aimed to develop and describe the methodological process for producing a questionnaire using the Delphi technique, with the help of low back pain specialists, targeted at identifying the prevalence and risk factors for chronic occupational low back pain healthcare professionals working in hospitals.

Materials and Methods

Study Design, Sample, and Ethical Aspects

This study is an exploratory crossectional survey. An expert committee validated the items in the developed questionnaire. The inclusion criteria for these professionals were physical therapists or orthopedists with expertise in low back pain. The inclusion criteria for questionnaire respondents in the second stage of the study were healthcare professionals working in a hospital environment for at least 2 years and presenting chronic low back pain for at least 3 months.

The developed questionnaire investigated contextual factors associated with occupational low back pain in clinical and surgical practice at the tertiary level. The final questionnaire was sent by email to healthcare professionals from the city of Belo Horizonte between February and July 2022. These professionals were recruited from the general population using a prior research list.

The Research Ethics Committee evaluated and approved the protocol for this study under opinion number 5.003.882. All participants signed an informed consent form.

Development and Application of the Questionnaire

A previous questionnaire on low back pain, the Roland Morris Disability Questionnaire, was the basis of our questionnaire since it evaluates and quantifies low back pain as a score to increase diagnostic precision and guide the necessary treatment. This tool assesses the physical limitations resulting from reported lumbar spine pain and consists of 24 "yes" or "no" questions regarding symptoms on the evaluated day, describing the back pain situation. Nusbaum et al.[7] translated, adapted, and validated it for the Brazilian population, allowing its usual application in interviews.

It is an easy and quick questionnaire, taking an average of five minutes to administer, a significant factor in choosing it as a reference. This questionnaire evaluates different clinical parameters to assess the disabilities caused by low back pain and its consequences on quality of life. Scores range from 0 to 24 per the sum of positive responses, with higher scores indicating higher disability.[7] It presents high internal consistency (Cronbach $\alpha = 0.92$) and interrater reliability with an intraclass correlation coefficient (ICC) of 0.95 and a 95% confidence interval (95% CI = 0.93–0.97), showing a good correlation with other pain scales.[8]

Therefore, after evaluating this questionnaire's positive and negative points, we created the first version of our questionnaire on the prevalence and risk factors associated with chronic occupational low back pain among healthcare professionals working at hospitals. This version carefully evaluated a specific type of low back pain in a well-defined population. To this end, we included pertinent questions to better diagnose the type of low back pain and its prevalence in the mentioned population, considering its peculiarities.

We used the Delphi technique to validate the final version of our questionnaire. This technique consists of an interactive estimation method to establish the content validity of a tool by systematically analyzing the opinions of experts on a given subject. After rounds of theoretical content analysis, in which experts shared their answers, the group reached a consensus.[9]

Data Analysis

We estimated the prevalence of responses to the proposed questionnaire using percentages. The descriptive analysis of the study sample employed measures of central tendency (mean and standard deviation) for continuous variables and absolute (n) and relative frequency (%) for categorical variables. We performed all analyses using the Statistical Package Social Sciences (SPSS, IBM Corp., Armonk, NY, USA) software, version 26.0.

Results

Questionnaire Validation using the Delphi Technique

For the first round of the Delphi technique, we sent the questionnaire electronically; for the second round, we sent it electronically and in person. The themes selected in the review guided the initial questionnaire preparation. We launched the questionnaire initially via Google Forms to 38 potential participants, as illustrated in ►**Fig. 1**. Of these, 4 declared themselves ineligible to answer the questionnaire because they did not meet all the inclusion criteria, and 21 did not answer the request for participation in the Delphi technique. In the first round, the panel of experts consisted of 13 participants, and the questionnaire had 27 items, with the initial 6 referring to the identification of the participants.

In the second and last round, the panel had the same 13 participants. These experts suggested excluding eight questions between the first and second rounds of the Delphi technique. Of these, 6 were not consensual regarding the

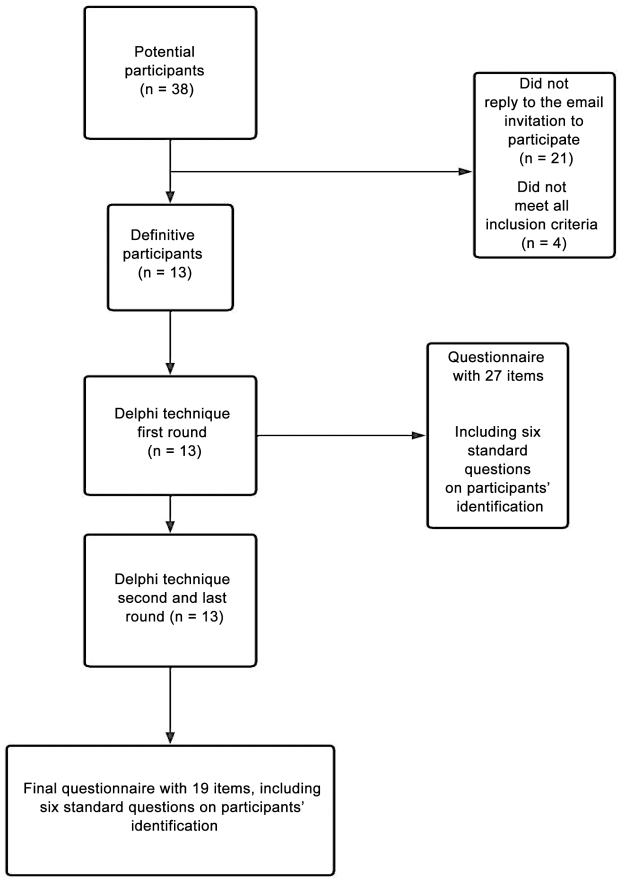


Fig. 1 Flowchart of the Delphi technique's application for questionnaire validation.

importance of the final score/diagnosis, and 2 did not reach a consensus for requiring a specific orthopedic terminology, a potential factor for reducing reproducibility on a large scale.

Thus, the final questionnaire had 19 items, again with the initial six items referring to identification, with suggestions for changing the vocabulary in six items (number 5 in the Identification section and numbers 2, 3, 4, 6, and 8 in the Validation section), with consensus on all items after changes. The items from this round comprise the final version of the questionnaire.

Application of the Final Version of the Questionnaire

The validated questionnaire (**Box 1**) was applied electronically via the Google Forms platform to 65 healthcare professionals (physicians, physical therapists, nurses, and nursing technicians). Our sample consisted entirely of healthcare professionals working in hospitals for at least 2 years and presenting chronic low back pain with symptoms for at least 3 months.

Participant Identification

Of the 65 research participants, 40 (61.5%) were men and 25 (38.5%) were women. As for profession, 50 (76.9%) participants were physicians, 7 (10.8%) were physical therapists, 4 (6.2%) were nurses, 3 (4.6%) were nursing technicians, and 1 (1.5%) was from another healthcare area. The maximum degree selected was Specialization and/or Residency, representing 38 (58.5%), Professional or Academic Master's degree 14 (21.5%), Doctorate 6 (9.2%), Bachelor's degree 4 (6.2%), Technician 2 (3.1%), and Academic Professor/Researcher 1 (1.5%). Concerning the weekly workload in a hospital environment, 28 (43.1%) worked 40 hours or more, 15 (23.1%) 30 to 40 hours, 12 (18.5%) 20 to 30 hours, and 10 (15.4%) worked up to 20 hours (►**Table 1**).

Questionnaire Responses

Of the study's 65 participants, 52 (80%) subjects reported remaining in the same position (sitting down or standing up) for most of their working hours in a hospital environment. During a shift (minimum of 12 hours) and/or a typical working day, 7 (10.8%) participants remained in uncomfortable positions affecting the lower back for 10 to 20 hours, 34 (52.3%) from 5 to 10 hours, and 24 (36.9%) from 0 to 4 hours. Furthermore, 47 (72.3%) subjects reported the need to change positions frequently during a procedure to have more comfort in the lower back.

We asked the participants if they avoided standing up or walking because of low back pain; 9 answered "yes", 35 (53.8%) said "no", and 21 (32.3%) responded "sometimes". Also, 8 (12.3%) avoided using stairs or ramps due to the pain, while 51 (78.5%) denied avoiding it and six (9.2%) answered "sometimes".

When asked about irradiation to the lower limbs, 4 (6.2%) responded "yes", 11 (16.9%) said "sometimes", and 50 (76.9%) answered "no".

Regarding signs of paresthesia in low back pain, 4 (6.2%) answered "yes", 56 (86.2%) stated "no", and 5 (7.7%) said "sometimes". The intensity of low back pain, from 0 to 10, at the time of completing the questionnaire was 0 (0.0%), 1 (47.7%), 2 (9.2%), 3 (15.4%), 4 (7.7%), 5 (7.7%), 6 (6.2%), 7 (4.6%), 8 (1.5%), 9 (0.0%), and 10 (0.0%). The average intensity of low back pain in the last 6 weeks, from 0 to 10, was 0 (0.0%), 1 (15.4%), 2 (15.4%), 3 (15.4%), 4 (15.4%), 5 (10.8%), 6 (9.2%), 7 (7.7%), 8 (7.7%), 9 (1.5%), and 10 (1.5%).

About the frequency of use of medication for low back pain in the last 3 months, 45 (69.2%) participants responded that they do not use it, 12 (18.5%) used it less than once a week, four (6.2%) used it once or twice a week, one (1.5%) used 3 to 5 times a week, and three (4.6%) used it daily. Furthermore, 32 (49.2%) participants had already consulted a specialist due to low back pain, and 38 (58.5%) performed some supplementary intervention (physical therapy, yoga, acupuncture, gym) due to low back pain (►**Chart 1**).

Discussion

The present study provided an efficient method of evaluating the prevalence and risk factors of occupational low back pain in healthcare professionals at the hospital level. A literature review reported the methodological quality of the Rolland Morris questionnaire was good. Thus, due to its high dissemination in the literature, easy applicability, and low cost, it was used as a guide for developing the occupational low back pain assessment questionnaire for healthcare professionals working in a hospital environment, which was employed to

Table 1 Characterization of the sample responding to the questionnaire developed in the study (n = 64)

Average age (years)	40.91
Male/female gender, n (%)	40/25 (61.5/ 38.5)
Professional qualification	
Medicine, n (%)	50 (76.9)
Physical therapy, n (%)	7 (10.8)
Nursing or nursing technician, n (%)	7 (12.3)
Highest Degree	
Bachelor's degree or Specialization, n (%)	45 (69.3)
Master's or Doctorate, n (%)	20 (30.7)

evaluate the degree of involvement of low back pain of occupational origin in this group.[9,10]

Occupational low back pain is the leading cause of disability in the world and one of the most prevalent complaints in primary care in Brazil. It is the most frequently reported spinal complication and is often inadequately or inefficiently managed. Healthcare professionals are usually exposed to risk factors for this condition due to excessive workload and inadequate posture.[8] Current research on occupational low back pain focuses on biomechanical factors and psychosocial variables that gained importance over time.[11]

Low back pain is a physical and psychosocial pathology. As a result, prospective cohort studies indicate that low work satisfaction and appreciation and excess stress at work from high demands and long working hours showed a significantly

Chart 1 Questionnaire on occupational chronic low back pain among healthcare professionals working at hospitals

In a typical week, how many hours do you work in a hospital setting?	40 hours or more 43.1%	30–40 hours 23.1%	20–30 hours 18.5%	20 hours 15.4%	
Do you stay in the same position (e.g., sitting down or standing up) during most of your working day in a hospital environment?	Yes 80%	No 20%			
During a shift (at least 12 hours) and/or typical workday, how long do you remain in uncomfortable positions affecting your lower back?	0–4 hours 36.9%	5–10 hours 52.3%	10–20 hours 10.8%		
Do you change position frequently during a procedure to have more comfort in your lower back?	Yes 72.3%	No 27.7%			
Because of your pain in the lower back, do you avoid standing up or walking?	Yes 13.8%	No 53.8%	Sometimes 32.3%		
Because of your lower back pain, do you avoid using stairs or ramps?	Yes 12.3%	No, 78.5%	Sometimes 9.2%		
Does your lower back pain radiate to your lower limbs?	Yes 6.2%	No, 76.9%	Sometimes 16.9%		
Does your lower back pain show signs of paresthesia (tingling)?	Yes 6.2%	No, 86.2%	Sometimes 7.7%		
How intense is your low back pain while you fill out the questionnaire from 0 to 10? (With 0 being none and 10 being the worst pain you have ever felt)	Sample average: 2.63 on the pain scale used				
What is the average intensity of low back pain in the last 6 weeks from 0 to 10? (With 0 being none and 10 being the worst pain you have ever felt)	Sample average: 4.07 on the pain scale used				
Have you been taking any medication for lower back pain over the last 3 months? How often do you take it?	Yes, less than once a week 18.5%	Yes, once or twice a week 6.1%	Yes, 3–5 times a week 1.5%	Yes, daily 4.6%	No 69.2%
Have you ever visited a specialist due to low back pain?	Yes 49.2%	No 50.8%			
Do you perform any supplementary interventions due to low back pain? (e.g., physical therapy, acupuncture, physical exercises at a gym, yoga etc.)	Yes 58.5%	No 41.5%			

increased odds ratio (OR) for the prevalence of low back pain.[12] Thus, specialists guide their treatment indications based on radiographic findings (presence of osteoarthritis, neuropathy, or both) and the pain scale, represented in the Roland Morris disability questionnaire. However, we believe this classification often does not consider the peculiarities of occupational low back pain, along with having weak or moderate reproducibility criteria, covering a portion of patients who are underdiagnosed, inappropriately treated, or both.[13,14]

Diagnosis for this condition is simple, relying on a characteristic clinical picture and imaging tests. However, the high-demand routine of healthcare professionals and inadequate body posture make occupational back pain management difficult since causal factors are unlikely to change. Thus, this condition presents a constant challenge for healthcare professionals at the tertiary level.[15]

The key issue in managing any disease is defining the best indication for each type of treatment. Questionnaires in clinical practice aim to stratify each case according to the stage of disease evolution, therefore allowing the determination of the best treatment. Therefore, a specific questionnaire for occupational low back pain among healthcare professionals at the hospital level is a simple and inexpensive way to classify the severity of the condition and assess the presence of a direct relationship between the harmful factors inherent to long-term work at a tertiary level, remaining in an orthostatic position for prolonged hours, poor adherence to physical exercise, and disease worsening. This information, along with the knowledge of the sociodemographic profile of the target group, assure better preventive and/or specialized therapeutic intervention.[16]

Disease-specific questionnaires are often considered superior to their generic counterparts for clinical applications. In turn, these are more appropriate when comparing different diseases or evaluating types of care across disease categories.[17] Therefore, although there are extensive classifications and studies on the prevalence of low back pain in Brazil, we realized there is no exclusive standardization for occupational low back pain in healthcare professionals at the hospital level.

In previous studies, work-related musculoskeletal pain was highly prevalent among healthcare professionals working in hospitals.[18–20] These pain conditions often relate to physical effort and psychological stress. However, a study with health professionals from a hospital in Switzerland showed poor posture at work as the main factor resulting in pain.[19] Likewise, we observed that maintaining the same posture for long periods and the discomfort from these positions are quite common in our sample.

Despite the notable exposure to risk factors for musculoskeletal pain, studies show a wide variety among different types of healthcare professionals. Furthermore, there is variability from study to study according to the questions asked and the metric used.[20]

This study has some limitations. The sample was limited to healthcare professionals working in the metropolitan region of Belo Horizonte, and it may not reflect the behavior of professionals from other places. Furthermore, the validated questionnaire was administered to 65 participants. However, the primary objective of the present study was to develop an expert-validated questionnaire.

Conclusion

The two-step Delphi technique contributed to developing and validating a questionnaire on the prevalence and risk factors associated with chronic occupational low back pain among healthcare professionals working at hospitals. The tool proved to be valid and easy to apply. Furthermore, after applying the final version of the questionnaire, we determined the prevalence and risk factors associated with low back pain, which can be used for both clinical or research purposes.

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

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Comparison of the Functional Outcomes of Arthroscopic Anterior Cruciate Ligament Reconstruction through the All-inside and Outside-in Techniques: A Double-Blinded Randomized Controlled Trial

Comparação dos resultados funcionais da reconstrução artroscópica do ligamento cruzado anterior pelas técnicas all-inside *e* outside-in: *Um ensaio clínico controlado, randomizado e duplo-cego*

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Abstract

Objective To compare the functional outcomes of anterior cruciate ligament (ACL) reconstruction with hamstring autograft (HA) through the all-inside (AI) technique with adjustable-loop cortical Endobutton (Smith & Nephew, Watford, Hertfordshire, England) on the sides of the femur and tibia and through the outside-in (OI) technique using an interference screw on the tibial side and a cortical Endobutton on the femoral side.

Materials and Methods The present is a double-blinded randomized controlled trial (RCT) of 44 patients undergoing arthroscopic ACL reconstruction from February 2019 to February 2022 in a tertiary care hospital. As per computer-based randomization, the patients were distributed into two groups: the AI and OI groups. Both groups were evaluated for 12 months using the Visual Analog Scale (VAS), the Lysholm Knee Scoring Scale, and part I (pain score) and part II (function score) of the Knee Society Score (KSS).

Results On postoperative day 2, the VAS score was significantly higher in the OI group ($p = 0.0001$), but insignificant ($p = 0.807$) at 6 weeks. At 3, 6, and 12 months of follow-up, the score on the Lysholm Knee Scoring Scale was significantly higher ($p = 0.001$) in the AI group. At 6 months, both parts of the KSS showed a significant difference, with

Keywords
- anterior cruciate ligament
- anterior cruciate ligament reconstruction
- arthroscopy
- postoperative complications
- randomized controlled trials as topic
- rupture

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the AI group presenting a better outcome ($p = 0.04$). However, at 12 months, the AI group presented a better score on part I of the KSS, but no differences were observed regarding part II.

Conclusion In a follow-up of 12 months, the patients submitted to the AI technique presented better outcome scores and pain relief than those submitted to the OI technique.

Resumo

Objetivo Comparar os resultados funcionais da reconstrução do ligamento cruzado anterior (LCA) com autoenxerto de isquiotibiais pela técnica *all-inside* (AI) com Endobutton (Smith & Nephew, Watford, Hertfordshire, Inglaterra) cortical de alça ajustável nos lados do fêmur e da tíbia e pela técnica *outside-in* (OI) com parafuso de interferência no lado tibial e Endobutton cortical no lado femoral.

Métodos Trata-se de um ensaio clínico controlado, randomizado e duplo-cego com 44 pacientes submetidos à reconstrução artroscópica do LCA de fevereiro de 2019 a fevereiro de 2022 em um hospital de cuidados terciários. De acordo com a randomização por computador, os pacientes foram distribuídos em dois grupos: AI e OI. Ambos os grupos foram avaliados durante 12 meses pela Escala Visual Analógica (EVA), a Escala de Pontuação do Joelho de Lysholm e pela parte I (pontuação de dor) e a parte II (pontuação de função) da escala Knee Society Score (KSS).

Resultados No segundo dia de pós-operatório, a pontuação média na EVA foi significativamente maior no grupo OI ($p = 0{,}0001$), mas insignificante (p 0,807) às 6 semanas. Aos 3, 6 e 12 meses de acompanhamento, a pontuação na Escala de Lysholm ($p = 0{,}001$) foi significativamente maior no grupo AI. Aos 6 meses, ambas as partes da KSS apresentam uma diferença significativa, com o grupo AI apresentando um desfecho melhor ($p = 0{,}04$). No entanto, aos 12 meses, o grupo AI apresentou uma pontuação melhor na parte I da KSS, mas não foram observadas diferenças na parte II.

Conclusão Em um acompanhamento de 12 meses, os pacientes submetidos à técnica AI apresentaram melhores pontuações de desfecho e alívio da dor do que aqueles submetidos à técnica OI.

Palavras-chave

- artroscopia
- complicações pós-operatórias
- ensaios clínicos controlados e randomizados como assunto
- ligamento cruzado anterior
- reconstrução do ligamento cruzado anterior
- ruptura

Introduction

Arthroscopic reconstruction of the anterior cruciate ligament (ACL) presents advantages such as a less invasive procedure and an earlier recovery. Many hospitals are performing arthroscopic ACL reconstruction as day-care surgery. The procedure can be performed through the all-inside (AI) technique, which only depends on the adjustable loop, or through the outside-In (OI) technique with a complete tibial tunnel using an interference screw and adjustable loop.[1]

In the OI technique, the graft is fixed with an interference screw on the tibial side and Endobutton (Smith & Nephew, Watford, Hertfordshire, England) on the femoral side. Biomechanical studies[2] have shown that the interference screws present low fixation strength due to graft slippage. Other worries associated with interference screws are graft maceration and the small tendon-to-bone contact for the biological incorporation of the graft.[2]

In the AI technique, two bone sockets are made on either side of the graft instead of the complete bone tunnels. The autograft is whip-stitched on both sides, and the sutures are attached to the cortical Endobutton on either side.[3] Recently, the use of adjustable-loop cortical Endobutton in both femoral and tibial sides came into practice, which presents the advantage of an implant-free tendon graft for bone fixation in both the femoral and tibial sides, which augments the tendon-to-bone biological integration.[4] The concern with the AI technique is graft elongation, which leads to an increased gap between the two cortical Endobuttons, which causes recurrence of the laxity and instability in the knee joint; moreover, it can lead to graft slippage.[5] In the literature, there are few studies comparing both methods in terms of functional outcomes; only two randomized controlled trials[6,7] and two prospective studies[8,9] have compared these two techniques. No studies have compared both methods with the use of an autograft. The present randomized control trial aimed to compare the functional outcomes of ACL reconstruction using the AI and OI techniques.

Materials and Methods

Study Design

The present prospective randomized double-blinded study with 2 parallel arms was conducted at a tertiary care hospital from February 2019 to February 2022, and it was approved

by the institutional Ethics Committee (IEC/AIIMS BBSR/PG THESIS/2018-19/38).

Inclusion Criteria

- Patients with ACL tear without improvement after the conservative management.
- Patients with knee flexion greater than 90°.
- Cases of ACL tear associated with medial or lateral meniscus tear injuries.
- Patients aged between 20 and 60 years.
- Patients with ACL tears with a history of injury within one year.

Exclusion Criteria

- Patients with multiligament knee injury.
- Patients with associated bony injuries of the lower limb and injury to the spine.
- Patients with chondral lesions of grade II or higher as per the Outerbridge classification.
- Revision ACL reconstruction.
- Patients with local skin lesions over the surgical site.

Randomization and Allocation Concealment

Patients with ACL tears who fulfilled the inclusion criteria were recruited after providing written informed consent. The patients were randomized into two groups using an online randomization software (www.randomization.com). Gender, age, injured side, presence of meniscal or chondral lesions, as well as the duration of the injury were recorded. Two surgeons (BPP and SKP) performed the surgery as per allocation. The investigator (GD) who evaluated and followed up the patients pre- and postoperatively in the outpatient clinic was also blinded about the procedure performed. Postoperatively, the patients were assessed according to the postoperative protocol. The randomization sequence was performed by another investigator (VP) who was not involved in the surgery, recruitment, or postoperative assessment of the patients.

The sample size was calculated based on the mean difference of 2 with an alpha error of 5% (95% confidence interval). Taking the power of 80%, we found that the sample size was of 19 patients in each group. Adding 15% of attrition to 19, which is 3, the sample size obtained was of 22 subjects in each group.

Surgical Technique

In all cases, routine diagnostic arthroscopy was performed using standard portals. Both semitendinosus and gracilis autografts were harvested for the OI technique, and only the semitendinosus graft was harvested for the AI technique. Femoral bone tunnels were made similarly in both techniques using standard jigs. However, the tibial tunnel for the AI technique was performed using a FlipCutter (Arthrex, Inc., Naples, FL, United States) drill, and, for the OI technique, a standard jig. In the AI technique, the whip-stitched autograft is held by cortical Endobutton on both the femoral and tibial sides, whereas in the OI technique it is is held by cortical Endobutton on the femoral side and an interference screw on the tibial side. Any associated meniscal or chondral lesions were debrided or partially resected along with index reconstruction. Following surgery, knee lavage was performed, followed by wound closure. An extended knee brace was used in both groups. After the procedure, all patients were sent to rehabilitation as per the post-operative protocol.

Rehabilitation

All patients underwent an accelerated rehabilitation protocol with closed-chain range of motion (ROM) exercises and full weight bearing with the long knee brace from postoperative day two, and open-chain ROM exercises and full weight bearing without the knee brace after two weeks, when they were instructed to perform home-based rehabilitation as per the protocol. The patients followed the rehabilitation protocol and usually returned to sports at six months.

Outcome Measures

Both groups of patients were evaluated before surgery and on the second and fifth days, second and sixth weeks, and third, sixth, and twelfth month after surgery. The scores on the Visual Analog Scale (VAS), the Lysholm Knee Scoring Scale, and the Knee Society Score (KSS) were evaluated in the third, sixth, and twelfth postoperative months using appropriate proforma by a blinded investigator (GD). Pain was classified based on the VAS score into mild (< 3), moderate (3 to 7), and severe (> 7). Linear regression analysis was performed regarding the VAS score on the second day (dependent variable) and the technique (independent variable).

As per the power analysis, we included 44 (38 male and 6 female) patients randomly allocated into 2 groups (AI and OI) with 22 patients in each (►**Fig. 1**).

Statistical Methodology

The statistical analysis was performed using the IBM SPSS Statistics for Windows (IBM Corp., Armonk, NY, United States) software.

Results

Demographics and Other Baseline Data

There was no significant difference regarding the demographic data (age, sex, and body mass index, BMI) or the other baseline data (duration of injury, laterality, physical activity, associated meniscal injury) between the two groups (►**Table 1a**).

The mean VAS score on the second postoperative day was significantly higher in the OI group ($p = 0.0001$). However, the mean VAS scores of both groups in the sixth postoperative week were not significantly different ($p = 0.807$) (►**Table 1b**).

Linear Regression Analysis

The linear regression analysis model was significant, with an R^2 value of 0.513 ($p < 0.05$). The change in technique from AI

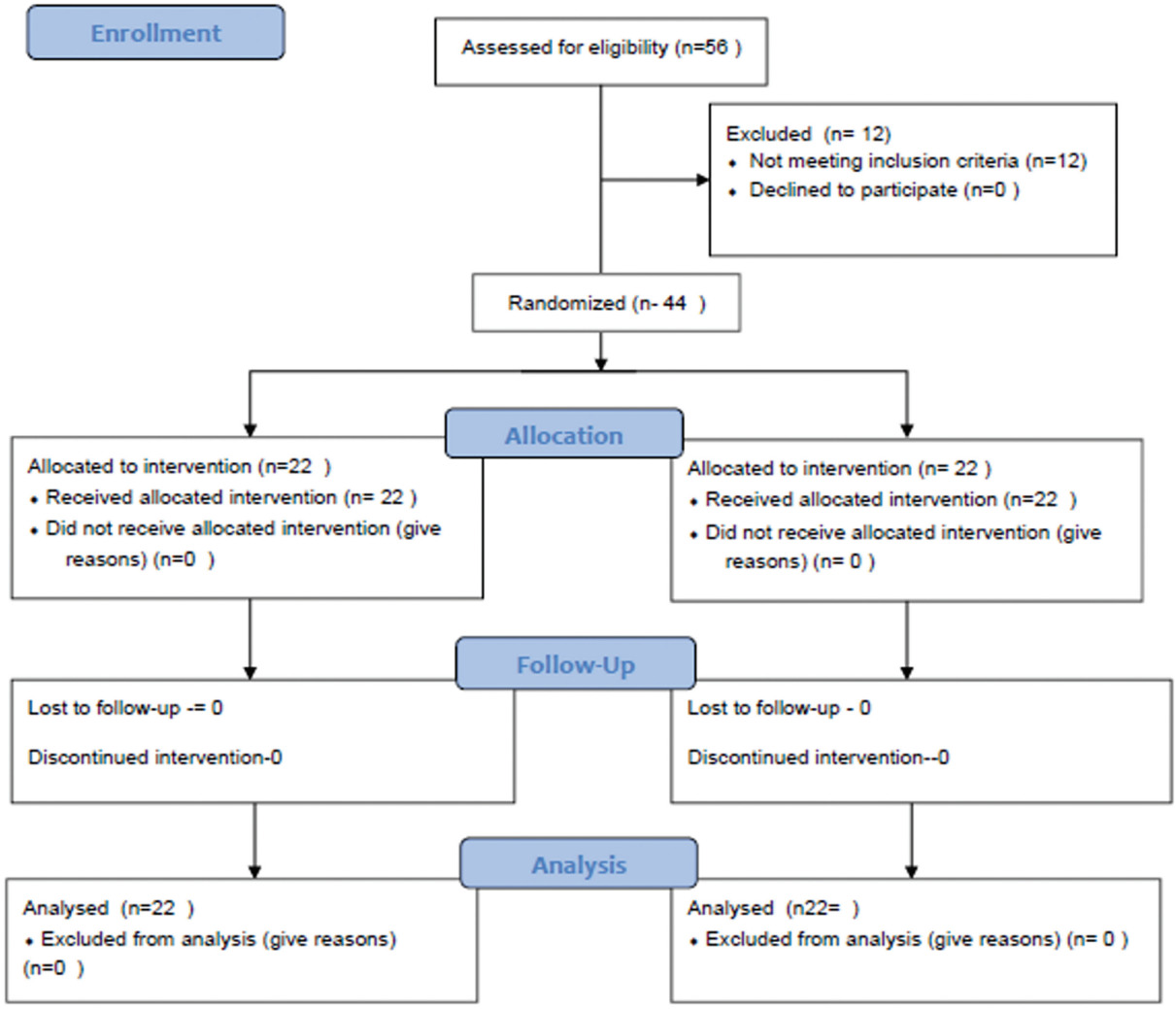


Fig. 1 Consolidated Standards of Reporting Trials (CONSORT) diagram.

Table 1a Baseline demographic data

	AI group (n = 22)	OI group (n = 22)
Male:female ratio	19:3	19:3
Age (years)	29	28.86
Duration of the injury (days)	150	159
Right:left ration	11:11	12:10
Mean body mass index (kg/m^2)	24.79	24.79
Physical activity	Sedentary lifestyle: 2; average: 15; sportsperson5	Sedentary lifestuyle: 3; average: 15; sportsperson: 4
Associated meniscal injury	8	7

Abbreviations: AI, all-in technique; OI, outside-in technique.

to OI altered the VAS score by 2.995 (►**Table 2**). Sex, BMI, age, and physical activity were also compared regarding the scores on the VAS, Lysholm scale, and the KSS, but they did not result in a significant model.

In the follow-up at the 3rd, 6th, and 12th postoperative months, the the score on the Lysholm scale ($p = 0.001$) was significantly higher in the AI group (►**Table 3**). In this scale, the functional outcome is classified into poor (score < 65),

Table 1b Visual Analog Scale (VAS) scores at baseline, on day 2, and in 6 weeks of follow-up

Data	AI (mean ± SD)	OI (mean ± SD)	95%CI (lower-upper)		*p*-value
Baseline VAS	0.45 ± 0.510	0.41 ± 0.503	-0.263	-0.263	0.767
VAS day 2	1.32 ± 1.359	4.27 ± 1.579	-3.851	-2.058	0.0001
Mean difference	0.86 ± 1.521	3.86 ± 1.612	-3.963	-2.037	0.0001
VAS 6 weeks	0.14 ± 0.640	0.18 ± 0.588	-0.419	0.329	0.807
Mean difference	-0.32 ± 0.894	-0.23 ± 0.869	-0.627	0.445	0.734

Abbreviations: 95%CI, 95% confidence interval; AI, all-in technique; OI, outside-in technique; SD, standard deviation.

Table 2 Linear regression analysis

	R^2	B	*p*-value
Technique	0.513	2.955	< 0.05
Visual Analog Scale score			

fair (score ranging from 65 to 83), good (score ranging from 84 to 90) and excellent (score > 90). At three months, only 1 patient in the AI group had a poor score compared to five in the OI group, and 21 in the AI group had a fair score compared to 17 in the OI group. At 6 months, 1 patient in AI group had a fair score compared to 4 in the OI group; 9 patients had a good score in the AI group compared to 17 in the OI group; and 12 patients in the AI group had an excellent score compared to 1 in the OI group. At 12 months of follow-up, all patients except 1 in each group had superior functional outcome scores, and 1 in each group had a good score. The KSS has two parts: the pain score (part I) and the function score (part II). There was a significant difference in part I of the KSS at 3 months ($p = 0.009$), but not in part II. At six months, both parts of the KSS showed a substantial difference between the two groups, with the AI group presenting a better score ($p = 0.04$). However, at 12 months of follow-up, the AI group presented significantly better scores on part I of the KSS ($p = 0.033$); regarding part II, there were no significant differences between the groups ($p = -0.543$) (►**Table 4**). However, both groups improved significantly in the comparison between the preoperative assessments and the follow-up. The anterior drawer test and the Lachman test showed no significant differences in laxity between the two groups either preoperatively or at the follow-up. However, there was a substantial difference in laxity preoperatively and at follow-up in both groups according to the Lachman and anterior drawer tests.

Complications

None of the patients underwent revision surgery. Six weeks postoperatively, 5 patients in the AI group (22.72%) and 12 in the OI group (54%) complained of altered sensation in the knee; 2 patients in the OI group developed foreign body sensation; and 1 patient in the AI group developed synovitis. Regarding joint effusion, 2 patients in the AI group and 3 in the OI group developed it. The foreign body sensation, synovitis, and joint effusion were resolved in every patient at 3 months of follow-up.

Discussion

In the literature, there are few studies comparing the AI and OI techniques in terms of functional outcomes; only two randomized controlled trials[6,7] and two prospective studies[8,9] have compared them. Volpi et al.[9] reported that, concerning adequate articular function and return to sports, there are no differences between the AI technique and the traditional ACL reconstruction using the semitendinosus and gracilis tendons. Lubowitz et al.[6] reported no differences in the scores on the International Knee Documentation

Table 3 Lysholm scale score at baseline and with 3, 6 and 12 months of follow-up

Data	AI (mean ± SD)	OI (mean ± SD)	*p*-value
Baseline	70.73 ± 0.456	70.64 ± 0.492	0.529
3 months	73.45 ± 4.906	68.14 ± 5.445	0.001
Mean difference after 3 months	2.73 ± 4.939	-2.50 ± 5.510	0.002
6 months	90.32 ± 4.202	85.64 ± 4.100	0.001
Mean difference after 6 months	19.59 ± 4.317	15.00 ± 4.220	0.001
12 months	97.95 ± 2.7	94.73 ± 3.33	0.001
Mean difference after 12 months	27.22 ± 0.116	24.09 ± 0.119	0.032

Abbreviations: AI, all-in technique; OI, outside-in technique; SD, standard deviation.

Table 4 Knee Society Score (KSS) at baseline and at 3, 6 and 12 months of follow-up

Data	AI (mean ± SD)	OI (mean ± SD)	*p*-value
KSS part I (baseline)	70.68 ± 0.477	70.59 ± 0.503	0.512
KSS part II (baseline)	69.68 ± 0.477	69.50 ± 0.512	0.230
KSS part I (3 months)	66.73 ± 5.978	60.73 ± 8.430	0.009
KSS part II (3 months)	51.64 ± 8.963	48.18 ± 9.825	0.230
Mean difference in KSS part I (3 months)	-3.95 ± 5.900	-9.86 ± 8.571	0.011
Mean difference in KSS part II (3 months)	-18.05 ± 8.941	-21.32 ± 9.544	0.247
KSS part I (6 months)	90.18 ± 2.986	86.73 ± 7.052	0.040
KSS part II (6 months)	88.23 ± 5.228	84.55 ± 6.710	0.049
Mean difference in KSS part I (6 months)	19.50 ± 2.988	16.14 ± 6.951	0.043
Mean difference in KSS part II (6 months)	18.55 ± 5.180	15.05 ± 6.586	0.050
KSS part I (12 months)	97.18 ± 3.14	94.14 ± 2.8	0.003
KSS part II (12 months)	98.45 ± 3.18	97.95 ± 2.5	0.556
Mean difference in KSS part I (12 months)	26.50 ± 1.9	23.55 ± 2.88	0.033
Mean difference in KSS part II (12 months)	28.81 ± 1.9	28.45 ± 2.11	0.543

Abbreviations: AI, all-in technique; OI, outside-in technique; SD, standard deviation.

Committee (IKDC) Knee Examination Form, the KSS, and the 12-Item Short-Form Health Survey (SF-12), nor in terms of tibial and femoral widening, but that ACL reconstruction with the AI technique resulted in lower pain scores on the VAS compared with baseline. In another study, Lubowitz et al.[7] concluded that there were no significant differences in knee anteroposterior stability or other outcomes comparing AI ACL allograft reconstruction using aperture fixation and using suspensory fixation. The graft length requirement in the AI group ranged from 6 cm to 6.5 cm, and, in the OI group, it ranged from 8.5 cm to 9 cm. The requirement of graft length was lower in the AI group, so greater graft thickness is available for ligament reconstruction.

In a systematic review published in 2018, de Sa et al.[10] reported a better functional outcome and low graft failure rate with the AI technique. Browning et al.[11] reviewed ACL reconstruction using aperture fixation or suspensory fixation and found that suspensory fixation resulted in lower graft failure rates and better knee stability. However, in the present study, with the Lachman and anterior drawer tests, we observed no significant differences in knee stability between both groups, and none of our patients underwent revision surgery. The difference in functional outcome between the two methods was not significant in previous studies.[6] However, in the present study, with a medium follow-up of 12 months, better functional outcomes were observed in the AI group. We found that the AI technique results in significant pain relief from the immediate postoperative period until up to six weeks. After that, there were no significant differences in the VAS scores between the groups. Benea et al.[12] concluded that the pain level was lower in the AI group than in the classic cortical fixation group at one month follow-up. In 2015, Lubowitz et al.[7] compared suspensory fixation using femoral and tibial cortical buttons and aperture fixation using a femoral cannulated interference screw and a tibial cannulated interference retrograde screw; the follow up was of two years, and the "primary outcome measure was knee anteroposterior (AP) stability measured using the KT-1000 device (MEDmetric, San Diego, CA). Secondary outcome measures included change in pain score on a visual analog scale versus preoperatively, narcotic consumption, International Knee Documentation Committee knee examination rating, International Knee Documentation Committee subjective evaluation score, Knee Society Scores, Short Form 12 scores, and radiographic analysis for socket widening". The authors[7] did not find any significant difference in any of these outcome scores. In 2014 Volpi et al.[9] compared pain and the functional outcome using the Tegner and Lysholm scales, and the IKDC score regarding reconstruction performed though the AI transtibial technique and the traditional transtibial technique with two years of follow-up, and they observed no significant changes in any of the outcomes. Return to sports is an important outcome measure after ACL reconstruction; however, it depends on the type of sport and rehabilitation protocol. The graft failure rates reported for AI ACL reconstruction in the literature[3,14–16] range from 4.9% to 12.7%; the mechanisms of failure in these studies were either trauma or sports-related injuries.

To conclude about the graft failure rate, the present study needs a longer follow-up. However, Connaughton et al.[3] reported similar overall results on subjective and objective outcome studies but a high rate of graft failure with the AI technique. However, their study[3] is biased because they took only allografts for the reconstruction, which have a high propensity to fail in young active individuals. Pallis et al.[17] observed high revision rates in ACL reconstructions using

allografts and recommended autografts for ACL reconstruction in young athletes. In 2017, Schilaty et al.[18] assessed the incidence of second ACL injury and the risk factors associated with it, and found that allografts are associated with a higher risk of graft failure when compared with hamstring and bone-patellar tendon autografts. No conclusive data regarding graft failure rates comparing AI and OI techniques with autografts is available in the literature. However, there is an increased chance of graft failure using hamstring autografts if the graft diameter is shorter than 8 mm.[19] The OI technique uses semitendinosus and gracilis autografts, whereas the gracilis tendon is spared in the AI technique. Magnussen et al.[19] concluded that gracilis tendon harvest will negatively affect knee flexion isokinetic torque at a low angular velocity. This finding is significant for sports that require high functional activity; hence, the authors[19] recommended preservation of the gracilis tendon whenever possible. The AI technique also results in lower graft site morbidity since the gracilis is spared.[20] Kouloumentas et al.[21] reported better preservation of knee flexion strength in AI ACL reconstruction than with the conventional OI technique. Monaco et al.[22] stated that the technique that spares the gracilis is minimally-invasive for ACL reconstruction and yields better flexion strength at low angular velocity than the full tibial tunnel technique.

All patients of both groups had undergone accelerated rehabilitation.[23]

The limitations of the present study are the relatively small sample size and the follow-up of only one year. This may explain the lack of graft failure among our patients.

Our findings show that the AI group presented lower levels of pain and better functional outcomes when followed for 12 months compared to the OI group, and that both techniques are successful in restorating knee ligamentous stability, and result in good patient-reported outcome measures and pain relief compared to the preoperative levels.

Main Outcome

The AI group presented better functional outcomes compared to the OI group.

Conclusion

In the present randomized controlled trial, we found that the AI and OI techniques with hamstring autograft for ACL reconstruction resulted in the restoration of knee stability and good patient-reported outcome measures. However, the AI group presented better scores on the Lysholm scale and pain relief in a follow-up of 12 months.

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

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The Influence of Different Hamstrings Assemblies on the Final Graft Diameter in Anterior Cruciate Ligament Reconstruction

A influência de diferentes montagens dos tendões flexores no diâmetro final do enxerto na reconstrução do ligamento cruzado anterior

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Abstract

Objective This study aimed to compare gracilis and semitendinosus tendon graft diameters in anterior cruciate ligament (ACL) reconstruction using quadruple, quintuple, and sextuple assemblies. Another objective was to evaluate the percentage of patients in which each assembly type is possible, depending on the length of each free tendon.

Methods Seventy-one patients underwent ACL reconstruction using hamstring tendons. We measured the diameters of the quadruple, quintuple, and sextuple assemblies in all patients. We recorded tendon length and graft diameter from three assembly types.

Results Assembly comparison showed a statistically significant difference ($p < 0.001$). In each assembly, graft diameter increased by 1 mm, a statistically significant value ($p < 0.001$). In 2.8% of patients, the only potential assembly was the quadruple assembly because the free lengths of the 2 tendons removed were lower than 24 cm. The quintuple assembly was possible in 23.9% of subjects, as only the semitendinosus had a minimum length of 24 cm. The sextuple assembly was possible in 73.2% of patients because both tendons were at least 24 cm in length.

Conclusion A quintuple or sextuple assembly is possible in 97.2% of cases since the final graft length of at least 8 cm is statistically significant between comparisons.

Keywords
- anterior cruciate ligament
- bone-patellar tendon-bone grafts
- hamstring tendons
- knee

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Resumo

Objetivo Buscamos comparar o diâmetro dos enxertos com utilização dos tendões grácil e semitendíneo na reconstrução do ligamento cruzado anterior (LCA) utilizando as montagens quádrupla, quíntupla e sêxtupla. Outro objetivo é avaliar em qual porcentagem de pacientes é possível cada tipo de montagem, em função do comprimento de cada tendão livre.

Métodos Setenta e um pacientes foram submetidos à reconstrução do LCA utilizando tendões isquitibiais. Foram medidos os diâmetros das montagens quádrupla, quíntupla e sêxtupla em todos pacientes. Registramos os comprimento dos tendões e o diâmetro do enxerto com os três tipos de montagens.

Resultados As comparações entre as montagens mostraram diferença estatisticamente significativa ($p < 0{,}001$). A cada montagem, aumentou 1 mm o diâmetro do enxerto e isso foi estatisticamente significativo ($p < 0{,}001$). Em 2,8% dos pacientes, somente a montagem quádrupla foi possível, pois os comprimentos livres dos 2 tendões retirados foram menores que 24 cm. Em 23,9% desses, foi possível a montagem quíntupla; pois somente o semitendíneo tinha comprimento mínimo de 24 cm e, em 73,2%, foi possível a montagem sêxtupla com o comprimento dos 2 tendões igual ou superior a 24 cm.

Conclusão Em 97,2% dos casos foi possível realizar a montagem quíntupla ou sêxtupla, já que o comprimento final do enxerto de no mínimo 8 cm apresenta diferença estatisticamente significante entre as comparações.

Palavras-chave

- enxertos osso-tendão patelar-osso
- joelho
- ligamento cruzado anterior
- tendões isquiotibiais

Introduction

Anterior cruciate ligament (ACL) reconstruction surgery is one of the most commonly performed procedures in orthopedics, with satisfactory clinical and functional outcomes.[1,2]

Anterior cruciate ligament reconstruction uses different grafts according to the surgeon's choice. These grafts include autografts of the patellar tendon, quadriceps tendon, flexor tendons (hamstrings), peroneus longus, and several allogeneic grafts.[3]

Medial flexor tendons have become popular due to their good clinical outcomes and lower knee morbidity compared with the patellar tendon.[4] However, ligament re-rupture with neoligament injury is a significant concern among surgeons. We know that graft thickness has a direct link to the re-rupture rate, and the flexor tendon diameter depends on the anatomy of each patient, potentially influencing the final quality of the graft assembly.

This study aimed to compare the diameter of hamstring grafts during ACL reconstruction using quadruple, quintuple, and sextuple assemblies by evaluating whether increasing the number of bands results in a thicker graft. Another objective was to evaluate the percentage of patients in whom each type of assembly is possible depending on the length of each free tendon.

Materials and Methods

The Human Research Ethics Committee approved this study under the Opinion Certificate number CAAE 57891522.0.0000.5128.

Seventy-one patients (57 men and 14 women) underwent ACL reconstruction between March 2021 and November 2021 using the medial flexor, gracilis, and semitendinosus tendons as grafts. The patients' ages ranged from 15 to 54 years, and the mean age was 32.54 years. Graft preparation occurred on an auxiliary table during the surgery. The semitendinosus and gracilis tendons were harvested using a closed tendon harvester (striper) and removed from the muscle tissue residue. Tendon measurements occurred separately, at first, to obtain their initial length. Next, we prepared the quadruple, quintuple, and sextuple assemblies. For the quadruple graft, we folded the semitendinosus and gracilis tendons once (double); for the quintuple graft, we folded the semitendinosus twice (triple) and the gracilis once (double). In the sextuple assembly, the two tendons were double-folded (triple). We measured the diameters of the three assemblies in all patients, regardless of which one we would use in the surgery. The surgeon decided on the final assembly to use in the procedure, and this decision does not fall within the scope of this work.

The assembly chosen for surgery was the thickest graft with a minimum length of 8 cm. If the 2 tendons had a length greater than or equal to 24 cm, a sextuple assembly, with 2 triple tendons, was possible. When the semitendinosus tendon was greater than or equal to 24 cm in length and the gracilis tendon was less than 24 cm, we could use the quintuple assembly with a triple semitendinosus and a double gracilis graft. If the two tendons were less than 24 cm long, we used the quadruple assembly with the 2 double tendons.

Table 1 Diameter (mm) comparison between assemblies.

Diameter (mm)	Mean	Standard deviation	Median	P25	P75	Minimum value	Maximum value	*P*-value*
Quadruple	8.0	0.8	8.0	7.5	8.5	6.0	10.0	
Quintuple	9.0	0.8	9.0	8.5	10.0	7.0	11.0	**< 0.001**
Sextuple	10.0	0.9	10.0	9.0	11.0	8.0	13.0	

*Kruskal-Wallis' test; Multiple comparisons: quadruple x quintuple; quadruple x sextuple; and quintuple x sextuple ($p < 0.001$)

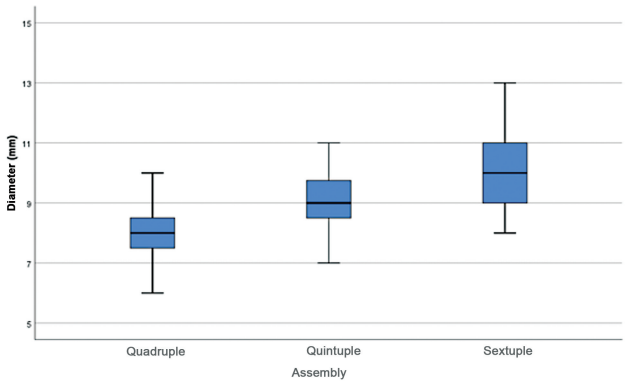


Fig. 1 Diameter (mm) comparison between assemblies.

Results

The sample consisted of 71 patients and the same number of grafts. The quadruple assembly diameter is statistically smaller than the quintuple and sextuple assemblies ($p < 0.001$), and comparisons between assembly pairs also showed a statistically significant difference ($p < 0.001$). The average difference from the quadruple to the quintuple assembly and from the quintuple to the sextuple assembly was a statistically significant increase of 1 mm in the graft diameter ($p < 0.001$) (►**Table 1**).

►**Fig. 1** illustrates this comparison.

Regarding the free length of the semitendinosus and gracilis tendons, we observed that only the quadruple assembly was viable in 2 patients (2.8%) as their length was lower than 24 cm. In 17 patients (23.9%), quadruple or quintuple assemblies was possible as the length of the semitendinosus graft was equal to or greater than 24 cm and the gracilis had less than 24 cm. Lastly, in 52 patients (73.2%), all assemblies were possible as the length of both tendons was equal to or greater than 24 cm (►**Table 2**).

Table 2 Potential assembly use per the free length of the semitendinosus and gracilis tendons

Assembly	n	%
Quadruple	2	2.8
Quintuple	17	23.9
Sextuple	52	73.2
Total	71	100.0

Discussion

Reconstruction of the anterior cruciate ligament has produced good joint stability and functional outcomes.[3]

The literature reports the relationship between graft diameter and its resistance and revision rate.[5,6] demonstrated a revision rate of 1.57% in patients with a graft diameter greater than 8 mm, 6.5% in patients with a graft between 7.5 and 8 mm, and 13.6% in patients with a graft smaller than 7 mm in diameter, reinforcing this relationship between re-rupture and graft thickness, consistent with the systematic review from Conte et al.[7]

Our work showed that in most cases, that is, in 97% of patients, a quintuple or sextuple assembly with a graft diameter greater than 8 mm was possible.

Calvo et al.[8] reported an increase of 2 mm in graft diameter in a group of patients in whom they converted from quadruple to quintuple assembly due to insufficient thickness. This quadruple group had an average diameter of 7.2 mm, which increased to 9.2 mm after conversion into a quintuple assembly. These data are consistent with our study, in which there was also an increase in graft thickness from the quadruple to the quintuple assembly but of only 1 mm.

Fritsch et al.[9] described a technique modifying the graft preparation to increase its diameter, which is also in line with the results of our study. These authors report that more important than the absolute size of the graft is the ability to obtain a graft of the appropriate size for each subject based on their size and demand.

Attia et al.[10] evaluated 413 patients with grafts measuring at least 8 mm in diameter. The quadruple graft preparation had an average diameter of 8.25 mm, compared to 9.14 for the quintuple graft and 8.95 for the sextuple graft. The average difference in graft diameter was statistically significant when comparing the quadruple with the quintuple and quadruple with the sextuple assemblies, which is consistent with our study. However, there was no statistical difference in diameter when comparing the quintuple and sextuple assemblies. The failure rate in the quadruple assembly was higher than in the quintuple and sextuple assemblies, with 9.1% versus 2.3% and 2.7%, respectively. However, this difference did not reach statistical significance when the graft was at least 8 mm in diameter.[10]

Tutkus et al.[2] evaluated 122 patients and used sextuple assemblies in 74 (60.7%) and quintuple assemblies in 48 (39.3%) of them. This finding is consistent with our study, in which we obtained quintuple assemblies in 23.9% and sextuple assemblies in 72.3% of patients. The average diameter

of the quintuple assembly was 8.9/8.3 mm in men/women, and of the sextuple assembly was 9.3/8.5 mm in men/women, respectively. In 98.4% of cases, the quintuple or sextuple assembly was significantly thicker than 8 mm. This is also consistent with our study since quintuple or sextuple assemblies were possible in 97.2% of cases, with average diameters of 9 mm and 10 mm, respectively.[2]

In a systematic review, Smith et al.[11] found an overall mean diameter of 8.4 mm for the quadruple graft and 9.1 mm for the quintuple graft, which is consistent with our study. However, there was no significant difference in failure rates or clinical outcomes between quadruple and quintuple grafts.

Due to the large variability in the diameter of hamstring grafts between patients, several authors have described the use of magnetic resonance imaging, weight, height, and gender to predict graft diameter before ACL reconstruction.[4,12,13]

Unlike patellar and quadriceps tendon grafts, the diameter of the flexor tendons does not depend solely on the surgeon's ability to harvest the appropriate size but rather on the anatomical variations of each patient. According to Pinheiro Júnior et al.,[13] height and gender are the most significant factors that help predict the diameter of the flexor tendons in their quadruple preparation. Our study did not consider these factors in predicting graft diameter. Likewise, we did not prospectively correlate graft thickness with the failure rate and clinical outcomes of surgery. These may be the subject of future studies.

Conclusion

The diameter of the quadruple assembly measured was, on average, 1 mm smaller than the quintuple assembly, which was, on average, 1 mm smaller than the sextuple assembly ($p < 0.001$). Assembly comparisons also showed a statistically significant difference ($p < 0.001$). In 97.2% of cases, it was possible to use a quintuple or sextuple assembly with a minimum final graft length of 8 cm.

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

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Outcomes of Anterior Cruciate Ligament Reconstruction in Patients with Associated Anterolateral Ligament Injury

Resultados da reconstrução do ligamento cruzado anterior em pacientes com lesão associada do ligamento anterolateral

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Abstract

Objective To evaluate if there is a significant difference in the outcomes of isolated anterior cruciate ligament (ACL) reconstruction in patients with or without associated anterolateral ligament (ALL) injury.

Methods We conducted a retrospective cross-sectional study through the analysis of medical records and the application of the questionnaires of the Lysholm Knee Scoring Scale and the International Knee Documentation Committee (IKDC) Subjective Knee Form to patients undergoing isolated ACL reconstruction.

Results The 52 participants included were divided into two groups: 19 with associated ALL injury and 33 with no associated ALL injury. None of the patients with associated ALL injury suffered an ACL rerupture, and 21.1% presented injuries to other knee structures after surgery. Among the patients with no associated injury, 6.1% suffered ACL rerupture, and 18.2% presented injuries to other structures after surgery ($p = 0.544$). Return to activities at the same level as that of the preoperative period occurred in 60% of the patients with associated ALL injury and in 72% of those with no associated injury ($p = 0.309$). The mean score on the Lysholm Knee Scoring Scale was of 81.6 points in patients with associated ALL injury, and of 90.1 in those with no associated injury ($p = 0.032$). The mean score on the IKDC Subjective Knee Form was of

Keywords
- anterior cruciate ligament
- anterolateral ligament
- articular ligaments
- knee

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70.3 points in patients with associated ALL injury and of 76.7 in those with no associated injury ($p = 0.112$).

Conclusion There was no statistically significant difference regarding graft injuries or new injuries to other structures, satisfaction with the operated knee, or the score on the IKDC Subjective Knee Form. Return to activity was similar in the groups with and without associated ALL injuries. The scores on the Lysholm Knee Scoring Scale were better, with a statistically significant difference in the group with no associated ALL injuries.

Resumo

Objetivo Avaliar se há diferença significativa nos resultados da reconstrução isolada do ligamento cruzado anterior (LCA) em pacientes com e sem lesão associada do ligamento anterolateral (LAL).

Métodos Foi realizado um estudo transversal retrospectivo com análise de prontuários e aplicação da Escala de Pontuação do Joelho de Lysholm e do Formulário Subjetivo de Joelho do International Knee Documentation Committee (IKDC) a pacientes com reconstrução isolada do LCA.

Resultados Os 52 participantes incluídos foram separados em 2 grupos: 19 com lesão associada do LAL e 33 sem lesão associada. Nenhum paciente com lesão associada do LAL sofreu rerruptura do LCA, e 21,1% tiveram lesões em outras estruturas do joelho após a cirurgia. Entre os pacientes sem lesão associada, 6,1% sofreram rerruptura do LCA, e 18,2% tiveram lesões em outras estruturas após a cirurgia ($p = 0,544$). O retorno às atividades no mesmo nível do que no pré-operatório foi observado em 60% dos pacientes com lesão associada do LAL e em 72% daqueles sem lesão associada ($p = 0,309$). Na Escala de Pontuação do Joelho de Lysholm, os pacientes com lesão associada do LAL obtiveram média de 81,6 pontos, e os sem lesão associada, média de 90,1 pontos ($p = 0,032$). No Formulário Subjetivo de Joelho do IKDC, os pacientes com lesão associada do LAL obtiveram média de 70,3 pontos, e os sem lesão associada, média de 76,7 pontos ($p = 0,112$).

Conclusão Não foi observada diferença estatística significativa quanto a lesões do enxerto ou novas lesões de outras estruturas, satisfação com o joelho operado ou pontuação no Formulário Subjetivo de Joelho do IKDC. O retorno às atividades foi semelhante nos grupos com e sem lesão associada do LAL, e os resultados na Escala de Pontuação do Joelho de Lysholm foram melhores, com diferença estatística significativa no grupo sem lesão associada do LAL.

Palavras-chave

- joelho
- ligamento anterolateral
- ligamentos articulares
- ligamento cruzado anterior

Introduction

Anterior cruciate ligament (ACL) injuries are common, and their incidence increases among the physically-active population, with significant consequences for the quality of life, activity index, joint stability, functionality, and risk of development of osteoarthritis.[1] However, even though surgical reconstruction is the treatment of choice, the success rate is influenced by patient- or graft-specific risk factors.[1,2]

In recent years, several studies[3,4] have sought to better characterize the anterolateral complex of the knee to minimize such risks and seek more effective treatment; the anterolateral ligament (ALL) has a critical stabilizing function for internal knee rotation, along with the ACL. Injuries to the ACL and ALL present worse postoperative outcomes compared with those of surgical ACL reconstruction alone due to the need to associate extra-articular procedures with intra-articular reconstruction.[5,6]

Based on this information, the present study retrospectively analyzed the outcomes of isolated ACL reconstruction in groups of patients with ACL injury associated or not with ALL injuries.

Materials and Methods

The present study was conducted after approval by the institutional Ethics in Research Committee (CAAE-61209722.0.0000.0020) and after the participants signed an informed consent form, and it follows resolution no. 466/2012 of the Brazilian National Health Council and the Declaration of Helsinki.

We performed an analysis of medical records and applied the questionnaires of the Lysholm Knee Scoring Scale and of the International Knee Documentation Committee (IKDC) Subjective Knee Form in their Portuguese versions[7,8] to all patients undergoing isolated ACL reconstruction by the same knee surgery group in 2019.

The study included patients with at least two years of follow-up, who had magnetic resonance imaging (MRI) scans performed in the acute phase of the injury (up to three weeks after the initial sprain) and underwent surgery within the first three months after the injury. Patients who refused to participate in the research or were unable to be contacted were excluded.

In the medical records, we collected data on sex, date of birth, date of injury, date of preoperative MRI scan, date of surgery, and operated side. The selected patients were interviewed and filled out the questionnaires. Initially, the participants answered whether they had a new injury to the ACL or to another structure that required surgery on the same knee. Those who did not have new injuries were asked about their satisfaction level with the surgery (very satisfied, satisfied, somewhat satisfied, or dissatisfied) and return to sports (better than before, the same as before, worse than before, or unable to return). In addition, they answered the Lysholm Scale and IKDC functional questionnaires.[7,8] Patients with new injuries were excluded from this stage because they did not meet the criterion of a minimum two years of postoperative follow-up.

Statistical Analysis

The analysis of the qualitative variables used the Chi-squared (χ^2) or the Fisher exact test. For the quantitative variable the Shapiro-Wilk normality test. Then, the Mann-Whitney test for non-normal data and the *t*-test for variables with Gaussian distribution. The results were analyzed though the IBM SPSS Statistics for Windows (IBM Corp., Armonk, NY, United States) software, version 23.0, with a confidence level of 5% for all tests applied.

Results

From the initial sample of 221 patients undergoing ACL reconstruction, we included 103 participants with MRI scans performed within the first 3 weeks who underwent surgery within 3 months after the injury. We excluded 1 patient who refused to participate in the research and 50 patients with incomplete medical records and whom we were unable to contact. The 52 participants evaluated were divided into 2 groups according to the presence or absence of ALL injuries before ACL reconstruction surgery (►**Fig. 1**).

The mean age of the patients was of 33.3 years for those with an associated ALL injury and of 38 years for those with no associated ALL injury. The sample was predominantly male, with 73.7% of male patients with an ALL injury and 87.9% of male subjects with no ALL injury. Regarding new injuries after 2 years, none of the patients with an ALL injury presented a new ACL injury, and 21.1% of patients had injured another knee structure (meniscus, cartilage, or another ligament). In patients without an ALL injury, 6.1% had a new ACL injury, and 18.2% injured another structure (►**Table 1**).

The mean age of the patients with no new knee injury was of 34.4 years among those with an associated ALL injury and of 39.6 years in those with no associated injuries. The sample remained predominantly male, with 73.3% of male patients with an ALL injury and 84% of male subjects with no ALL injury. As for satisfaction with the operated knee, most participants from both groups were very satisfied, including

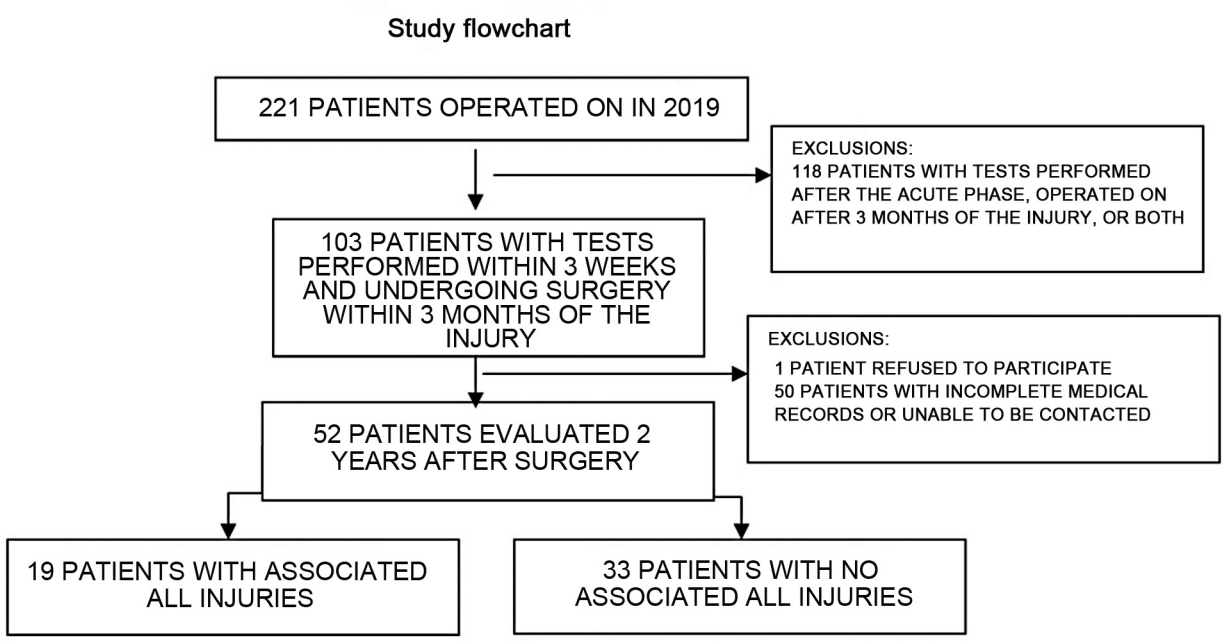


Fig. 1 Study flowchart. **Abbreviation:** ALL, anterolateral ligament.

Table 1 Age, sex, and new injuries

Variable	With ALL injury (n = 19)	Without ALL injury (n = 33)	*p*-value
Age (years): mean ± SD	33.3 ± 8.8	38 ± 10.4	0.243
Male sex: n (%)	14 (73.7)	29 (87.9)	0.260
New knee injury: n (%)			
- Yes, new ACL injury - Yes, in another structure - No new injury	0 (0) 4 (21.1) 15 (78.9)	2 (6.1) 6 (18.2) 25 (75.8)	0.544

Abbreviations: ACL, anterior cruciate ligament; ALL, anterolateral ligament; SD, standard deviation.

Table 2 Satisfaction, return to sports, and functional scores

Variable	With ALL injury (n = 19)	Without ALL injury (n = 33)	*p*-value
Age (years): mean ± SD	34.4 ± 9.4	39.6 ± 10.5	0.118
Male sex: n (%)	11 (73.3)	21 (84)	0.444
Satisfaction: n (%)			
- Very satisfied - Satisfied - Somewhat satisfied - Dissatisfied	7 (46.7) 5 (33.3) 3 (20) 0 (0)	13 (52) 10 (40) 1 (4) 1 (4)	0.367
Return to activities: n (%)			
- Better than before - Same as before - Worse than before - Unable to return	2 (13.3) 9 (60) 4 (26.7) 0 (0)	3 (12) 18 (72) 2 (8) 2 (8)	0.309
Lysholm Knee Scoring Scale: mean ± SD	81.6 ± 18.6	90.1 ± 15.5	0.032
IKDC Subjective Knee Form: mean ± SD	70.3 ± 15.4	76.7 ± 14.3	0.112

Abbreviations: ACL, anterior cruciate ligament; ALL, anterolateral ligament; IKDC, International Knee Documentation Committee; SD, standard deviation.

46.7% with an ALL injury and 52% with no ALL injury ($p = 0.367$).

Regarding return to activities, 60% of the patients with ALL injuries and 72% of those without them ($p = 0.309$) resumed them at the same level as in the preoperative period.

As for the functional questionnaires, the mean score on the Lysholm Scale was of 81.6 points among patients with an ALL injury, and of 90.1 points in those with no ALL injury ($p = 0.032$), and the mean IKDC score was of 70.3 points in patients with an ALL injury and if 76 .7 points in subjects with no ALL injury ($p = 0.112$) (►**Table 2**).

Discussion

Analyzing the new ACL graft injury rate, the present study we did not observe significant differences or the need for new surgeries in patients with or without associated ALL injuries. However, some studies[6,9,10] have shown that an associated injury increases the rates of ACL graft rupture and reoperation. However, a large retrospective study[11] with combined reconstruction did not reveal a significant difference concerning isolated ACL reconstructions. The disadvantages of associated injury and advantages of combined reconstruction would result from the anatomical and biomechanical properties of the ALL in terms of rotational stabilization of the knee along with the ACL. Cadaveric studies[12–14] have shown that recovery of knee biomechanics and kinetics to preinjury levels only occurs in combined reconstructions of associated injuries.

Some researchers[14–18] consider the presence of a higher criterion for increased risk of ACL rerupture, that is, postoperative positive residual pivot, or two minor criteria for increased risk of reinjury as an indication for combined reconstruction. However, to date, there has been no standardization of the indications for extra-articular ALL reconstruction associated with intra-articular ACL reconstruction, with several authors[3,5,14–18] highlighting the need for more robust studies on the topic.

Regarding functional results and postreconstruction patient satisfaction, most studies[10,14–23] show objective and/or subjective improvement with combined reconstruction. Nevertheless, there is still much controversy in the literature, with most studies showing no statistically significant difference, except regarding the presence of joint hypermobility

associated with significant knee rotational instability, in which combined reconstruction has led to better patient satisfaction.[10,16,17,19,21] As far as the return to daily activities and sports, combined reconstruction has resulted in functional improvement, especially in populations with knee hypermobility.[15–17] However, there is still no objective consensus regarding the benefits of combined reconstruction. The IKDC and Lysholm functional scores show better results, but these improvements are only statistically relevant in a few studies.[6,9,10,16,19–21,23] We observed better IKDC scores after isolated ACL reconstructions in patients with no associated ALL injury, but without statistically significant difference, and significantly better Lysholm scores in patients undergoing isolated reconstruction with no associated ALL injuries.

Since the ALL is a recently characterized structure, the literature clearly shows the need for longer follow-up to determine the presence or absence of long-term benefits from combined ALL and ACL reconstruction with prospective, randomized, controlled clinical studies with a large number of patients.[1,9,14–16,20,24,25]

The present study has certain important limitations. As a retrospective study, there is a risk of some biases typical of a non-prospective study. A higher number of cases would be the best option to increase the power of the statistical analysis and demonstrate potential differences between the groups. We had 221 patients operated on during the period and included in the study. However, only 103 underwent imaging exams and surgery at the times considered ideal, and we were unable to contact 51 patients. The mean age of the patients in the present study (33.3 years) was above the mean age observed in similar studies (24 years)[11]

Conclusion

Patients undergoing ACL reconstruction with and without an associated ALL injury presented no difference regarding the rates of new injuries or new surgery. Both groups presented similar results regarding satisfaction with the knee, IKDC score, and return to activities. The Lysholm score was better in patients with no associated ALL injury.

Authors' Contributions:
Each author contributed individually and significantly to the development of the article. JPFG wrote and reviewed the article, analyzed the results, developed the statistical analysis, participated in the intellectual conception of the study, and coordinated the entire project; LBR collected data, analyzed the results, and wrote and reviewed the article; ELG and ARRC collected data, and wrote and reviewed the article; PRB analyzed the results and developed the statistical analysis; and MVD: reviewed the article and participated in the intellectual conception of the study.

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

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Analysis of Surgical Procedures on the Forearm and Hand and Their Relationship with Complex Regional Pain Syndrome: A Cross-sectional Study

Análise dos procedimentos cirúrgicos no antebraço e na mão e sua relação com a síndrome da dor regional complexa: Um estudo transversal

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Abstract

Objective Complex regional pain syndrome (CRPS) requires further understanding. Thus, the present study aimed to analyze if pre- and intraoperative factors may be related to the development of CRPS in the postoperative period.

Methods We reviewed 1,183 medical records of patients undergoing forearm and hand surgeries from 2015 to 2021. The data of interest, that is, diagnosis, incisions, synthesis material, and anesthesia, were collected, tabulated, and statistically analyzed, with subsequent calculation of the odds ratios.

Results Most patients were female, aged between 30 and 59 years, and sought the service electively (67% of the cases). The diagnoses included soft tissue trauma (43%), bone trauma (31.6%), and compressive syndromes (25.5%). During this period, 45 (3.8%) subjects developed CRPS. The statistical analysis showed that the chance of developing CRPS is twice as high in patients with compressive syndrome, especially carpal tunnel syndrome (CTS), which represented most surgeries performed in our service (24%). Two or more incisions occurred in 7.6% of the cases, which tripled the chance of developing postoperative CRPS. Gender, age, use pf synthetic material, type of anesthesia type did not statistically increase the risk of developing postoperative CRPS.

Keywords
- carpal tunnel syndrome
- complex regional pain syndromes
- hand injuries
- nerve compression syndromes
- orthopedic precedures

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Conclusion In short, the incidence of CRPS is low; however, it is critical to know and recognize the risk factors for prevention and active screening in the postoperative period.

Resumo

Objetivo A síndrome da dor regional complexa (SDRC) precisa ser mais bem compreendida. Assim, este estudo objetiva analisar se fatores pré e intraoperatórios poderiam estar relacionados ao desenvolvimento de SDRC no pós-operatório.

Métodos Foram revisados 1.183 prontuários de pacientes submetidos a cirurgias no antebraço e na mão entre 2015 e 2021. Os dados de interesse, como diagnóstico, incisões, material de síntese e anestesia realizada, foram coletados, tabulados e submetidos a testes estatísticos com posterior cálculo da razão de chances.

Resultados A maioria dos pacientes era do gênerofeminino, com idade entre 30 e 59 anos, que buscaram o serviço de forma eletiva (67% dos casos). Os diagnósticos agrupados de forma geral foram: traumas de partes moles (43%), traumas ósseos (31,6%) e síndromes compressivas (25,5%). Durante esse período, 45 pacientes (3,8%) evoluíram com SDRC. A análise estatística mostrou que a chance de desenvolver SDRC é duas vezes maior em pacientes com síndrome compressiva, especialmente a síndrome do túnel do carpo (STC), que representou a maioria dos cirurgias realizadas em nosso serviço (24%). Em 7,6% dos casos, foram realizadas duas ou mais incisões, o que triplicou a possibilidade de SDRC pós-operatória. Gênero, idade, uso de material de síntese, ou tipo de anestesia não aumentaram estatisticamente o risco de SDRC no pós-operatório.

Conclusão Em suma, a incidência de SDRC é baixa, mas é importante conhecer e reconhecer os fatores de risco para a prevenção e a busca ativa no pós-operatório.

Palavras-chave
- lesões da mão
- procedimentos ortopédicos
- síndrome do túnel do carpo
- síndromes da dor regional complexa
- síndromes de compressão nervosa

Introduction

Complex regional pain syndrome (CRPS) is a clinical condition characterized by persistent pain disproportionate to the injury, with changes in sensitivity, motricity, and vascularization. If the condition persists, it leads to skin changes and atrophy in the affected area.[1–3] It occurs predominantly in the peripheral region of the upper limbs,[2] but it can affect any portion of the body.[1–4] Its etiology is not entirely understood. The diagnosis is clinical, based on the Budapest criteria (►**Table 1**), and, to date, there are no specific supplementary tests.[1–3] The syndrome often occurs after trauma, surgery, or conditions affecting the local nervous system,[2–4] and it is 2 to 4 times more common in women aged between 20 and 50 years.[1–4] Patients undergoing surgery are more susceptible to developing CRPS than those not undergoing surgery.[3,5] Therefore, the objective of the present study was to analyze whether interventions performed during the surgical procedure to treat the main conditions in the routine of the hand surgery outpatient clinic contribute or not to the development of postoperative CRPS.

Materials and Methods

The Ethics Committees of the two institutions where the data were collected approved the present study, which complied with institutional guidelines and Resolution no. 466/20112 of the Brazilian National Health Council. The study was cross-sectional, observational, retrospective, and included all patients who underwent a surgical procedure from January 2015 to December 2021. These surgeries were performed by a hand surgeon who is a member of an orthopedics team working at a regional healthcare unit. After hospital discharge, patients were referred to the outpatient clinic for follow-up with the same surgeon to ensure consistency in the clinical analysis. This process is especially relevant in CRPS due to its diverse signs and symptoms and the current lack of a gold-standard diagnosis, leading to the need for uniform clinical assessments throughout medical follow-up. The diagnosis was based on the Budapest criteria, including constant pain inconsistent with any triggering event accompanied by other signs and symptoms, as outlined in ►**Table 1**.

Among all operated patients, we selected those diagnosed with CRPS at least 30 days after surgery. Patients with conditions treated non-surgically, duplicate records in the system, or subjects with complications but who had not undergone surgery during the preestablished period were excluded from the study.

Data were collected exclusively by analyzing medical records. Details such as gender, age, year of admission, nature of the admission (elective or emergency), and general and specific diagnoses were recorded, as well as specific information about the surgical procedure, including number of

Table 1 Budapest clinical criteria for complex regional pain syndrome

Continuous pain disproportional to any trigging event in addition to at least one symptom reported by the patient in three of the following four categories, and symptoms from at least two categories evidenced by the doctor during the visit
Sensory: Reports of hyperalgesia, allodynia, or both
Vasomotor: Reports of temperature difference, change in skin color, or both
Sudomotor/edema: Reports of edema, changes in sweating, and/or sweating asymmetry
Motor/trophic: Reports of decreased range of motion, motor dysfunction (weakness, tremor, dystonia), and/or trophic changes (hair, nail, skin)
Lack of other diagnoses that better explain the signs and symptoms

incisions, synthesis materials, type of anesthesia administered during the procedure, and the subsequent development (or not) of postoperative CRPS.

Data tabulation was made through the Excel (Microsoft Corp., Redmond, WA, United States), version 2013, software. Next, we performed the statistical analysis, that is, application of the Chi-squared test followed by univariate logistic regression analysis. We included variables with statistically significant results in the multivariate analysis to identify whether there was an independent association with CRPS. The results were expressed as odds ratios (ORs) and 95% confidence intervals (95%CIs), and OR was established when the *p*-value was lower than 0.05 ($p < 0.05$). All these statistical analyses used the R application (R Foundation for Statistical Computing, Vienna, Austria), version 3.8.

Quantitative data were expressed as frequencies and percentages to facilitate understanding. Regarding qualitative information, the most significant values are mentioned in the text, and general data are shown in a table for better analysis and visualization during the discussion.

Results

During the analyzed period, 1,183 subjects underwent surgery, including 770 (65.1%) women and 413 (34.9%) men. The overall mean age was of 49.6 ± 17 years. According to the Budapest criteria, 45 (3.8%) patients, with a mean age of 53.02 ± 13 years, developed CRPS during the postoperative follow-up.

Regarding the nature of the admission, most patients sought the service electively, resulting in 795 procedures (67.2%), while emergency surgeries, mainly resulting from fractures, totaled 388 cases (32.8%).

Patients undergoing surgical procedures were categorized according to the nature of the condition: soft tissue injuries (507; 42.9%), fractures (374; 31.6%), and compressive syndromes (302; 25.5%). This last set included carpal tunnel syndrome (CTS), accounting for 284 (24%) procedures, and ulnar nerve compression, with 18 (1.5%) interventions. The most frequently performed procedures after CTS were fractures of the forearm bones, mainly the distal radius, with 267 surgeries (22.6%), and fractures of the hand bones, with 110 (9.3%) cases.

Regarding the number of incisions performed on the same patient for treatment, most subjects (1,093; 92.4%) required a single surgical approach. On the other hand, 90 (7.6%) cases required 2 or more incisions.

As for the fixation material, 753 (63.7%) cases did not use specific rigid synthetic material, mostly including decompressions and tenorrhaphies. The materials most frequently used in the surgeries were Kirschner wires in 240 (20.3%) cases, and volar plates in 126 (10.7%) cases.

Regarding the choice of anesthesia, intravenous general anesthesia predominated, totaling 607 (51.3%) procedures, closely followed by plexus block in 576 (48.7 %) patients.

The statistical analysis identified an increased risk of developing CRPS in the postoperative period. The presence of disease or compressive syndrome ($p = 0.0361$), the specific diagnosis of CTS ($p = 0.0426$), and the performance of 2 or more surgical incisions ($p = 0.0194$) increased this risk. The multivariate logistic analysis showed that compressive syndrome (OR: 2; 95%CI: 1.09–3.69), CTS (OR: 1.98; 95%CI: 1.07–3.67), and the performance of 2 or more incisions (OR: 2.7; 95%CI: 1.26-6.18) alone increased the chance of developing postoperative CRPS. ►**Table 2** summarizes the results.

Discussion

Complex regional pain syndrome is a debilitating and complex condition mainly affecting the periphery of the upper limbs. It is predominantly unilateral and associated with sensory, vasomotor, and dystrophic changes.[1,2,4] It can be preceded by a local known lesion, but it is idiopathic in 10% of the cases.[1,3,5,6] The symptoms often begin 15 to 30 days after the injury,[2,7] the diagnosis is clinical, and, currently, there are no validated tests to confirm it. The literature reports divergent data regarding its incidence, with comprehensive estimates,[1,2,5,7] and regarding the risk factors, including comorbidities such as depression, fibromyalgia, rheumatoid arthritis, and metabolic disorders.[1–5]

The development of CRPS occurs in two main phases, each with its features: in the acute or hot phase, proinflammatory mediators are released, resulting in symptoms such as paresthesia, hyperalgesia, anodynia, signs of vasomotor dysfunction, marked edema, and dyskinesia;[1,3,6] and the chronic or cold phase is characterized by activation of keratinocytes, fibroblasts, and osteocytes, leading to increased expression of adrenergic receptors and hyperstimulation of the sympathetic nervous system, which causes local vasoconstriction, with pale, cold, and sticky limbs.[1,3,6] The symptoms are often

Table 2 Surgical procedures performed and incidence of complex regional pain syndrome (CRPS)

		Patrients: n(%)	CRPS patients: n(%)	*p*-value (Chi-squared)	Odds ratio	95% confidence interval
Condition that led to the surgical procedure	Soft tissue lesions	507(42.9)	15(3)	0.074	–	–
	Fractures	374(31.6)	12(3.2)			
	Compressive syndromes	302(25.5)	18(6)	0.036	2	1.09–3.69
Reason for the surgeries	Carpal tunnel syndrome	284(24)	17(6)	0.042	1.98	1.07–3.67
	Forearm bone fracture	267(22.6)	11(4.1)	0.204	–	–
	Hand bone fracture	110(9.3)	1(0.9)			
	Trigger finger	98(8.3)	4(4.1)			
	Material removal/ debridement	80(6.8)	0			
Number of incisions	1	1093(92.4)	37(3.4)	0.019	2.7	1.26–6.18
	≥ 2	90(7.6)	8(8.9)			
Synthesis material	None	753(63.7)	32(4.2)	0.722	–	–
	Kirschner wire	240(20.3)	6(2.5)			
	Volar plate	126(10.7)	6(4.8)			
	Dynamic compression plate	20(1.7)	1(5)			
	Herbert screw	20(1.7)	0			
Anesthesia	General intravenous anesthesia	607(51.3)	22(3.8)	1	1.01	0.56–1.83
	Plexus block	576(48.7)	23(3.8)			

subjective and, if the process is not interrupted, it leads to alopecia, nail changes, muscle atrophy, and chronic pain.[1,2,6]

Among the 1,138 subjects operated on during the 5 years of research, 45 (3.8%) presented postoperative CRPS. Both in the total group of operated subjects and among those who developed CRPS, most patients were women, with an average age of 49 to 53 years.[1–4] Although Harden et al.[1] and Dutton and Rhee,[3] as well as other authors, have highlighted the prevalence of CRPS in women, which is three times higher than in men, this gender association has not been shown to increase the risk of this complication.[1,3,7]

Studies with multiple patients with CRPS, as mentioned by Taylor et al.,[6] have identified the origin of this chronic pain, and they mention trauma, fractures, surgeries, and CTS, which together corresponded to more than 50% of the causes.[1,3,6] Most patients in the present study sought elective care (67%), scheduling surgical procedures on an outpatient basis, mainly for CTS (284 cases; 24%). The remainder (33%) were treated as urgent or emergent cases due to injuries requiring early intervention, such as fractures.

The different clinical conditions resulting in surgical intervention evaluated in the present study (►**Table 3**) fell into 3 broad groups: soft tissue trauma (43%), bone trauma (31.6%), and compressive syndromes (25.5%). In the statistical analysis of these general groups, only patients with compressive syndromes, mainly CTS, were twice as likely to develop CRPS during the postoperative period compared to any other condition. A review by A. Souza et al.[7] reported an incidence of 2% to 5% of CRPS after CTS decompression. These authors[7] also mentioned that chronic tunnel compression leads to hypersensitivity of the median nerve, local ischemia, and pain before treatment. For Gong et al.,[8] intense pain before surgery is a significant risk factor for subsequent CRPS development, highlighting the importance of prior sensitization of the nervous system for pain.[8] Similarly, this prior stimulation in people with fibromyalgia scheduled for a surgical procedure for carpal tunnel decompression increased the CRPS risk by approximately twofold.[6,9]

Anesthetic preparation plays an essential role in the intraoperative period. In the present study, the predominant approach was intravenous general anesthesia (51.3%). As mentioned by A. Souza et al.[7] and Da Costa et al.,[9] the anesthetic method, whether general intravenous or plexus block, does not increase the risk of developing postoperative CRPS. However, both studies[7,9] pointed to an association between the prolonged use of pneumatic tourniquets, regardless of the anesthetic technique, and the development of

Table 3 General and specific diagnoses of the patients

General diagnosis	*Specific diagnosis*	*n*	*%*
Bone trauma	Hand bone fracture	110	9.3
	Forearm bone fracture	267	22.6
Soft tissue trauma	Synovial cyst	69	5.8
	De Quervain	29	2.5
	Trigger finger	98	8.3
	Hammer finger	27	2.3
	Dupuytren	16	1.4
	Material removal/debridement	42	3.6
	Adductor tenoplasty	15	1.3
	Tenorrhaphy	69	5.8
	Scaphoid pseudoarthrosis	15	1.3
	Miscellaneous	44	3.7
Compressive syndrome	Ulnar decompression	18	1.5
	Carpal tunnel syndrome	284	24
Total		1,183	100

complex pain. Disproportionate pain in the postoperative period in the week after the traumatic event is another relevant predictive factor for the subsequent development of CRPS.[3] With this understanding, Da Costa et al.[9] consider plexus block a protective factor against CRPS, as it can reduce pain stimulation during surgery and maintain prolonged pain control in the postoperative period.[9]

Another important consideration in the intraoperative setting involves incisions. Buller et al.[10] raised concerns about simultaneously performing surgeries for CTS and Dupuytren contracture.[10] They noted that this approach could slightly increase the likelihood of developing CRPS due to the length of the incisions required for both procedures. On the other hand, Rochlin et al.[11] reported a greater risk of CRPS in cases of extensive incisions or incisions performed on multiple fingers; however, they did not identify the specific relationship between the simultaneous performance of fasciotomy and carpal tunnel decompression described by Buller et al.[10] These authors reported that CRPS incidence does not change even when the procedures are performed in an open or endoscopic fashion.[10,11] In the present study, we observed that patients undergoing multiple incisions on the forearm and hand (7.6%) are 3 times more likely to develop CRPS, which is consistent with the literature findings on the increase in complex pain complications.[10,11]

For Jo et al.,[5] open fractures or those with significant instability tend to be more associated with the development of CRPS. They result from high-energy trauma with extensive damage to adjacent soft tissues and an intense concomitant inflammatory process.[5] DeGeorge et al.[12] observed that volar support plates used in unstable fractures or osteoporotic metaphyseal bones present complication rates ranging from 3% to 36%. The main complications included temporary paresthesias and acute CTS. These authors[12] did not record complex pain among the 647 surgeries evaluated. Most patients evaluated in the present research underwent decompression or tenorrhaphy procedures (63.7%). The treatment of most fractures was percutaneous (20.3%), that is, with low damage to soft tissues, which is consistent with the idea by Jo et al.[5] that the synthetic material is not directly responsible for CRPS progression, in contrast to previous trauma.[5]

The incidence of CRPS after surgical procedures in our sample was low, which is in line with the literature.[1,3,5,12] The most relevant risk factors included previous diagnosis of compressive syndrome, especially CTS, and the performance of two or more incisions in the hands. We suggest a more detailed analysis of CTS decompression surgeries in future studies.

Conclusion

When analyzing the surgical interventions, we concluded that performing two or more incisions substantially increased the risk of developing postoperative complex pain. The present study showed that CRPS is independent of the procedure, approach, synthetic material, or type of anesthesia. We strongly highlight the crucial role of sound preoperative planning and preventative measures to reduce the risk of developing CRPS.

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

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Anatomical Study of the Relationship between the Riché-Cannieu Anastomosis and the Kaplan Cardinal Line

Estudo anatômico da relação entre a anastomose de Riché-Cannieu e a linha cardinal de Kaplan

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Abstract

Objective To identify the location of the Riché-Cannieu anastomosis (RCA) in relation to the Cardinal Kaplan Line (KCL) and the Y line.

Methods A total of 20 hands of 10 recently-deceased adult male cadavers aged between 27 and 66 years were dissected for the investigation of the relationship of the most distal point of the RCA with the KCL and with the Y line, drawn from the axis of the third metacarpal head, following the longitudinal axis of the hand.

Results In 20 limbs, the most distal point of the nerve communication was positioned distally in relation to the KCL. The Y line was positioned on the radial side in relation to the most distal point of the RCA in 14 limbs, and it was positioned on the ulnar side in relation to the Y line in 6 limbs. The crossing between the KCL and the Y line occurred proximal to the RCA in 18 limbs; in 1 hand, it was positioned distal to the intersection between these lines; and in another hand, the KCL was positioned exactly on the RCA.

Conclusion Knowledge of these anatomical relationships can prevent damage to nerve branches and thus also prevent paralysis of intrinsic muscles in surgical procedures in the palm of the hand.

Keywords
- anatomy
- cadaver
- dissection
- hand
- median nerve
- anastomosis, surgical
- upper extremity/ anatomy and histology

Resumo

Objetivo Identificar a localização da anastomose de Riché-Cannieu (ARC) em relação à linha cardinal de Kaplan (LCK) e à linha Y.

Work developed at the Department of Surgery, Faculdade de Ciências Médicas e da Saúde, Pontifícia Universidade Católica de São Paulo, Sorocaba, São Paulo, Brazil.

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Palavras-chave
- anastomose cirúrgica
- anatomia
- cadáver
- dissecção
- extremidade superior/anatomia e histologia
- mão
- nervo mediano

Métodos Ao todo, 20 mãos de 10 cadáveres adultos do sexo masculino com idades entre 27 e 66 anos, recentemente falecidos, foram dissecadas para a investigação da relação do ponto mais distal da ARC com a LCK e a linha Y traçada a partir do eixo da cabeça do terceiro metacarpo seguindo o eixo longitudinal da mão.

Resultados Nos 20 membros, o ponto mais distal da comunicação nervosa era distal à LCK. A linha Y estava no lado radial em relação ao ponto mais distal da ARC em 14 membros, e no lado ulnar em relação à linha Y em 6 membros. O cruzamento entre a LCK e a linha Y foi proximal à ARC em 18 membros; em 1 mão, era distal à intersecção entre essas linhas e, em outra mão, a LCK estava exatamente na ARC.

Conclusão O conhecimento dessas relações anatômicas pode prevenir danos aos ramos nervosos e, assim, também prevenir a paralisia dos músculos intrínsecos em procedimentos cirúrgicos na palma da mão.

Introduction

Some anatomical references are important in the surgical approach to the anatomical structures of the palm. Certain surface lines on the hand enable the identification of noble structures in deep locations. The Kaplan Cardinal Line (KCL) is defined as "a line drawn from the apex of the interdigital crease between the thumb and index finger towards the ulnar side of the hand, to a point 2 cm distal to the pisiform bone".[1,2]

The Riché-Cannieu anastomosis (RCA) was first described by two French anatomists, Riché[3] and Cannieu,[4] as a neural connection between the deep branch of the ulnar nerve and the thenar motor branch of the median nerve. Axons derived from these two nerves can cross and alternate motor innervation of the intrinsic muscles of the hand. The presence of such nerve connections may pose a risk of iatrogenic injury during surgical procedures and make it difficult to interpret electrophysiological studies in the diagnosis of neuropathies.[5]

There are three other types of anomalous neural connections between the median and ulnar nerves in the upper limb: the Martin-Gruber anastomosis (in the forearm, communicating nerve fibers originating from the median nerve that go to the ulnar nerve),[6] the Marinacci anastomosis (called reverse anastomosis of Martin-Gruber)[7] and the Berrettini anastomosis (communication between the common digital nerves of the ulnar and median nerves on the palmar surface of the hand).[8] Multiple aberrant connections between the median and ulnar nerves can occur in different combinations.[5]

The objective of the present study is to relate the RCA with the KCL and the Y line, to enable safer surgical access when approaching the structures of the palm.

Materials and Methods

The present study was approved by the institutional Ethics in Research Committee under CAAE: 70113723.1.0000.5373.

A total of 20 hands were dissected from 10 recently deceased adult male cadavers, aged between 27 and 66 years, available at the Department of Anatomy of Pontifícia Universidade Católica de São Paulo (PUC-SP). The dissected hands showed no lesions, deformities, or scars. Dissections were performed with the aid of a magnifying glass (with a magnification of 2.5x). The dissection technique was initiated by an incision proximal to the wrist crease, in the interval between the flexor carpi radialis and palmaris longus muscles, extending distally into the palm of the hand. The palmar skin, subcutaneous tissue and palmar fascia were removed. The superficial and deep flexor tendons were sectioned 2 cm proximally to the flexor retinaculum and distally reflected. The median nerve was identified proximally to the transverse carpal ligament, and the ligament was sectioned longitudinally on its ulnar side. The median nerve branches were dissected distally. The ulnar nerve was also identified in the wrist, proximal to the Guyon canal, and its deep motor branch was followed distally until its communication with branches of the median nerve. With a microsurgical forceps, the terminal fascicles of these two nerves were dissected on the surface of these muscles, or in the thickness of their muscle mass. The distance from the most distal point of the RCA in relation to the KCL and the distal margin of the transverse carpal ligament was measured in 20 limbs of 10 cadavers. A line (Y line) was drawn through the center of the third metacarpal head towards the carpal tunnel, following the longitudinal axis of the hand. The Y line was related to RCA and KCL. Schematic drawings of the pieces were made, which were systematically photographed.

Results

The RCA was identified in the twenty dissected hands. We observed that the anastomotic branch of the ulnar nerve always came from its deep branch (►**Figs. 1** and **2**). The anastomotic component of the median nerve was represented by fascicles from the recurrent branch of the median nerve in eleven hands (►**Figs. 3** and **4**). In six hands, the anastomotic fascicles originated from the main trunk of the median nerve (►**Figs. 4** and **5**). In three hands, the anastomotic branch originated from the radial collateral nerve of the thumb (►**Figs. 1** and **4**).

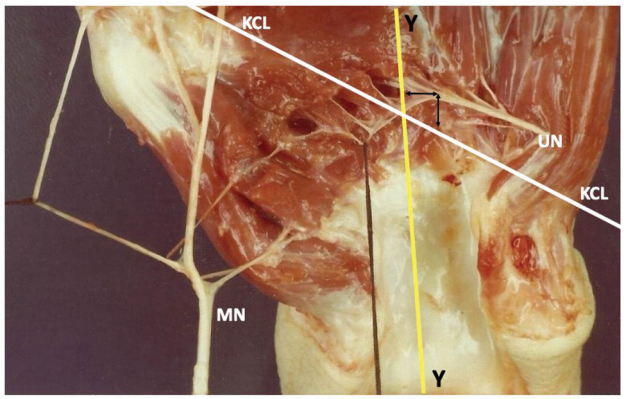


Fig. 1 The Y line was positioned on the radial side in relation to the most distal point of the ARC in 14 limbs. In one hand, the intersection between the Kaplan cardinal line (KCL) and the Y line was positioned exactly on the Riché-Cannieu anastomosis (RCA). Abbreviations: MN, median nerve; UN, ulnar nerve.

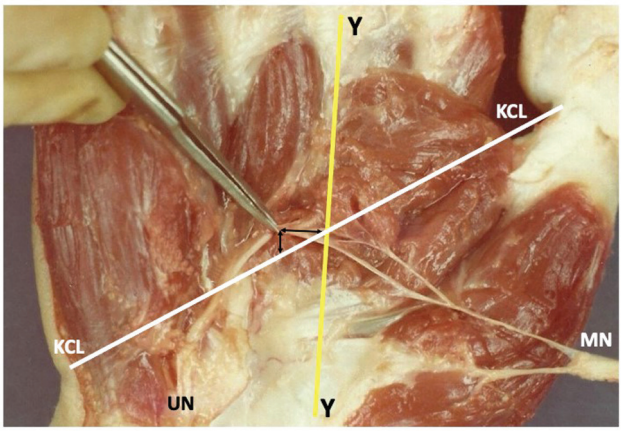


Fig. 3 In one hand, the crossing between these lines occurred distal to the RCA. Abbreviations: MN, median nerve; UN, ulnar nerve.

The most distal point of the RCA was positioned distal in relation to the KCL in the 20 dissected limbs, with a distance ranging from 0.3 cm to 2.5 cm, with a mean of 1.4 cm (►**Fig. 6**). The distance from the RCA to the distal margin of the transverse carpal ligament ranged from 1.3 cm to 3.4 cm, with a mean of 2.4 cm. The Y line was positioned on the radial side in relation to the most distal point of the RCA in 14 limbs, with a distance ranging from 0.2 cm to 1.2 cm, and a mean of 0.5 cm (►**Figs. 1** and **6**). In 6 hands, the Y line was positioned on the ulnar side in relation to the most distal point of the RCA, with a distance ranging from 0.2 mm to 0.8 mm, and a mean of 0.6 mm (►**Figs. 6** and **7**). The crossing between the KCL and the Y line occurred proximal to the RCA in 18 limbs, with a distance of 0.4 cm to 2.7 cm, and a mean of 2.0 cm (►**Figs. 8** and **9**). In 1 hand, the crossing between these lines occurred distal to the RCA, with a distance of 0.4 cm (►**Figs. 3** and **9**). In another hand, the intersection between the KCL and the Y line was positioned exactly on the RCA (►**Figs. 1** and **9**).

Discussion

Analyzing the literature, we observed that there is no consensus regarding the definition of the KCL, and four different descriptions were found.[1,2,9,10] Vella et al.[9] showed that most surgeons used the KCL as a reference in the surgical procedure. The KCL described by Kaplan[2] in 1966 was considered, and it was drawn from the junction of the line that starts at the apex of the interdigital crease between the thumb and index finger, heading towards the ulnar edge of the hand, up to a point 2 cm distal to the pisiform bone.

In the present study, we identified the RCA in all dissected hands. The most distal point of nerve communication was located distally in relation to the KCL in all limbs. The distance from the RCA to the distal margin of the transverse carpal ligament ranged from 1.3 cm to 3.4 cm, with a mean of 2.4 cm. The Y line drawn from the third metacarpal axis, following the longitudinal axis of the hand, was positioned on the radial side in relation to the most distal point of the RCA in most limbs. The crossing between KCL and the Y line

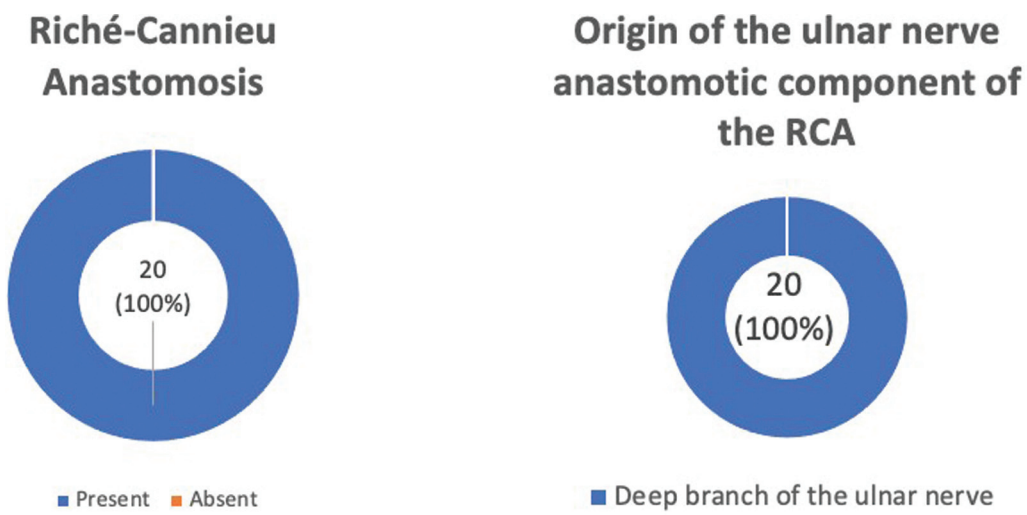


Fig. 2 Graphics of the results of the presence of the RCA and origin of the anastomotic component of the ulnar nerve of the RCA.

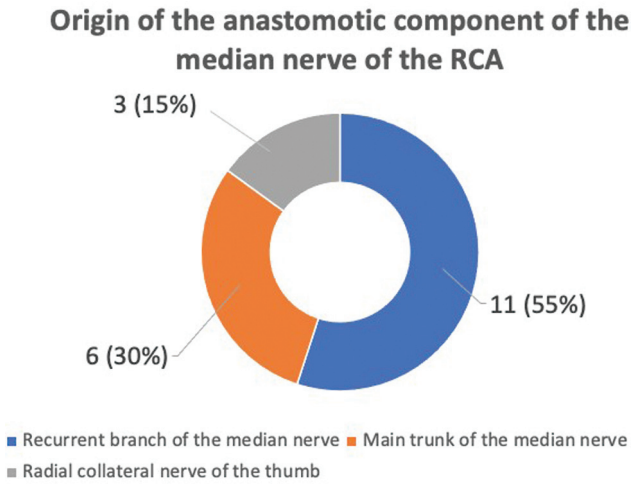


Fig. 4 Graph of the results of the origin of the anastomotic component of the median nerve of the RCA.

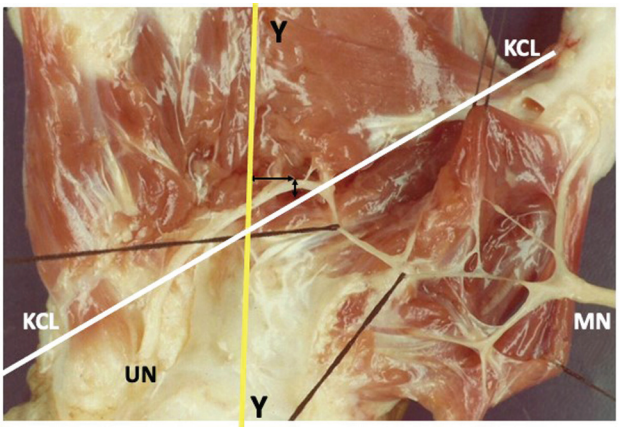


Fig. 5 The intersection of the KCL and the Y line was positioned proximal to the RCA. The anastomotic fascicles originated from the main trunk of the median nerve. Abbreviations: MN, median nerve. UN, ulnar nerve.

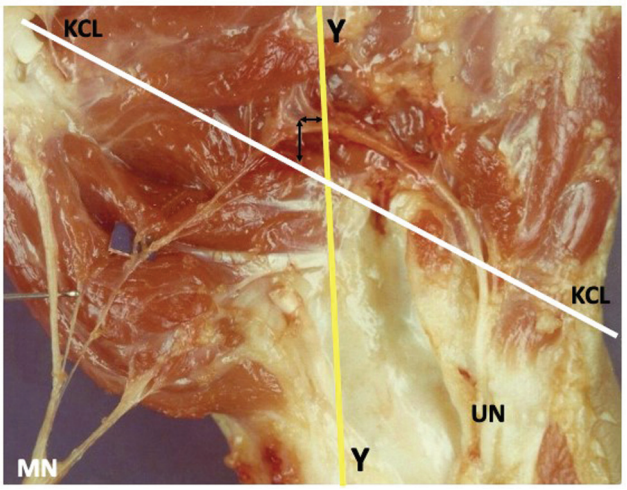


Fig. 7 In six hands, the Y line was positioned on the ulnar side in relation to the most distal point of the RCA. Abbreviations: MN, median nerve; UN, ulnar nerve.

occurred proximal to the RCA in 18 limbs. In one hand, the crossing between the KCL and the Y line occurred distal to the anastomosis, and in another, it was positioned exactly over the RCA.

Analyzing the literature, we identified studies that relate neurovascular structures located in the palm of the hand with the KCL, but we did not identify studies that report the relationship between the RCA and the KCL. Other investigators have used the KCL to describe the location of surgical incisions for procedures such as open carpal tunnel release,[10–12] endoscopic carpal tunnel release,[13] and fasciectomy in the treatment of Dupuytren disease.[14]

Jurbala and Burbank[15] performed a distal-to-proximal approach to the carpal tunnel using high-resolution ultrasound guidance. The median nerve was visualized longitudinally by ultrasonography within the carpal tunnel; then, the

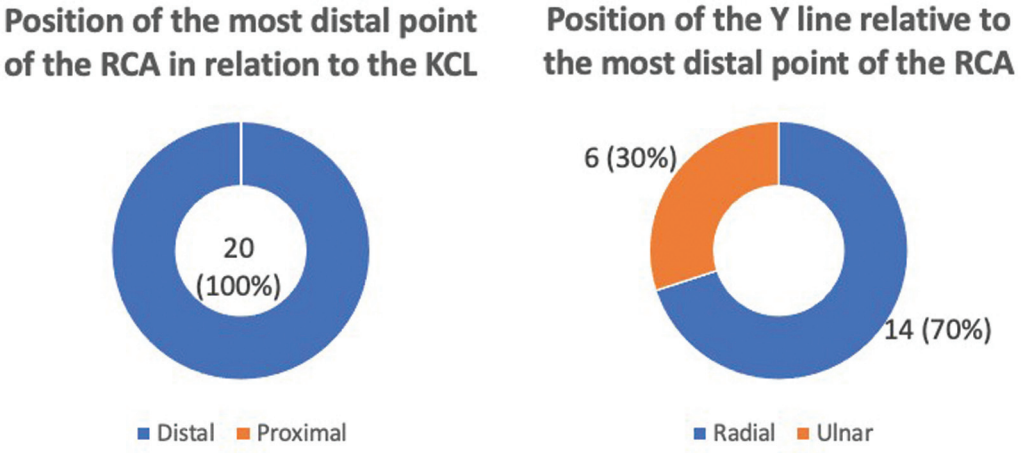


Fig. 6 Graphs of the results of the position of the most distal point of the RCA in relation to the KCL and the position of the Y line in relation to the most distal point of the RCA.

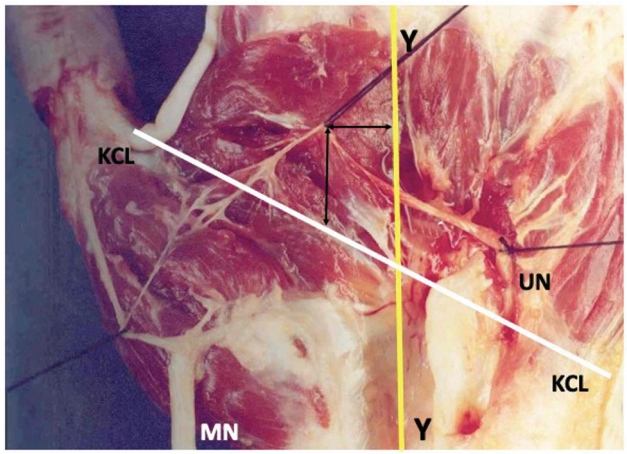


Fig. 8 The crossing between the KCL and the Y line occurred proximal to the RCA in 18 limbs. Abbreviations: MN, median nerve.; UN, ulnar nerve.

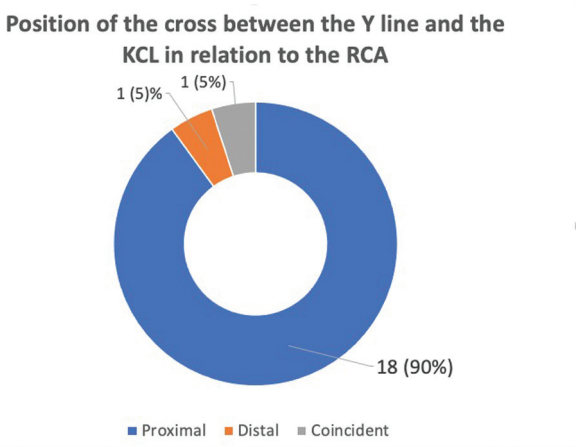


Fig. 9 Graph of the results of the position of the crossing between the Y line and the KCL in relation to the RCA.

transducer was moved in an ulnar direction in relation to the KCL. The authors[15] reported that this method offers an alternative to carpal tunnel infiltrations. The use of ultrasound guidance enables the surgeon to visualize and prevent damage to neurovascular structures near the median nerve and guide the needle to the site of maximum nerve compression.

Eskandari et al.[16] carried out a study on 37 hands of 34 patients who underwent the carpal tunnel release procedure. A radiological labeling technique was used to determine the location of the thenar motor branch of the median nerve in relation to the KCL.

Ruch et al.[17] related the KCL to the palmar cutaneous nerves of the median and ulnar nerves and reported that a longitudinal incision following the ulnar margin of the middle finger, 2 cm proximal to the KCL, should result in less damage to these nerve branches, and thus reduce the incidence of painful neuromas during open carpal tunnel release.

Dashe and Jones[18] presented a method of exposure and safe removal of the hamate hook in cases of pseudarthrosis with pain symptoms. They[18] used as a reference for the access route to the KCL and the line that accompanies the ulnar margin of the ring finger, to avoid damage to the deep branch of the ulnar nerve.

Some authors have related the KCL with the arterial arches of the palmar surface of the hand.[19–22] Panchal and Trzeciak[19] performed an anatomical study on 30 cadavers, dissecting 60 hands, to describe the relationship between the KCL and the superficial palmar arterial arch. They believe that, from a clinical point of view, the KCL is the most predictable marker to identify the superficial palmar arch.

McLean et al.[20] carried out an anatomical study on 48 cadaveric hands in specimens aged between 50 and 75 years, with the aim of evaluating the distance between the superficial palmar arch and the KCL. Likewise, Panchal and Trzeciak[19] anatomically correlated the KCL with the superficial and deep palmar arterial arches.

Kwiatkowska et al.[21] dissected twenty upper limbs from cadavers. They related the deep structures of the palm with the creases of the palm of the hand but considered that the palmar creases are very variable between people, and genetics has a lot of influence on the formation of the creases. They consider that the middle palmar crease is parallel to the KCL. Gelberman and North[23] described a more limited incision relating the KCL to the palmar cutaneous branch of the median nerve, considering it to be the ideal access for open carpal tunnel incisions.

In Brazil, we found only one study[24] that related structures of the palm of the hand with the existing creases, in which the authors relate the superficial and deep arterial arches with the wrist creases.

Ma et al.[25] modified the Agee endoscopic portal technique to approach and release the carpal tunnel using the KCL as a reference, and they recorded that the mean distance between the distal margin of the transverse carpal ligament and the KCL ranged from 8.6 mm to 10.7 mm, with an average of 10.0 mm.

Conclusion

The most distal point of the RCA was positioned distally to the KCL in 20 limbs and, in 14 of them, radially in relation to the Y line. The crossing between the KCL and the Y line occurred proximal to the RCA in 18 limbs. Knowledge of these anatomical relationships can prevent damage to nerve branches and thus also prevent paralysis of intrinsic muscles in surgical procedures in the palm of the hand.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Orthopedic Injuries in Beach Tennis Players in Brazil

Lesões ortopédicas nos praticantes de beach tennis no Brasil

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Abstract

Objective To analyze the epidemiological data of orthopedic injuries in beach tennis players.

Methods We conducted a cross-sectional study, through a questionnaire, with 185 beach tennis players during tournaments and training sessions in two cities. The questionnaire comprised anthropometric data, as well as data on length of time practicing the sport and reported orthopedic injuries.

Results We excluded 25 of the 185 interviewees. Of the 160 players studied, 51.9% were male and 48.1%, female. The average age was of 40.4 years, the average height was of 1.73 m, the average weight was of 75.6 kg, and the average body mass index (BMI) was of 25.2 kg/m^2. Orthopedic injuries were reported by 48.8% of the participants, 30.0% in the lower limbs, 11.3% in the spine, and 25.0% in the upper limbs, with an incidence of 0.82 per one thousand hours of practice. Correlating the incidence of injuries with age, weight, height, and BMI, we only found relevance between the higher average age in patients with lower- and upper-limb injuries. Players who had no previous experience with other racket sports had fewer injuries. Other parameters, such as gender, use of the two-handed *backhand*, dominant side, participation in competitions, and practice of other sports did not show statistically significant differences.

Conclusion Orthopedic injuries were found in almost half of the beach tennis players, primarily in the lower limbs. Age, experience with other racket sports, category, hours

Keywords
- beach tennis
- epidemiology
- sports medicine
- tennis/injuries

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of training per week, and length of time playing the sport influenced the incidence of orthopedic injuries.

Resumo

Objetivo Analisar os dados epidemiolügicos das lesões ortopédicas nos praticantes de *beach tennis*.

Métodos Foi realizado um estudo transversal, por meio de questionário, em 185 praticantes de *beach tennis*, durante torneios e treinos, em duas cidades. O questionário consistiu na coleta de dados antropométricos, além de dados relativos ao tempo de prática do esporte e às lesões ortopédicas referidas.

Resultados Excluímos 25 dos 185 entrevistados. Dos 160 praticantes estudados, 51,9% eram do sexo masculino, e 48,1%, do feminino. A média de idade foi de 40,4 anos, a média da estatura foi de 1,73 m, a média do peso, de 75,6 kg, e a média do índice de massa corporal (IMC), de 25,2 kg/m^2. A presen ça de lesões ortopédicas foi relatada por 48,8% dos praticantes, sendo 30,0% nos membros inferiores (MMII), 11,3% na coluna, e 25,0% nos membros superiores (MMSS), com incidência de 0,82 a cada mil horas de prática. Correlacionando a incidência de lesões com idade, peso, altura e IMC, encontramos relevância apenas entre a média de idade maior nos pacientes com lesão nos MMII e MMSS. Os jogadores que não tinham experiência prévia com outros esportes com raquete tiveram menos lesões. Demais parâmetros, como sexo, uso do *backhand* com duas mãos, lado dominante, participação em competições e prática de outros esportes não obtiveram diferenças estatisticamente significantes.

Conclusão Lesões ortopédicas foram encontradas em quase a metade dos praticantes de *beach tennis*, preferencialmente nos MMII. Idade, experiência com outros esportes de raquete, categoria, horas de treino por semana e tempo de prática do esporte influenciaram na incidência de lesões ortopédicas.

Palavras-chave
- beach tennis
- epidemiologia
- medicina esportiva
- tênis/lesões

Introduction

Beach tennis (BT) was created in Italy around 1987,[1] and it arrived in Brazil in 2008.[2] The Brazilian Beach Tennis Confederation estimates around three hundred thousand players, with a significant growth following the pandemic.[2] The sport is a mixture of traditional tennis, beach volleyball, and badminton.[3]

Despite the considerable number of players, we have found only one article[1] on orthopedic injuries in BT, from a study performed in France. There have been several studies on injuries in field tennis players, but these data cannot be transposed to BT since court and sand sports differ not only in the surface but also in the racket and the kinematics of the sport.[3]

The present study aims to obtain epidemiological data on orthopedic injuries in BT players, to enable health professionals to get to know possible injuries and establish treatment and prevention targets for Brazilian players.

Materials and Methods

A cross-sectional study was conducted through a questionnaire applied in person by the same author to 185 BT players during tournaments and training sessions at clubs in the cities of São Paulo and São Caetano do Sul, Brazil, between September 2021 and January 2022. All players agreed to participate voluntarily in the interview. The inclusion criteria were individuals over 18 years of age who had been practicing the sport regularly for at least 6 months. Interviewees who were unable to complete the questionnaire were excluded.

In the first part, the following data was collected: age, gender, height, weight, body mass index (BMI), and dominant side. In the second part, we investigated practice time (in months, days per week, and hours per week), participation in competitions, category, experience with other sports, and use of the backhand with both hands. The classification by category was self-reported and divided, according to performance in competitions, into "Pro" (professional), followed by categories A, B, C, and beginner.

The last part was the collection of data related to the presence of injuries and the segment in which they had occurred: the spine, upper limbs (ULs), and lower limbs (LLs). The injuries were self-reported.

Regarding the analysis of injuries, previous orthopedic injuries that could interfere with the practice of BT were disregarded. If an interviewee reported a previous asymptomatic injury, this was not considered when analyzing the data .

To obtain the incidence of injuries for every one thousand hours, the time spent practicing the sport for each participant was determined by multiplying the variables "training time (hours/week)" and "time spent practicing

(months)," considering an estimate of four weeks in each month.

The data was analyzed using the Student *t*-test, the Chi-squared test, and the test of equality of two proportions, using the software IBM SPSS Statistics for Windows (IBM Corp., Armonk, NY, United States), version 20.0, Minitab 16 (Minitab, LLC, State College, PA, United States), and Excel Office 2010 (Microsoft Corp., Redmond, WA, United States), and considering a significance level of 5%.

The present study was approved by the Brazilian National Research Ethics Committee under CAAE 56741122.8.0000.5479.

Results

Of the 185 players, 25 were excluded due to questionnaires that had not been fully filled out. Of the 160 practitioners analyzed, 83 were male (51.9%) and 77 were female (48.1%). The average age was of 40.4 years, ranging from 18 to 66 years. The average height was of 1.73 m, the average weight was of 75.6 kg, and the average BMI was of 25.2 kg/m^2.

Of those interviewed, 144 were right-handed, and 16 were left-handed. Concerning the length of time they had been practicing the sport, most (46.3%) had been practicing for up to 12 months, followed by 33.8% who had been practicing between 13 and 36 months, and 20%, over 36 months. Most players trained for 2 to 4 hours per week, accounting for 28.1%, and only 16.3% trained for more than 10 hours per week. In total, 71 (44.4%) players were beginners, 34 (21.3%) were in category C, 40 (25.0%) were in category B, and only 15 (9.4%) were in categories A or Pro. Many had practiced racket sports before (56.9%), and 52.5% did not practice other sports concurrently.

The presence of orthopedic injuries was reported by 78 practitioners (48.8%). The highest prevalence was found in the LLs, accounting for 48 injuries (30.0% of all injuries). Regarding the other segments, 18 spinal injuries (11.3%) and 40 UL injuries (25.0%) were reported.

A total of 94,572 hours of practicing the sport were obtained, with 78 injuries, with an incidence of 0.82 injuries per one thousand hours practiced (95% confidence interval [95%CI]: 0.18).

Concerning spinal injuries, 55.6% of the participants had spinal disc problems. In the ULs, the injuries with the highest prevalence were tendinopathy (47.5%) and epicondylitis (32.5%). In the LLs, knee injuries were the most common, with meniscus injuries (31.3%), followed by patellofemoral pain (25%), and ligament injuries (14.6%).

Correlating the incidence of injuries with age, weight, height, and BMI, there was only a statistically significant difference between the mean age of individuals with LL injuries (44.3 years with injury versus 38.8 years without injury) and UL injuries (45.6 years with injury versus 38.7 years without injury), with no statistical difference in spinal injuries.

We also found that players with no previous experience in other racket sports had fewer injuries (52.4%; $p = 0.015$). In addition, the prevalence of injuries found according to the length of time the players had been practicing BT was not proportional. In players who had been practicing for up to 12 months and in those practicing with more than 36 months of practice, 28.2% and 25.6% of injuries were found respectively; thus, the highest number of players with orthopedic

Table 1 Correlation between players with and without injury and the parameters "experience in other racket sports," "time spent practicing BT," "category," and "BT training time"

		Without injury		With injury		Total		*p*-value
		N	%	N	%	N	%	
Experience in other racket sports	No	43	52.4%	26	33.3%	69	43.1%	0.015
	Yes	39	47.6%	52	66.7%	91	56.9%	
Time spent practicing BT (months)	Up to 12	52	63.4%	22	28.2%	74	46.3%	< 0.001
	From 13 to 36	18	22.0%	36	46.2%	54	33.8%	
	More than 36	12	14.6%	20	25.6%	32	20.0%	
Category	A/Pro	6	7.3%	9	11.5%	15	9.4%	< 0.001
	B	10	12.2%	30	38.5%	40	25.0%	
	C	12	14.6%	22	28.2%	34	21.3%	
	Beginner	54	65.9%	17	21.8%	71	44.4%	
BT training time (hours/week)	0–2 hours	26	31.7%	13	16.7%	39	24.4%	0.007
	2–4 hours	24	29.3%	21	26.9%	45	28.1%	
	4–6 hours	14	17.1%	8	10.3%	22	13.8%	
	6–8 hours	5	6.1%	6	7.7%	11	6.9%	
	8–10 hours	8	9.8%	9	11.5%	17	10.6%	
	> 10 hours	5	6.1%	21	26.9%	26	16.3%	

injuries was found among those who had been practicing between 13 and 36 months (33.8%; $p < 0.001$) (►**Table 1**). There was a higher incidence of injury in individuals who trained more hours per week ($p = 0.007$) (►**Table 1**).

The time spent practicing BT and the player category were statistically relevant regarding the presence of injuries. In the spine, players who had been practicing between 13 and 36 months were found to have 50% of injuries, while in the ULs, the rate was of 45%, and, for the LLs, it was of 47.9% for the same length of time practicing the sport. In category B players, around 33.3% had spinal injuries, 37.5% had UL injuries, and 39.6% reported LL injuries. Other parameters, such as gender, two-handed backhand, dominant side, participation in competitions, and practice of other sports did not show statistically significant differences.

Discussion

The present study provides information on BT injuries in the Brazilian population. Although the total number of participants was relatively small and concentrated in a single metropolitan region, the study showed a homogeneous population, with no statistical differences in terms of gender, age, weight, or height of the players. In the present study, orthopedic injuries were considered all symptomatic injuries reported by the athlete that arose or worsened due to practicing BT.[4]

As for the incidence of injuries, 78 (48.8%) players had orthopedic injuries, a figure similar to that found in the study by Berardi et al.[1] We obtained 0.82 injuries for every one thousand hours played, a figure slightly different from that of the survey by Berardi et al.[1], with an incidence of 1.81 injuries, and from studies on tennis,[5–8] with an incidence of 1.5 to 20 injuries for every one thousand hours played. We believe that because we interviewed active players, and most of them during competitions, injured players may have been left out of the study.

Injuries occurred mainly in the LLS, followed by the ULs and the spine. This distribution of locations differed slightly from that described by Berardi et al.,[1] with the most injuries occurring in the ULs (48.3%), followed by the LLs (43.4%), and the torso (8.4%). However, reviews of epidemiological studies on tennis show a distribution of injuries similar to that found in the present study, with LL injuries being the most common (31% to 67%), followed by the ULs (20% to 49%), and the torso/spine (3% to 21%).

The shoulder was the most injured site in the ULs in the French[1] and Brazilian analyses. In contrast, studies on tennis players[5–8] found that the elbow was most affected, with lateral epicondylitis being the most prevalent. This difference between tennis and BT is probably due to the biomechanics of each sport. In BT, most movements occur above the head, which probably leads to more shoulder injuries.[1]

In the LLs, injuries occurred more in the knee. However, in the previous study on BT,[1] the most common injuries were to the thigh and feet. The ankle and thigh are the most common injury sites in tennis players.[5] It is recognized that sand sports require more energy expenditure and muscle work when compared to hard court sports;[9,10] therefore, the ankle, hip, and knee may be more injured. However, this data was not found in the study by Berardi et al.,[1] but corroborated the data found in the present study, with higher rates of injuries reported in the LLs.

In the present study, patients with a reported orthopedic injury had a higher average age when compared to those without injuries ($p < 0.001$); this was also verified regarding the location of the injury, which remained statistically relevant in UL and LL injuries, but not significant for spinal injuries. The same was not found in the other studies on BT[1] and tennis.[5] Thoroughly analyzing the studies, the average age in the present study is higher than in the others. This may have made age a relevant factor in the present analysis.

A higher injury rate was found in those who had already practiced or were practicing another similar sport (66.7%). In addition, the length of time practicing the sport also seemed to influence the appearance of injuries, as did the category of the players. Practicing BT for up to 12 months and spending less time training per week resulted in lower rates of orthopedic injuries, while the beginner category also had fewer reported injuries. In previous studies on tennis,[5] it is recognized that a greater volume of training or playing is correlated with the presence of injuries; however, the beginner category of players, be them of tennis[5] or BT,[1] seems to present a higher rate of injuries, which differs from the data found in the present study.

Other parameters, such as gender, dominant side, use of the backhand with both hands, participation in competitions, and practice of other sports were not statistically significant in players with or without orthopedic injuries in the present study.

The limitations of the present study were mainly found in the cross-sectional design, in which there was no differentiation between chronic and acute injuries. In addition, the diagnosis of the orthopedic injury was based on the athlete's report, which can lead to bias in data collection.

Conclusion

Orthopedic injuries were found in almost half of the BT players, preferably in the LLs, with an incidence of 0.82 injuries for every one thousand hours played. Age, experience with other racket sports, category, hours of training per week, and length of time practicing the sport influenced the incidence of orthopedic injuries.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Prevalence of Musculoskeletal Pain in Amateur Golfers in the State of São Paulo: A Cross-sectional Study

Prevalência de dor musculoesquelética em golfistas amadores do estado de São Paulo: Um estudo transversal

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Abstract

Objective To verify the prevalence of musculoskeletal pain in amateur golfers in the State of São Paulo, Brazil.

Methods The present is a cross-sectional study performed from September 2019 to March 2020 in golf clubs affiliated to Federação Paulista de Golfe (São Paulo Golf Federation). Federation players were evaluated regarding data on golf practice and sport routine by a main investigator, though an assessment form with multiple-choice questions, to determine sample characteristics and recent pain intensity by the Visual Analogue Scale.

Results Approximately 359 amateur golfers were analyzed. The prevalence of pain was of 55.15% (95% confidence interval [95%CI]: 50.0% to 60.3%); the average pain intensity according to the VAS was moderate (mean ± standard deviation: 5.21 ± 2.04; odds ration [OR]: 47,98%). The golfer's age range was significantly associated with the presence of pain ($p < 0.05$). The highest prevalence estimate of pain was of 68.80% in the age group between 30 and 39 years (OR: 7,33; 95%CI: 2,26 to 23,85; $p = 0,0009$). The segments most affected by pain were the upper limbs (65.66%), followed by the spine (59.09%) and the lower limbs (32.83%).

Conclusion There is a high prevalence rate of pain in Brazilian amateur golfers, especially in younger players in the age group between 30 and 39 years.

Keywords
- cross-sectional studies
- golf
- musculoskeletal pain
- prevalence

Resumo

Objetivo Verificar a prevalência de dores musculoesqueléticas em golfistas amadores do estado de São Paulo.

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Métodos Este é um estudo transversal realizado de setembro de 2019 a março de 2020 em clubes de golfe afiliados à Federação Paulista de Golfe. Jogadores federados foram avaliados quanto a dados da prática de golfe e da rotina esportiva por um investigador principal, por meio de um formulário de avaliação com questões de múltipla escolha, para a determinação das características da amostra e da intensidade da dor recente pela Escala Visual Analógica (EVA).

Resultados Cerca de 359 golfistas amadores foram analisados. A prevalência de dor foi de 55,15% (intervalo de confiança de 95% [IC95%]: 50,0% a 60,3%); a intensidade média da dor segundo a EVA foi moderada (média $\pm$ desvio padrão: 5,21 $\pm$ 2,04; razão de probabilidades [*odds ratio*, OR, em inglês]: 47,98%). A faixa etária dos golfistas esteve significativamente associada à presença de dor ($p < 0,05$). A maior estimativa de prevalência de dor foi de 68,80% na faixa etária de 30 a 39 anos (OR: 7,33; IC95%: 2,26 a 23,85; $p = 0,0009$). Os segmentos mais acometidos por dor foram os membros superiores (65,66%), seguidos da coluna (59,09%) e dos membros inferiores (32,83%).

Conclusão Há uma alta taxa de prevalência de dor em golfistas amadores brasileiros, especialmente em jogadores mais jovens, na faixa etária de 30 a 39 anos.

Palavras-chave
- dor musculoesquelética
- estudos transversais
- golfe
- prevalência

Introduction

Golf is one of the most popular sports,[1] with 66 million players worldwide. Since 2016 the number of players has increased by over 5.5 million.[2]

And like any other sport, it can also lead to musculoskeletal injuries and, consequently, musculoskeletal pain. In a systematic review from 2009,[3] the authors reported that the prevalence of injuries in amateur golfers ranged from 17% to 62%. These injuries occurred throughout the competitive lives of the golfers; however, there may have been a memory bias (when participants did not they accurately remember the events).[4]

Additionally, studies on the prevalence of injuries presented other significant biases, such as the failure to mention the sample size calculation, the inclusion and exclusion criteria, and the adopted definition of injury in the sport.[5]

In Brazil there are $\sim$ twenty thousand practitioners of this sport, and recent data on the prevalence of pain is not known in the country. To answer the clinical question about the prevalence of pain in recent golf practice, the performance of an observational study with methodological quality is necessary.[6,7] Therefore, the aim of the present study was to verify prevalence of musculoskeletal pain in amateur golfers in the state of São Paulo.

Methods

Study Design

The present was an observational, cross-sectional study conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[8]

Ethics Committee

The present study involved human participants, and it was approved by the institutional Ethics in Research Committee under CAAE 14666619.4.0000.5505. The participants signed the consent to participate in the study, which was performed according to the Declaration of Helsinki.

Study Location

The study was conducted in 14 golf clubs located in the state of São Paulo, Brazil, which were affiliated to Federação Paulista de Golfe (São Paulo Golf Federation).

Eligibility Criteria

The inclusion criteria were Brazilian amateur golfers, affiliated to Federação Paulista de Golfe for more than 1 year, of any sex, and over 18 years of age. Players who underwent medical or physical therapy treatment for orthopedic surgery or bone fracture in the previous year and those who refused to sign the informed consent form were excluded.

Outcomes

The primary outcome was the prevalence of musculoskeletal pain in the past six months.

Procedure

An assessment form was developed with thirty questions that, on an average, required five minutes to be filled out. These questions addressed demographic data, data on presence of pain during golf practice in the past six months assessed using a visual analogue scale (VAS),[10] a body diagram of the pain sites,[11] duration of pain, time of pain onset, whether the pain affected swing, time spent away from the game due to the pain, and data about the sport.

Considering that pain is perceived in a specific region of the body, and that it originates in the bones, muscles, ligaments or tendons, and that it can be acute or chronic,[12] the concept of pain used in the present study was pain that occurred during or after golf training or a golf match, regardless of the time off, duration of pain and need for medical attention.

From September 2019 to March 2020, one of the study researchers administered the assessment form in person, and the golfers were approached once after the game. The researcher explained the study, the questionnaire, the selection criteria and the guarantee of data protection and confidentiality to the players. After the application of the eligibility criteria, the golfers who agreed to participate in the research signed the informed consent form.

Case Set

The participants were selected based on convenience, and the sample size was determined based on the total number of golfers affiliated (4 thousand players) to Federação Paulista de Golfe in 2019. to determine the sample size (representative of this population), the following values were used: 50% of expected pain frequency, 95% confidence interval (95%CI) and 5% sampling error; these measurements yielded a sample size of 350 amateur golfers.[13]

Statistical Analysis

Data were tabulated in a Microsoft Excel 365 spreadsheet (Microsoft Corp., Redmond, WA, United States), and the analyses were performed using the R statistical software (R Foundation for Statistical Computing, Vienna, Austria). Initially, a descriptive analysis of all variables was performed. For the categorical/qualitative variables, absolute and relative frequencies were used, and for the quantitative variables, mean, standard deviation, median, minimum and maximum values and percentages were used. Based on the regression model analysis, the odds ratios (ORs) were estimated with their respective 95%CIs. The Chi-squared and Fisher exact tests were used as categorical variables. For all analyses, the level of significance was set at 5%.

Results

In total, 415 players were approached. However, based on the eligibility criteria, 56 players were excluded from the study, as shown in ►**Fig. 1**.

As a result, 359 amateur golfers were interviewed, and their general characteristics are shown in ►**Table 1**.

As shown in ►**Table 1**, $\sim$ 87% of the included participants were males and 13% were females, and 94% of the players were right-handed. The mean age of the participants was of 54 ± 12 years, with a higher number of participants in the age group of 50 to 59 years (32%). The analyzed data indicated a mean body mass index (BMI) of $27 \pm 4\,kg/m^2$, with 67.4% of the players being overweight or obese.

The mean number of years of golf experience was of 15 ± 12, and the mean skill level/handicap was of 19 ± 8. Regarding the weekly training time, 75% of the included golfers trained for $\leq$ 30 minutes on the putting green, 55% trained for 30 minutes on the drive range, and 67% used 0 to 60 balls in the drive-range training.

Overall, 29% of golfers practiced golf-specific physical conditioning, 61% performed warm-up exercises, 19% reported performing stretching exercises, and 40,9% practiced sports other than golf, mainly swimming, tennis, and running.

►**Table 2** shows that the prevalence of pain in the past 6 months was of 55.15% (95%CI: 50.0% to 60.3%; $n = 198$) among amateur golfers.

The segments most affected by pain in the past 6 months were the upper limbs (65.66%), followed by the spine (59.09%), and the lower limbs (32.83%). However, regarding the site of the pain, the lumbar spine was the most affected (48.48%), followed by the shoulder (29.80%), and the elbow (26.77%). As the players had the option of selecting multiple sites, the total frequency of data exceeded 100%.

When the participants were asked about their pain intensity using the VAS, the intensity category between 4 and 6.99 (moderate pain) was found the most frequent (48%), and the mean pain intensity was found to be of 5.2. The duration of pain was found to be $<$ 1 week for 36.9% of the participants. Of the participants who experienced pain, 50% reported that its onset wsas when they were training for or playing golf.

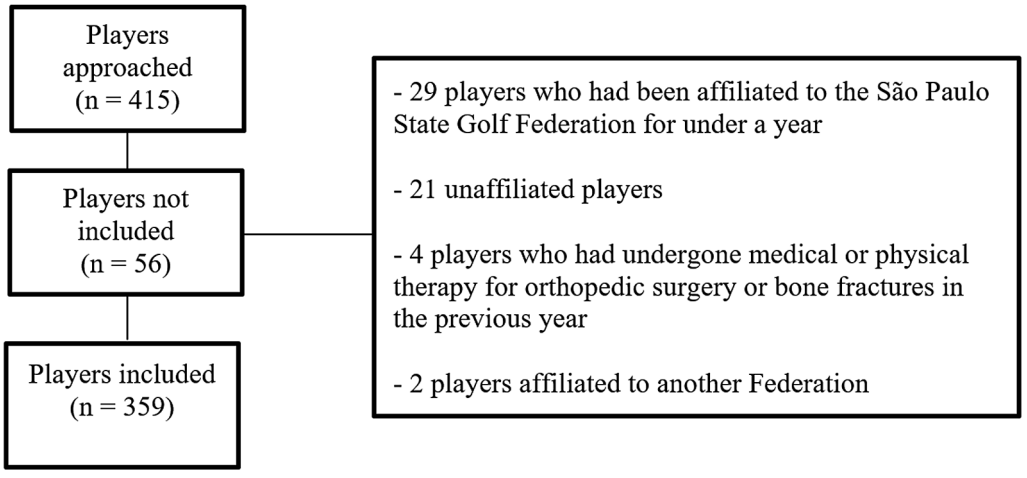


Fig. 1 Flowchart for eligibility.

Table 1 General characteristics of 359 amateur golfers

Numerical variables	Mean(± standard deviation)	Median (minimum value; maximum value)
Age (years)	53.91(± 12.26)	55.00 (21.00; 86.00)
Body mass index (kg/m^2)	26.66(± 03.61)	26.45 (17.97; 50.71)
Years of playing golf	15.04(± 11.77)	12.00 (01.00; 65.00)
Skill level/handicap	18.88(± 07.68)	18.00 (00.00; 40.00)
Tournaments per year	08.06(± 07.77)	6.00 (00.00; 50.00)
Matches per week	02.10(± 00.95)	2.00 (01.00; 06.00)
Categorical variables	**Category**	**n (%)**
Sex	Male	311 (86.60%)
	Female	48 (13.40%)
Dominance	Right-handed	338 (94.20%)
	Left-handed	21 (05.80%)
Age group (years)	20–29	11 (03.1%)
	30–39	32 (09.1%)
	40–49	83 (23.5%)
	50–59	113 (32.0%)
	60–69	26 (07.4%)
	≥ 70	
Body mass index (kg/m^2)	18.50–24.99	117 (32.6%)
	25.00–40.00	242 (67.4%)
Weekly visits to the golf course	1–2 times	264 (73.50%)
	3–4 times	87 (24.20%)
	5–6 times	8 (02.20%)
Drive-range training time per week (minutes)	0–30	199 (55.40%)
	31–59	81 (22.60%)
	≥ 60	79 (22.00%)
Putting green practice time per week (minutes)	0–30	269 (74.90%)
	31–59	70 (19.50%)
	≥ 60	20 (05.60%)
Number of drive-range training balls	0–60	241 (67.10%)
	61–120	94 (26.20%)
	≥ 121	24 (06.70%)
Specific physical conditioning for golf	Yes	105 (29.20%)
	No	254 (70.80%)
Other sports	Yes	147 (40,90%)
	No	212 (59,10%)
Warm-up	Yes	220 (61.30%)
	No	139 (38.70%)
Stretching	Yes	68 (18.90%)
	No	291 (81.10%)
Method of carrying the golf bag*	Cart or electric car	126 (35.10%)
	Caddy	117 (32.60%)
	Manually pushing and pulling the cart	111 (30.90%)
	On the shoulder	15 (04.20%)

Note: *The total frequency was > 100% because the answer could include more than one category.

Table 2 Descriptive analysis of musculoskeletal pain variables during the past 6 months ($n = 198$)

Numerical variables	Mean ± standard deviation	Median (minimum value; maximum value)
Pain intensity	5.21 ± 2.04	5 (1; 10)
Categorical variables	**Category**	**n (%)**
Presence of pain	Yes	198 (55.15%) 95%CI: 50.0–60.3%
Sex	Male	168 (84.80%)
	Female	30 (15.00%)
Pain intensity (Visual Analogue Scale)	1–3.99	56 (28.28%)
	4–6.99	95 (47.98%)
	7–9.99	42 (21.21%)
	10	05 (02.53%)
Pain segment*	Upper limbs	130 (65.66%)
	Spine	117 (59.09%)
	Lower limbs	65 (32.83%)
Site of pain*	Lumbar	96 (48.48%)
	Shoulder	59 (29.80%)
	Elbow	53 (26.77%)
	Knee	26 (13.13%)
	Hip	19 (09.60%)
	Dorsal	15 (07.58%)
	Hand	12 (06.06%)
Time of pain onset*	Playing golf	74 (37.37%)
	After the game	67 (33.83%)
	Unknown	37 (18.68%)
	Coaching golf	25 (12.63%)
	After training	11 (5.56%)
Swing phase*	Acceleration + impact	68 (34.34%)
	Follow-through	60 (30.30%)
	Backswing	42 (21.21%)
	No pain performing these gestures	54 (27.27%)
Duration of pain	< 1 week	73 (36.9%)
	8–30 days	37 (18.7%)
	31–60 days	18 (09.1%)
	61–90 days	29 (14.6%)
	> 90 days	41 (20.7%)
Pain at the time of the interview	No	122 (61.61%)
	Yes	76 (38.39%)

Abbreviation: 95%CI, 95% confidence interval.
Note: *The total frequency was > 100% because the answer could include more than one category.

►**Table 3** demonstrates the consequences of pain in golfers, with 65,6% not needing to withdraw from training or playing golf because of pain.

As shown in ►**Table 4**, the golfers' age range and specific physical conditioning for golf showed a significant association with the presence of pain ($p < 0.05$). Golfers aged between 30 and 39 years presented 7.34 (95%CI: 2.24 to 24.06) times more chance of having experienced golf-related pain in the past 6 months than those aged ≥ 70 years ($p < 0.05$).

Moreover, among golfers who underwent specific physical conditioning for golf, 65.7% experienced pain, whereas among those who did not undergo specific physical conditioning, 50.8% experienced pain. Golfers who underwent

Table 3 Descriptive analysis of consequences of golf-related musculoskeletal pain in the last 6 months ($n = 198$)

Variables	Category	n (%)
Healthcare	Yes No	97 (49%) 101 (51%)
Physiotherapy	Yes No	106 (54%) 92 (46%)
Time spent away from training for or playing golf	< 1 week	21 (10.6%)
	8–30 days	31 (15.7%)
	31–90 days	5 (02.5%)
	> 90 days Did not stop	11 (05.6%) 130 (65,6%)
Biomechanical alteration of swing	Yes	106 (53.54%)
	No	92 (46.46%)

specific physical conditioning for golf presented 1.86 (95%CI: 1.16 to 2.98) times more chance of experiencing pain ($p < 0.05$).

Discussion

The present is a cross-sectional study which aimed to assess the prevalence of pain in the months before the interview among amateur golfers affiliated to Federação Paulista de Golfe. The period of six months was chosen to reduce memory bias. Hence, the present study was designed employing sample size calculation, eligibility criteria, pain definition, and in-person data collection.

In the present study, 13.4% participants were females and 86.6% were males; these proportions were similar to those found in the literature[14–18] and Federação Paulista de Golfe.

Pain was found to be highly frequent in amateur golfers, with a prevalence of 55.2% in the past 6 months. In the literature, the prevalence of injuries in golfers ranges from 17.1% to 62%.[14–21] These studies analyzed the site of the injury, not the injury itself. Regarding pain intensity, 76.26% of the players were found to have mild-to-moderate pain, with a mean VAS score of 5 to 7. This finding is consistent with an injury study that assessed pain intensity and reported a mean intensity of seven on the VAS.[17]

Injury severity can be classified according to how long a player must be away from sport.[22,23] In the present study, 66% of players with pain did not have to stop playing or training golf due to pain, because they reported the pain was mild or not very relevant. This result contradicts that of the study by McHardy et al.,[17] in which 55.2% of the injured players had to take breaks of two to three weeks from games or training because of the injury.

On the day of the interview, 38% of the players with pain answered that, although they were in pain, they practiced the sport. This result supports those of the literature that states that injuries can impair golf performance, but they do not necessarily prevent players from playing or competing in the sport.[22,23] The anatomical segments most affected by pain were the upper limbs, followed by the spine and the lower limbs. This result is similar to that of a study by Theriault et al.,[15] in which the upper limbs were reported to be the most affected region. However, when analyzing pain in relation to anatomical site, we found that the lumbar spine (48%) was the most commonly affected site, supporting the findings of the aforementioned systematic review[3] and most cross-sectional studies.[17,20,24,25] In the present study, the shoulder was found to be the second site most commonly affected by pain, followed by the elbow. In addition, the right side of golfers was affected by pain in 61% of the cases. Thus, it can be said that the trail side or the right side was more commonly affected, since the sample contained 95% of right-handed participants. Golf is an asymmetrical sport; thus, the muscles on the right and left sides are activated differently. For right-handed golfers, the right side is the trail side and the left side in a right-handed golfer is the lead arm.[26]

Some authors state that injuries in amateur golfers may occur because of the biomechanics of the swing movement associated with inadequate techniques, or due to the volume of practice.[26] One of the types of swing is the modern swing, in which greater angular displacement of the lumbar spine occurs, which, in turn, can cause injuries in both professional and amateur golfers.[22,27] In contrast, upper-limb injuries can occur when the club hits a stationary object, such as a rock, a tree root or even hard ground, which results in sudden deceleration of the movement that causes pain and injuries in the region, which may also be related to training volume.[22,27]

In golf, the swing is divided into phases: takeaway, backswing, acceleration, impact, early follow-through and late follow-through.[28] In the present study, the phase most associated with pain was the acceleration phase, followed by the follow-through. These findings are inconsistent with those of McHardy et al.,[17] who found that 30.2% felt pain during the follow-through phase, and 17% felt pain during the acceleration or impact phases.

The frequency of pain increases with golf play time, training, and playing experience. This may facilitate the onset of pain due to increased exposure/practice volume. Most athletes spent less than 30 minutes per week practicing on the putting green and drive range (54% and 77%,

Table 4 Analysis of factors (related to golf) associated with the presence of pain during the past 6 months among amateur golfers in the state of São Paulo, Brazil ($n = 359$)

Variable	Category	n (%)	Pain		OR (95%CI)	*p*-value
			Absence: n (%)	Presence: n (%)*		
Age (years)	20–29	11 (3.06%)	6 (54.6%)	05 (45.4%)	2.90 (0.64–13.12)	0.1656
	30–39	32 (8.91%)	10 (31.2%)	22 (68.8%)	7.34 (2.24–24.06)	0.0010**
	40–49	83 (23.1%)	34 (41.0%)	49 (59.0%)	4.86 (1.75–13.45)	0.0024**
	50–59	113 (31.4%)	41 (36.3%)	72 (63.7%)	5.68 (2.10–15.40)	0.0006**
	60–69	88 (24.5%)	45 (51.1%)	43 (48.9%)	3.03 (1.10–08.34)	0.0314**
	> 70	32 (8.91%)	25 (78.1%)	7 (21.9%)	Ref.	
Body mass index (kg/m^2)	18.50–24.99	117 (32.6%)	50 (42.7%)	67 (57.3%)	Ref.	—
	25.00–40.00	242 (67.4%)	111 (45.9%)	131 (54.1%)	0.88 (0.56–1.37)	0.576
Golf experience (years)	≤ 12$	190 (52.9%)	77 (40.5%)	113 (59.5%)	1.45 (0.96–2.20)	0.0814
	> 12	169 (47.1%)	84 (49.7%)	85 (50.3%)	Ref.	—
Putting green training duration	≤ 30 minutes$	269 (74.9%)	116 (43.1%)	153 (56.9%)	Ref.	
	> 30 minutes	90 (25.1%)	45 (50.0%)	45 (50.0%)	0.76 (0.47–1.22)	0.2568
Drive-range training duration	≤ 30 minutes$	199 (55.4%)	93 (46.7%)	106 (53.3%)	Ref.	
	> 30 minutes	160 (44.6%)	68 (42.5%)	92 (57.5%)	1.19 (0.78–1.80)	0.4229
Physical disability (handicap index)	≤ 18$	189 (52.6%)	81 (42.9%)	108 (57.1%)	1.18 (0.78–1.80)	0.4243
	> 18	170 (47.4%)	80 (47.1%)	90 (52.9%)	Ref.	
Method of carrying the golf bag						
Golf cart	No	233 (64.9%)	102 (43.8%)	131 (56.2%)	1.13 (0.73–1.75)	0.5794
	Yes	126 (35.1%)	59 (46.8%)	67 (53.2%)	Ref.	
Caddy	No	242 (67.4%)	107 (44.2%)	135 (55.8%)	1.08 (0.69–1.68)	0.7289
	Yes	117 (32.6%)	54 (46.2%)	63 (53.8%)	Ref	
Shoulder	No	344 (95.8%)	154 (44.8%)	190 (55.2%)	1.08 (0.38–3.04)	0.8845
	Yes	15 (4.2%)	7 (46.7%)	8 (53.3%)	Ref.	
Manually pulling/ pushing the cart	No	248 (69.1%)	116 (46.8%)	132 (53.2%)	0.78 (0.49–1.22)	0.2729
	Yes	111 (30.9%)	45 (40.5%)	66 (59.5%)	Ref.	
Physical conditioning for golf	No	254 (70.8%)	125 (49.2%)	129 (50.8%)	Ref.	
	Yes	105 (29.2%)	36 (34.3%)	69 (65.7%)	1.81 (1.11–2.95)	0.0175**
Warm-up	No	139 (38.7%)	62 (44.6%)	77 (55.4%)	1.02 (0.66–1.56)	0.9415
	Yes	220 (61.3%)	99 (45.0%)	121 (55.0%)	Ref.	
Stretching	No	291 (81.1%)	129 (44.3%)	162 (55.7%)	0.12 (0.66–1.90)	0.6829
	Yes	68 (18.9%)	32 (47.1%)	36 (52.9%)	Ref.	

Abbreviations: 95%CI, 95%confidence interval; OR, odds ratio; Ref., reference category of the independent variables.
Notes: *Outcome event. $Median of the sample. **Statistically significant.

respectively). This may facilitate the onset of pain – not from overuse, but from poor swing technique.

Golfers with a handicap below 18 reported the highest frequency of pain (58.5%); this is similar to the results of studies in the literature, which reported that injuries were more frequent in players with a lower handicap.[13,19,23] The authors of the present study believed that a higher handicap index (less skilled players) was associated with pain. However, in the statistical analysis, no differences were observed between those with higher and lower handicaps (indicating that this parameter was not statistically significant).

Most participants in the present study (67.2%) were overweight or moderately-to-severely obese. This is consistent with a study published in 2020 by Instituto Brasileiro de Geografia e Estatística (IBGE, Brazilian Institute of Geography and Statistics), which reported that 1 in 4 Brazilian adults were obese until 2019.[29] The frequency of pain in the current study was higher in players with a BMI > 25 kg/m^2, with 53.7% of the players being overweight or obese.

These data are consistent with thoe of a literature report in which 44.6% of the players were overweight.[21]

Approximately 35,1% of golfers preferred using a golf cart over walking around the course; this can lead to a decrease in the beneficial effects of walking. The rise on the use of golf carts may increasingly undermine the inherent health benefits derived from the sport, with negative consequences, such as obesity.[30] In the present study, we believed that the method used to carry the golf bag, especially carrying the bag on a shoulder, and manually pulling and pushing the golf cart, would present a predictive association with pain, but the differences associated with these factors were not statistically significant.

In the present study, age showed a statistically significant association with pain. Golfers who were in the age group of 30 to 69 years presented a greater association with pain, with the category of 30 to 39 years being 7.34 times more likely to experience pain than those aged $\geq$ 70 years. These results are consistent with those of some studies in the literature, in which golfers over 40 years of age were found to have a greater chance of injury, presenting a risk of injury 5 times greater than those aged $>$ 70 years.[17,18] We believe that the reason why players under 70 years old experience more pain is their desire to hit long distances, using a lot of force in the swing. As a result, they overload the musculoskeletal system and, consequently, cause injuries and pain. Additionally, younger players experience stress at work that can influence the outcome. However, this is a matter that still needs to be investigated.

In the present study, physical conditioning exercises showed a significant association with the frequency of pain. Golfers who perform physical conditioning exercises are 1.86 (95%CI: 1.16–2.98) times more likely to experience pain ($p < 0.05$). However, details on physical conditioning, duration and frequency per week were not questioned. The players may have begun golf-specific fitness training because of the pain, which could influence the outcome.

With the current prevalence study, we obtained data from amateur golfers that can be used in the development of hypotheses and sample calculation for future prospective studies.

Limitations of the Study

Since the present is a cross-sectional study, we can report an association, but cannot establish causality, for there is no determination of temporal relationships between exposure and outcome, only the development of hypotheses about the cause or associated factors.

Conclusion

The prevalence of golf-related pain in the 6 months preceding the assessment was found to be of 55.15%. Pain was more frequent in the upper limb segment, and younger players aged 30 to 69 years were more likely to experience pain than those aged $\geq$ 70 years.

Authors' Contributions

Each author made significant individual contributions to the development of this work. DRG: conceptualization (lead), data curation (lead), formal analysis (lead), investigation (lead), methodology (lead), project administration (lead), supervision (lead), writing of the original draft (lead), and writing – review and editing (lead); MPS: conceptualization (supporting), formal analysis (supporting), methodology (supporting), project administration (supporting), validation (supporting), visualization (supporting), and writing – review and editing (supporting); MJST: conceptualization (supporting), formal analysis (supporting), methodology (supporting), supervision (supporting), validation (supporting), visualization (supporting), writing of the original draft (supporting), and writing – review and editing (supporting); JCB: conceptualization (supporting), formal analysis (supporting), methodology (supporting), project administration (supporting), validation (supporting), visualization (supporting), writing – review and editing (supporting); All authors reviewed and approved the final version submitted for publication.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Anatomic Total Shoulder Arthroplasty Outcomes Were Not Negatively Affected by the COVID-19 Pandemic

Os desfechos da artroplastia anatômica total do ombro não foram afetados negativamente pela pandemia de Covid-19

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Abstract

Objective To investigate whether patients undergoing anatomic total shoulder arthroplasty (ATSA) between January and March 2020 experienced different postoperative outcomes than patients in 2019. We hypothesized that patients in 2020 would have less access to physical therapy (PT) and experience different postoperative outcomes.

Methods Records from patients who received ATSA between January 1st, 2019, and March 17th, 2019, and January 1st, 2020, to March 17th, 2020, were analyzed. Patient data, including demographic information, range of motion (ROM), strength, and PT was collected and compared between the two groups. The 2020 patients were contacted by phone during October 2022 and patient-reported metrics were gathered.

Results The present study identified 24 patients in 2019 and 27 patients in 2020 who underwent ATSA during the specified time frame and had a minimum 1-year follow-up. Patients in 2019 experienced improvements in forward elevation (FE) ROM (125.4° to 146.7°; $p = 0.008$), external rotation (ER; 33.0° to 47.7°; $p < 0.001$), and internal rotation (IR; S1 to L4; $p = 0.019$). Patients in 2020 also experienced significant improvements in FE (120.2° to 141.1°; $p = 0.009$), ER (32.9° to 42.0°; $p = 0.037$), and IR (S1 to L3; $p = 0.002$). Patients in 2020 terminated PT earlier (2019: 125.8 days; 2020: 91.1 days; $p = 0.046$) and completed fewer sessions (2019: 21.4 sessions; 2020:

Keywords
- arthroplasty, replacement
- COVID-19
- postoperative period
- shoulder

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13.1 sessions; $p = 0.003$). At the final follow-up, patients in 2020 reported an average Visual Analogue Scale (VAS) pain score of 1.67 ± 1.1.

Conclusion Despite decreased PT, patients who underwent ATSA in 2020 had significant improvements in ROM and strength and were comparable to patients in 2019.

Resumo

Objetivo Investigar se os pacientes submetidos à artroplastia total anatômica do ombro (ATAO) entre janeiro e março de 2020 tiveram resultados pós-operatórios diferentes dos pacientes operados em 2019. Nossa hipótese é a de que os pacientes de 2020 teriam menos acesso à fisioterapia (FT) e apresentariam desfechos pós-operatórios diferentes.

Métodos Foram analisados os prontuários de pacientes submetidos à ATAO de 1° de janeiro de 2019 a 17 de março de 2019 e de 1° de janeiro de 2020 a 17 de março de 2020. Os dados dos pacientes, incluindo informações demográficas, amplitude de movimento (ADM), força e FT foram coletados e comparados entre os dois grupos. Os pacientes de 2020 foram contatados por telefone durante outubro de 2022, e as métricas relatadas por eles pacientes foram coletadas.

Resultados Este estudo identificou 24 pacientes em 2019 e 27 pacientes em 2020 que foram submetidos à ATAO durante o período especificado e tiveram acompanhamento mínimo de 1 ano. Os pacientes em 2019 apresentaram melhoras na ADM de elevação anterior (EA; 125,4° a 146,7°; $p = 0{,}008$), rotação externa (RE; 33,0° a 47,7°; $p < 0{,}001$) e rotação interna (RI; S1 a L4; $p = 0{,}019$). Os pacientes em 2020 também apresentaram melhoras significativas de EA (120,2° a 141,1°; $p = 0{,}009$), RE (32,9° a 42,0°; $p = 0{,}037$) e RI (S1 a L3; $p = 0{,}002$). Os pacientes de 2020 terminaram a FT mais cedo (2019: 125,8 dias; 2020: 91,1 dias; $p = 0{,}046$) e fizeram menos sessões (2019: 21,4 sessões; 2020: 13,1 sessões; $p = 0{,}003$). No acompanhamento final, os pacientes de 2020 relataram uma pontuação média de dor na Escala Visual Analógica (EVA) de $1{,}67 \pm 1{,}1$.

Conclusão Apesar da menor realização de FT, os pacientes submetidos à ATAO em 2020 apresentaram melhoras significativas na ADM e na força e foram comparáveis aos pacientes de 2019.

Palavras-chave
- artroplastia de substituição
- Covid-19
- ombro
- período pós-operatório

Introduction

Anatomic total shoulder arthroplasty (ATSA) is the current gold-standard procedure for patients with end-stage glenohumeral arthritis who require shoulder replacement.[1] The volume of ATSA has been steadily increasing over the last few decades due to several factors, including the aging population and expanding indications for surgery.[2] Current rehabilitation protocols and timelines for ATSA vary between organizations; however, most follow similar principles of initial immobilization, reintroduction of passive range of motion (ROM), restoration of active ROM, and strength training.[1] Throughout the recovery process, physical therapy (PT) has been considered essential to achieve maximum shoulder function postoperatively.[3]

The coronavirus disease 2019 (COVID-19) pandemic shutdowns interrupted the normal standard of care for patients receiving ATSA. The recent literature has illustrated that there was an associated decrease in surgical volume and hospital length of stay, with an increase in discharge-home rates and the use of telemedicine for follow-ups.[4–6] There is, however, a paucity of literature examining the effects of the pandemic shutdowns on long-term postoperative rehabilitation and patient outcomes. Understanding these effects could provide insight for future management, thus warranting further study.

The purpose of the present study is to examine the impact of the COVID-19 pandemic on patient PT attendance and surgical outcomes after ATSA at a tertiary medical center. We hypothesize that patients affected by the pandemic completed fewer PT sessions and likely experienced inferior ROM and strength testing at the final follow-up.

Materials and Methods

Patient Cohort

The present study was approved by the institutional review board (number: 2022H0150). Patients who had undergone ATSA between January 1st, 2019, and March 17th, 2019, and January 1st, 2020, to March 17th, 2020, were identified using the Current Procedural Terminology (CPT) codes 23470, 23472, 23473, and 23474, and screening operative reports

for primary ATSA. All procedures were performed by four fellowship-trained orthopedic surgeons at a single tertiary care medical center. Patients undergoing revision ATSA and those with less than one year of postoperative follow-up were excluded from the analysis.

Data Collection

Demographic, ROM, strength testing, and physical therapy data were collected from patients' medical records. Information on ROM included measurements of forward elevation (FE), external rotation (ER), and internal rotation (IR) from before and after surgery. Strength testing data was also collected from before and after surgery, and included measurements of FE, ER, and IR. Postoperative physical therapy information was collected, including the date of the first session, the date of the last session, and the number of completed sessions.

Subjective data was gathered by contacting all patients who had undergone surgery in 2020. Patients were contacted by phone during October 2022 and queried about their current Visual Analog Scale (VAS) pain score and Single Assessment Numeric Evaluation (SANE) score for each shoulder. Additionally, they were asked to report whether they felt the COVID-19 pandemic led to any unanticipated delays in postoperative PT and whether they thought it adversely affected their recovery. The SANE score was chosen as the primary patient-reported outcome metric (PROM) because of the literature supporting its interrater reliability with the American Shoulder and Elbow Surgeons (ASES) and Western Ontario Rotator Cuff (WORC) scores.[7]

Statistical Analysis

Demographic, preoperative, perioperative, and postoperative data from both the 2019 and 2020 cohorts were analyzed. Categorical data was analyzed using the Chi-squared test, along with the Fisher Exact test when appropriate. A two-sample *t*-test or Mann-Whitney U test was performed on continuous data depending on the normality of the sample. Normality was determined using the Kolmogorov-Smirnov test. Additionally, the F-test for equality of variance was used to compare variance between the two groups.

Results

Patient Demographic Data

A total of 51 patients with a minimum 1-year follow-up were included in the study. There were 24 patients in the 2019 cohort and 27 patients in the 2020 cohort. A total of six patients were excluded from analysis due to not meeting follow-up criteria. All of the patients underwent primary ATSA. There was no significant difference in follow-up length between the 2019 and 2020 cohorts (2019: mean – 2.2 years; standard deviation [SD] – $\pm$0.60 years; 2020: mean – 2.13 years; SD – $\pm$0.46 years; $p = 0.56$). Neither was there a significant difference in patient age at the time of surgery (2019: mean – 62.9 years; SD – $\pm$10.0 years; 2020: mean – 60.3 years; SD – $\pm$10.5; $p = 0.39$).

Of the 2019 cohort, 54.2% were male patients while 48.1% of the 2020 cohort were male subjects ($p = 0.68$). The proportion of patients who received surgery on their right shoulder in 2019 was of 33.3% compared with 59.2% in 2020 ($p = 0.064$). Finally, 16.7% of patients in the 2019 cohort had a history of surgery in the affected shoulder compared with 14.8% of patients in 2020 ($p = 0.86$). Of the patients in 2019 who had received prior surgery, 1 underwent arthroscopic labral repair, 1 received arthroscopic debridement and decompression, and 2 underwent arthroscopic rotator cuff repair (RCR). From the 2020 cohort, prior surgeries included 2 arthroscopic labral repairs and 2 arthroscopic RCRs. A comparison of demographic data from each group can be found in ►**Table 1**.

Clinical Characteristics

Patients in the 2019 cohort experienced significant improvements in their ROM following ATSA. The FE was improved from 125.4° $\pm$ 31.9° to 146.7° $\pm$ 18.8° ($p = 0.008$); ER measurements improved from 33.0° $\pm$ 15.6° to 47.7° $\pm$ 12.2° ($p < 0.001$); and IR ability also improved from S1 to L4 ($p = 0.019$). Patients in the 2019 cohort also experienced significant improvements in strength for FE (5- to 5; $p = 0.031$) and ER (5- to 5; $p = 0.036$), but not IR (5 to 5; $p = 0.12$). The average time from the date of surgery to the first postoperative appointment was of 16.1 (SD: $\pm$7.9) days.

Patients in the 2020 cohort also experienced significant improvements in their ROM: FE was improved from 120.2° $\pm$ 28.8° to 141.1° $\pm$ 25.9° ($p = 0.009$); ER improved from 32.9° $\pm$ 16.5° to 42.0° $\pm$ 13.7° ($p = 0.037$); and IR improved from S1 to L3 ($p = 0.002$). Patients in the 2020 cohort did not experience significant improvements in strength for FE (5- to 5-; $p = 0.38$), ER (5- to 5-; $p = 0.29$), or IR (5 to 5; $p = 0.76$). The average time from the date of surgery to the first postoperative appointment was of 12.8 (SD: $\pm$1.6) days.

Table 1 Patient Demographic Comparison

Cohort	2019 ($n = 24$)	2020 ($n = 27$)	*p*-value
Age (years): mean $\pm$ SD	62.9 $\pm$ 10.0	60.3 $\pm$ 10.5	0.39
Follow-up (years): mean $\pm$ SD	2.2 $\pm$ 0.60	2.13 $\pm$ 0.46	0.56
Male patients (%)	54.2%	48.1%	0.68
Right shoulder (%)	33.3%	59.2%	0.064
History of surgery (%)	16.7%	14.8%	0.86

Abbreviation: SD, standard deviation.
Note: All significant *p*-values are in bold ($p < 0.05$).

Table 2 Postoperative Clinical Outcomes Comparison

Cohort	2019 ($n = 24$)	2020 ($n = 27$)	p-value
Forward elevation (°): mean ± SD	146.7 ± 18.8	141.1 ± 25.9	0.39
External rotation (°): mean ± SD	47.7 ± 12.2	42. ± 13.7	0.13
Internal rotation	L4	L3	0.42
Strength – forward elevation	5/5	5-/5	0.17
Strength – external rotation	5/5	5-/5	0.18
Strength – internal rotation	5/5	5/5	0.12

Abbreviation: SD, standard deviation.
Note: All significant p-values are in bold ($p < 0.05$).

There were no significant differences in patient ROM or strength postoperatively between the two groups. A comparison of postoperative data can be found in ►**Table 2**.

Patients in the 2 groups did not differ significantly in the time taken to initiate PT (2019: 30.5 ± 12.9 days; 2020: 31.1 ± 12.2 days; $p = 0.88$). Patients in the 2020 cohort terminated PT more quickly (2019: 125.8 ± 70.7 days; 2020: 91.1 ± 47.0 days; $p = 0.046$) and completed fewer PT sessions compared with patients in the 2019 cohort (2019: 21.4 ± 10.8 sessions; 2020: 13.1 ± 8.4 sessions; $p = 0.003$). A comparison of PT data can be found in ►**Table 3**.

Patient-Reported Outcomes and COVID-Related Delays

Of the 2020 cohort, 2 patients (7.4%) did not complete any PT after ATSA, 2 additional patients (7.4%) noted a delay in initiating PT, and 10 patients (37.0%) noted that their postoperative recovery was negatively affected by the COVID-19 pandemic. When patients were contacted by phone during October 2022, they reported an average VAS pain score of 1.67 ± 1.1, an average SANE score on the affected shoulder of 77.0 ± 15.8, and an average SANE score on the unaffected shoulder of 91.1 ± 10.4.

Complications and Revisions

There was 1 complication in the 2019 cohort, and 1 complication in the 2020 cohort ($p = 0.95$): the patient in the 2019 cohort ruptured his subscapularis and underwent revision surgery 3 months after the index procedure, and the patient from the 2020 cohort developed an infection and underwent revision surgery 11 months after their index ATSA.

Discussion

The COVID-19 pandemic has changed clinical practice throughout numerous areas, yet the effects of this recent pandemic on patients undergoing ATSA remains unclear. Prior to this pandemic, normal postoperative management following ATSA included frequent PT with an emphasis on routine therapy as a means of restoring strength, function, and quality of life.[8] In contrast to reverse shoulder replacement, protecting the subscapularis repair is critical to obtain a good outcome after ATSA. In the current retrospective, single-center study, we analyzed and compared demographic, ROM, strength, and PT data between pre-pandemic and pandemic cohorts. The most important findings suggest that despite fewer PT sessions following ATSA, ROM, strength, and SANE scores were not significantly affected by the COVID-19 pandemic. These findings suggest that patients with limited access to PT care may similarly benefit from ATSA.

The pandemic demanded various adaptations, including an increase in telehealth visits and fewer PT sessions.[5] While events such as this recently-experienced COVID-19 pandemic are unpredictable, much can be learned and translated from the adaptations and clinical responses that ensued. Pertinent to the present study, large cohorts of patients who previously had ample access to non-essential medical care were abruptly quarantined and/or unable to continue with elements of their orthopedic treatments. While this disruption was unintended, the limitations experienced may in some regards reflect those of underserved populations and limited-resource nations where PT and high-quality postoperative care may not be

Table 3 Physical Therapy Comparison

Cohort	2019 ($n = 24$)	2020 ($n = 27$)	p-value
Time from surgery to first session (days): mean ± SD	30.5 ± 12.9	31.1 ± 12.2	0.88
Time from first session to last session (days): mean ± SD	125.8 ± 70.7	91.1 ± 47.0	**0.046**
Number of sessions: mean ± SD	21.4 ± 10.8	13.1 ± 8.4	**0.003**

Abbreviation: SD, standard deviation.
Note: All significant p-values are in bold ($p < 0.05$).

routinely available.[9] As previously discussed, the objective of the present study was to investigate whether interruptions and delays in PT from the COVID-19 pandemic led to poorer outcomes following ATSA.

Parisien et al.[10] and Sabbagh et al.[5] were among the first authors to assess the utilization and impact of telehealth driven by the COVID-19 pandemic among orthopedic surgery patients. They observed significant telehealth utilization and no difference in patient satisfaction and PROMs compared with traditional in-person clinic follow-ups. Seetharam et al.[6] identified an increased number of outpatient TSAs at their institution during the pandemic, with a significant reduction in length of stay and 90-day readmission rate. Another study[4] looking at TSA covered by Medicare found an overall decrease in shoulder arthroplasty volume by 14% during the COVID-19 pandemic, with an average hospital stay decreasing by 16%, and no significant change in 30-day hospital readmission rates.

Secondary to mandated lockdowns and clinical judgment, numerous patients experienced limited access to their routine PT care. Wang et al.[9] reported similar findings, in which the COVID-19 shutdown decreased the availability of elective care. Similar to these findings, among our 2020 cohort, the COVID-19 pandemic led to earlier termination of PT and fewer overall PT sessions, culminating in 37% of patients citing the pandemic as a negative influence on their recovery following ATSA.

Historically, PT has been foundational in the perioperative restoration of strength and ROM.[11,12] Among our patients, strength and ROM favorably improved in both the 2019 and 2020 cohorts. Patients in 2019 and 2020 experienced comparable improvements in FE, ER and IR ROM. Regarding strength, patients in 2019 experienced significant improvements in FE and ER, but not IR. Notably, patients in 2020 did not experience significant improvements in FE, ER, or IR. These findings suggest that PT may be required to ensure adequate postoperative strength recovery, yet ROM may be restored similarly without PT. With decreased access to PT, our patients exhibited a similar ROM improvement and diminished strength recovery.

To further delineate these changes in strength and to continue quantifying the effects of the pandemic on ATSA, the SANE and VAS scores, as well as the PROMs, were obtained from the 2020 cohort. We found that 2 patients (7.4%) did not complete any PT, and 2 additional patients (7.4%) noted a delay in initiating their PT. A total of 10 patients (37.0%) noted that their postoperative recovery was negatively affected by the COVID-19 pandemic. When patients were contacted by phone during October 2022, they reported an average VAS pain score of 1.67, a SANE score on the affected shoulder of 77.0, and a SANE score on the unaffected shoulder of 91.1. The current literature estimates that the patient acceptable symptomatic state (PASS) for ATSA to be 75.5 for the SANE score and 1.5 for the VAS pain score.[12,13] Patients in our 2020 cohort approached or exceeded these benchmarks 2.5 years after surgery, suggesting that even patients with limited access to PT may still go on to achieve clinical significant improvements.

As there are many factors that influence patient recovery after surgery, it is difficult to say with certainty how much PT is required for patients to achieve satisfactory results. However, from our small cohort, we observed that patients who met criteria for acceptable improvement completed an average of 16.3 ± 7.2 PT sessions. This approximation was made by comparing our patients' improvement in FE ROM to the minimal clinically-important difference (MCID) of $23.1° \pm 5.8°$ established by Simovitch et al.[14] and by calculating the number of sessions completed by those who exceeded the MCID threshold.

In summary, despite less PT and the perceived negative effect of the pandemic shutdowns, ATSA patients in 2020 demonstrated similar clinical and physical therapy outcomes when compared with a similar cohort of 2019 patients at our institution, aside from diminished strength recovery.

Limitations

The present study has numerous limitations to address. Inherent to the design of this retrospective study, there is institutional selection and treatment bias that may be observed in the presented findings. Despite this limitation, best clinical practice recommendations were followed, and all orthopedic care was underseen by fellowship-trained surgeons from one academic medical center. Further, the present study is limited in its sample size and selection bias, which further limits the statistical power and generalizability of the presented observations. Finally, PT protocols may vary greatly across institutions, and this may influence the lack of observed difference between cohorts.

Conclusion

The COVID-19 pandemic shutdowns led to many changes in postoperative management of ATSA patients. As a whole, patients in the 2020 cohort ended PT more quickly and completely fewer sessions, with 37% stating that their recovery was adversely affected by the pandemic. Despite these setbacks, patients in the cohort still obtained satisfactory outcomes in ROM, SANE, and VAS pain scores. These findings suggest that patients who have limited access to PT may still go on to achieve acceptable results following ATSA.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Effects of Biomimetic Shoes on Healthy Young Children's Gait

Efeitos do uso de calçado biomimético na marcha de crianças típicas

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Abstract

Objective To compare the spatial-temporal parameters and walking kinematics of toddlers wearing biomimetic shoes, regular shoes (daily use owned shoes), and barefoot.

Methods Spatial-temporal parameters (speed, step length, and stride width), the mean vertical displacement of the center of mass (COM), knee flexion peak, and maximal foot height were analyzed.

Results Children were not different in biomimetic shoes and barefoot conditions on speed, step length, and COM vertical displacement. There was no difference among conditions on stride width and foot height. The knee flexion peak was greater in shod conditions than barefoot. The regular shoes showed greater COM vertical displacement than biomimetic shoes and barefoot.

Conclusion The findings showed that shoes affected the walking pattern in young children, but a shoe with a biomimetic design had a lesser effect on the walking pattern.

Keywords
- biomechanics
- biomimetics
- child
- gait
- infant
- shoes
- walking

Resumo

Objetivo O objetivo deste trabalho foi comparar os parâmetros espaço temporais e cinemáticos da marcha de crianças típicas em três condições: descalças, usando calçados biomiméticos e, calçados de uso diário (não biomiméticos - próprios das crianças).

Métodos Foram analisadas variáveis espaço temporais (velocidade, comprimento e largura da passada), deslocamento vertical do centro de massa (CM), pico de flexão do joelho e altura máxima do pé, coletados via avaliação tridimensional do movimento.

Resultados Comparado com a condição descalça, o uso do calçado biomimético não foi estatisticamente diferente em relação a velocidade da marcha, comprimento da passada e altura do pé. A largura da passada e a altura do pé não foi diferente estatisticamente entre as

Palavras-chave
- biomecânica
- biomimético
- caminhada
- criança
- lactente
- marcha
- sapatos

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condições estudadas. O pico de flexão do joelho foi maior nas condições com calçados comparado a condição descalça. Os calçados de uso diário apresentaram maior deslocamento vertical do COM do que nas condições com o calçado biomimético e descalço.
Conclusão: Os achados deste trabalho reafirmam que o uso do calçado influencia a marcha de crianças, ainda mais na fase de desenvolvimento da marcha mas, que calçados com um design biomimético tem menores impactos no padrão de marcha das crianças.

Introduction

Shoes are the primary interface between the body and the ground. They contribute to how ground reaction forces are applied to the foot and transferred to the entire body.[1,2] The effect of shoes on young children's gait is poorly understood.[3] The walking alone developmental landmark happens in toddlers, on average, around twelve months.[4] It is a new experience since they almost had never practiced the dynamic bipedal and unipedal stances necessary to master walking.[5] Furthermore, the gait pattern adopted by young children differs from adults due to anthropometrics (e.g., body mass distribution) and continuous refinements characteristic of task development.[6] The unique characteristics of young children's gait contribute to the importance of external elements, such as shoes, in developing this critical motor benchmark.[7]

Clothing, footwear, and different terrains influence children's movements but are rarely reported in research studies.[8] Urban life establishes mandatory requirements for shoes to comply with social and safety rules. The primary role of shoes is to protect the toddler's foot from injury due to rough or uneven surfaces, excessive impact, and cold and wet environments.[8–10] Shoes provide many benefits but also have disadvantages[11] It has been suggested that optimum foot development occurs in the barefoot environment.[8–10] Therefore, children's shoe designs should provide an experience similar to the barefoot condition, considering shock absorption and load distribution.[10,12]

Walking barefoot develops foot muscle strength and mobility and contributes to the variability in the medial plantar arch.[9,13] Moving around in nature often involves walking on a soft substratum such as sand, affecting locomotion mechanics and energy.[14] Walking in the real world involves negotiating challenges over uneven surfaces, requiring constant adjustments of the body's movement pattern to maintain stability. Michael et al.[15] stated that anatomically shaped shoes permit biologically normal structure and foot function. Taking inspiration from a natural design (i.e., biomimetism), a commercially available shoe for children at a young age used sand as a model to develop its midsole through polymers to simulate walking over a soft substratum. As a nature-inspired design, this shoe claims to respect the morphology of the toddler's feet (rounded forefoot) and provide better conditions for foot development.[16]

This study investigated whether using biomimetic shoes affects young children's walking patterns. More specifically, this study aimed to compare the spatial-temporal parameters and walking kinematics of toddlers wearing biomimetic shoes, regular shoes (daily use owned shoes), and barefoot. This work hypothesized that walking with biomimetic shoes would have a similar pattern to the barefoot condition than regular shoes.

Methods

Study Design and Participants

This experimental study was a cross-sectional, repeated measures trial. Twenty typically developing children (1 to 3 years old) participated in this study. The sample was recruited based on a convenience sampling method with the help of the universitýs students and local community members. The inclusion criteria were children full term of birth, typically developed without prior history of significant medical issues, capable of independent walking (i.e., walking without support), and foot size between 10 to 16.6 cm. The exclusion criteria were children over 3 years old, complaining of any pain during gait, using any systematic neurologic medication, and unable to complete the entire measurement setup. Informed consent was obtained from all the parents, and the procedures were approved by the University's Ethics Review Committee (66806317.1.0000.5149).

Procedures

The laboratory settings and the experimental procedures were adapted to offer a comfortable environment to the children. Before gait recording, one parent initially held the child by the hand to explore the environment and get used to it. Lower limb kinematic data were acquired based on 13 retro-reflective markers (diameter of 8 mm) placed on the sacrum, femoral greater trochanters, lateral femoral epicondyles, lateral malleoli, calcaneal tuberosities, first and fifth metatarsal heads (►**Fig. 1**). Bilateral lower limb kinematics were collected to consider functional asymmetries described in previous studies in healthy toddlers.[5] Mainly lateral markers were used since pilot tests showed that the medial markers frequently fall, thus needing re-attachment during the assessment. The data were collected during gait using Qualisys ProReflex MCU motion analysis system (QUALISYS MEDICAL AB®, Gothenburg, Switzerland) at a sample rate of 120 Hz. A flowchart showing from data collection to the kinematic analysis is shown in ►**Fig. 2**. Children walked in three randomized testing conditions: barefoot, biomimetic shoe (►**Fig. 3** - Noeh®, www.noeh.com.br, Noeh Baby, Brazil), and regular shoe (daily use owned footwear – ►**Fig. 4**). The barefoot condition was collected as the baseline assessment of gait parameters to compare with the shod

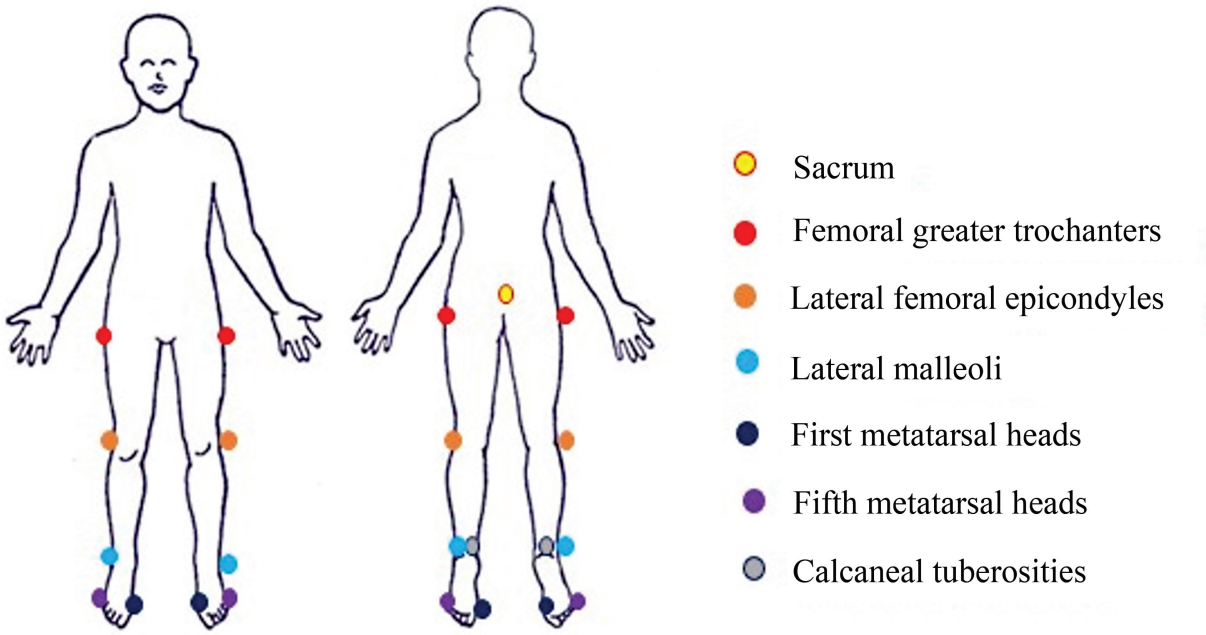


Fig. 1 Marker setup protocol used to collect spatial-temporal and kinematic parameters.

conditions. The biomimetic shoe (►**Fig. 3**) presents a biomimetic design with a dynamic midsole, as described by Lage (2014). Besides, no children were familiarized with this biomimetic shoe before data collection. The shoe size was checked a priori to ensure the appropriate fit. For the regular shoes (►**Fig. 4**), the parents were asked to bring the most comfortable and daily used covered shoes apart from flip flops or open sandals.All children wore only disposable diapers for the data acquisition. Each participant walked around ten trials in each experimental condition.

During data recording, the children were encouraged to walk toward a parent or researcher at a self-selected speed. Children walked over a raised platform (10 cm high), and all procedures were performed by the same experienced examiner and three trained scientific assistants. A person responsible for the child and one research staff remained alongside the children to prevent them from falling.

Data Analysis

Data files were tracked using Qualisys Track Manager Software (QUALISYS MEDICAL AB®, Gothenburg, Switzerland). Kinematic data were exported to be processed under Visual3D software (C-Motion, Inc., Rockville, USA). Raw data were initially filtered using a lowpass, fourth-order Butterworth filter with a cut-off of 6 Hz. The following limb segments were defined as stick figures (►**Fig. 5**): pelvis (a line connecting from the sacrum marker to the femoral greater trochanter marker), thigh (a line connecting from femoral great trochanter marker to the lateral femoral epicondyle marker), shank (a line connecting from lateral femoral epicondyle to lateral malleolus marker), and foot (a line connecting from calcaneal tuberosity marker to the medium point between first and fifth metatarsal heads). The events necessary to define the gait cycle were created based on the method adapted for toddlers by Ivanenko et al.[17] Briefly, the elevation angle (α in ►**Fig. 5**) of each limb corresponds to the angle between the main limb axis and the vertical (z). Initial contact and foot-off were determined with the higher and lower elevation angle values, respectively. Furthermore, all events were visually checked individually, and adjustments were made when necessary.

Thirty to forty gait cycles from each subject were chosen for analysis. Each gait cycle was normalized to 100% (initial contact to the following initial contact). The following spatial-temporal parameters were extracted: walking speed, step length, and stride width. Also, the mean vertical displacement of the body's center of mass (COM)[18] was calculated based on the retro-reflective marker placed on the sacrum. Studies showed that this marker could essentially estimate the vertical displacement of the COM.[18] Finally, the following variables related to the elevation of the foot from the ground were calculated: the knee flexion peak[19,20] and maximal foot height during the swing phase. The maximal foot height was considered the maximum peak of vertical displacement of the foot́s center of mass.

Statistical Analysis

The assumptions of normality and homogeneity of variance were confirmed before running the inferential tests. A one-way repeated-measures analysis of variance (ANOVA) was used to investigate the effect of condition (barefoot, biomimetic shoes, and regular shoes) on speed, stride width, and mean vertical displacement of COM. A two-way repeated-measures ANOVA was used to investigate the effect of the condition and the side (right and left) on step length, knee flexion peak, and maximal foot height. A *post hoc* test was performed to identify pairwise differences when the ANOVA

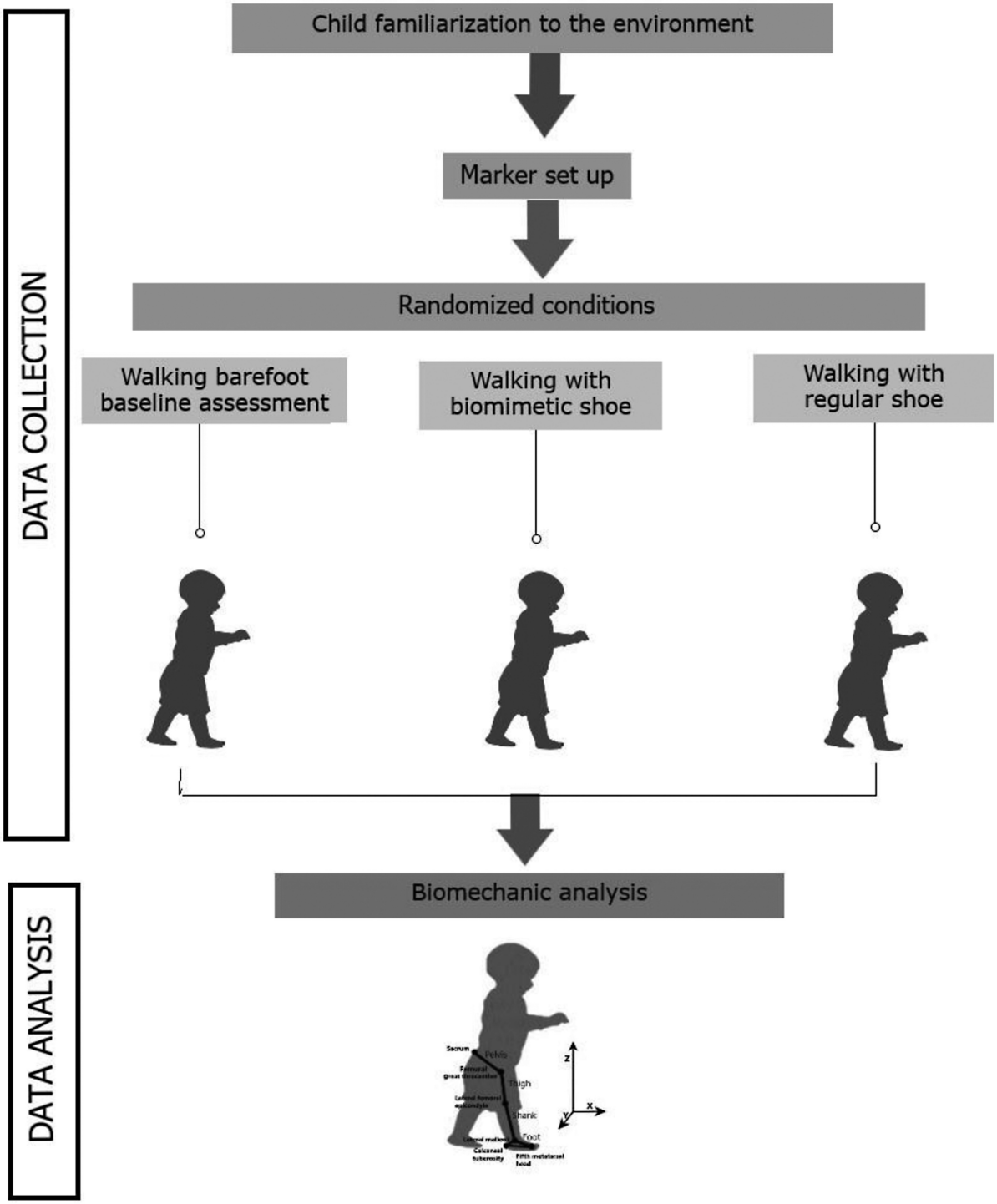


Fig. 2 Flowchart showing from data collection to data analysis: i) child was familiarized with the biomechanical collection environment; ii) passive markers protocol was applied to anatomical landmarkers; iii) child was oriented to walk in three randomized conditions (barefoot, biomimetic shoes and regular shoes); iv) biomechanical analysis.

identified a significant main effect. A type I error probability of 0.05 was considered for all the analyses. Cohen's *f* and *dz* effect size was calculated and interpreted as follows: small ($f = 0.10$ and $dz = 0.20$), medium ($f = 0.25$ and $dz = 0.50$), and large ($f = 0.40$ and $dz = 0.80$) (Cohen, 1969). Statistical analysis was performed using IBM SPSS Statistics 22.0 (IBM Corp., Armonk, NY, USA).

Results

►**Table 1** shows descriptive data, p-values, effect sizes, and statistical power of the inferential statistics for spatial-temporal and kinematics parameters. Initially, twenty children were recruited; however, nineteen children's data (52% of girls, age: 14.8 ± 2.0 months, body mass: 10.23 ± 1.19 kg,

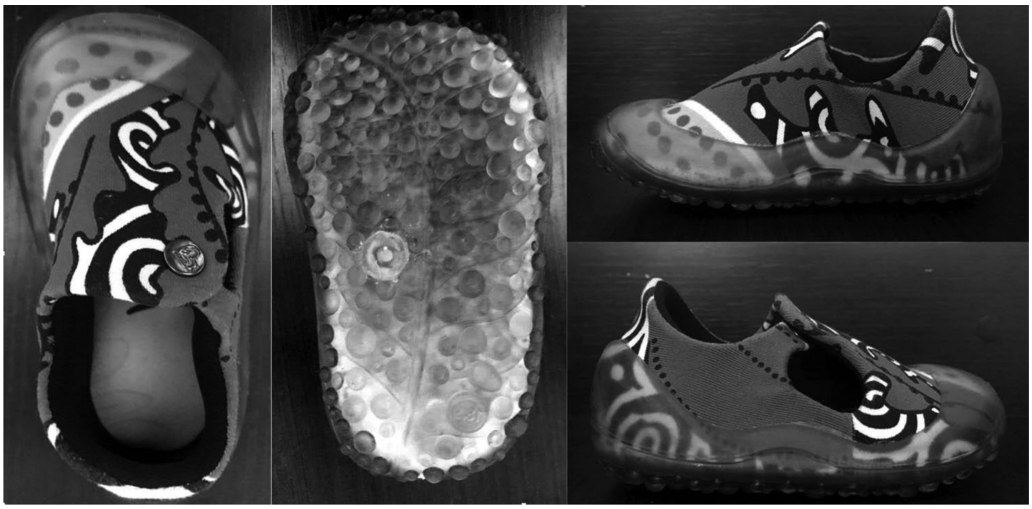


Fig. 3 The biomimetic shoe. Images from left to right show the shoe's up, down, medial side, and lateral side views.



Fig. 4 Image with two exemplars of daily used regular shoes.

and height: 0.77 ± 0.04 m) were analyzed. They all had more than one month of walking alone experience. One toddler was excluded since the child refused to perform one of the investigated conditions. Besides, one child presented knee angle data of only one side at the regular shoe condition due to missing data on the other side. All children came with a regular, daily use shoe: all flat shoes (no heel height): 33.3% wearing shoes, as illustrated in ►**Fig. 4** (right), and 66,6% with shoes, as shown in ►**Fig. 4** (left).

Spatial-temporal Parameters

Speed was different among conditions (►**Table 1**). *Post hoc* analysis showed that children walked slower when using

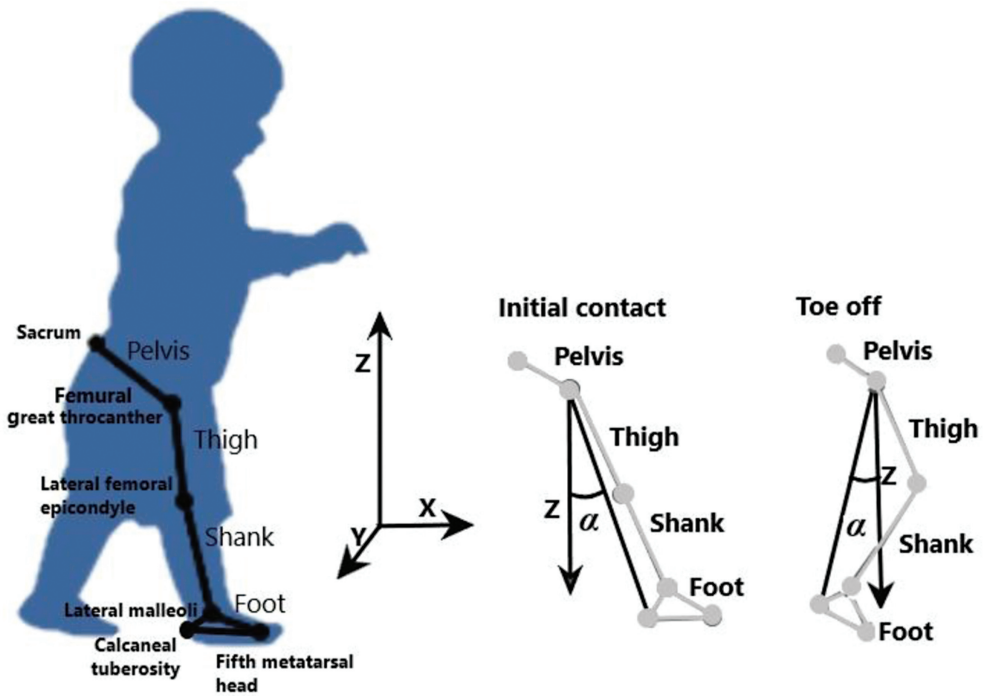


Fig. 5 Anatomical markers used to model lower limb body segments: pelvis, thigh, shank, and foot. Elevation angles (α) were computed relative main limb axis (from femoral great trochanter to calcaneal tuberosity) and vertical (Z). Initial contact was determined as the highest elevation angle (α) and foot-off as the lowest elevation angle (α).

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Table 1 Descriptive and inferential statistics of spatiotemporal and kinematics variables ($n = 19$)

Variable	Descriptive statistics – Mean (SD)						ANOVA			*Post hoc* – Condition Main Effect		
	Biomimetic shoe		Barefoot		Regular shoe		Main effect		Interaction effects	Biomimetic shoe X Barefoot	Biomimetic shoe X Regular shoe	Barefoot X Regular shoe
	Right	Left	Right	Left	Right	Left	Condition	Side				
Spatial-temporal parameters												
Speed (*m/s*)	0.59 (0.20)		0.63 (0.21)		0.69 (0.24)		$p = 0.05^*$ F (2,36) = 3.21 $f = 0.42$ Power = 0.58			$p = 0.28$ t (18) = -1.12 $dz = 0.26$ Power = 0.18	$p = 0.02^*$ t (18) = -2.52 $dz = 0.58$ Power = 0.66	$p = 0.19$ t (18) = -1.37 $dz = 0.31$ Power = 0.25
Step length (*m*)	0.23 (0.05)	0.21 (0.06)	0.22 (0.05)	0.22 (0.05)	0.24 (0.06)	0.24 (0.06)	$p = 0.04^*$ F (2,36) = 3.58 $f = 0.45$ Power = 0.63	$p = 0.35$ F (1,18) = 0.92 $f = 0.23$ Power = 0.15	$p = 0.06$ F (2,36) = 3.08 $f = 0.42$ Power = 0.56	$p = 0.96$ t (18) = -0.06 $dz = 0.01$ Power = 0.05	$p = 0.02^*$ t (18) = -2.49 $dz = 0.57$ Power = 0.65	$p = 0.06$ t (18) = -1.98 $dz = 0.45$ Power = 0.47
Stride width (*m*)	0.11 (0.03)		0.11 (0.02)		0.11 (0.02)		$p = 0.71$ F (2,36) = 0.34 $f = 0.14$ Power = 0.10					
Kinematic parameters												
COM mean vertical displacement (*m*)	0.016 (0.006)		0.016 (0.006)		0.019 (0.006)		$p = 0.02^*$ F (2,36) = 4.13 $f = 0.48$ Power = 0.69			$p = 0.82$ t (18) = -0.23 $dz = 0.05$ Power = 0.06	$p = 0.01^*$ t (18) = -2.99 $dz = 0.68$ Power = 0.81	$p = 0.05^*$ t (18) = -2.06 $dz = 0.47$ Power = 0.50
Knee flexion peak (°)	76.5 (9.4)	71.1 (9.0)	71.0 (11.0)	67.5 (9.2)	75.0 (9.1)	75.1 (13.8)	$p = 0.01^*$ F (1.5,34) = 6.48 $f = 0.62$ Power = 0.80	$p = 0.06$ F (1,17) = 3.92 $f = 0.48$ Power = 0.46	$p = 0.19$ F (1.3,34) = 1.73 $f = 0.31$ Power = 0.27	$p < 0.01^*$ t (18) = 3.92 $dz = 0.90$ Power = 0.96	$p = 0.48$ t (17) = -0.73 $dz = 0.17$ Power = 0.10	$p = 0.01^*$ t (17) = -2.81 $dz = 0.66$ Power = 0.73
Maximal foot height (*m*)	0.098 (0.017)	0.096 (0.017)	0.089 (0.014)	0.089 (0.013)	0.093 (0.019)	0.092 (0.018)	$p = 0.07$ F (2,36) = 2.85 $f = 0.40$ Power = 0.52	$p = 0.41$ F (1,18) = 0.72 $f = 0.20$ Power = 0.13	$p = 0.87$ F (2,36) = 0.15 $f = 0.10$ Power = 0.07			

Note: SD = Standard deviation; COM = Center of mass, * = p £ 0.05; F (x,y) = F statistic (degrees of freedom), f = Cohen's f effect size, dz = Cohen's dz effect size.

biomimetic shoes than regular shoes. Biomimetic and regular shoe conditions were not different from barefoot.

Step length was also different among conditions (►**Table 1**). *Post hoc* analysis showed that children presented a shorter step length using biomimetic shoes than regular shoes. There was no difference in step length between shod conditions and barefoot. Also, there was no difference between right and left step lengths and interaction effect between condition and side.

Stride width was not different among conditions (►**Table 1**).

Kinematic Parameters

The mean vertical displacement of COM was greater in the regular shoe condition than in barefoot and biomimetic shoe conditions (►**Table 1**). Besides, this variable did not present a statistical difference between biomimetic shoe and barefoot conditions.

Knee flexion peak was also different among conditions. *Post hoc* analysis showed that shod conditions had a greater knee flexion peak than barefoot. This variable was not different between shod conditions. Also, there was no difference between right and left knee flexion peaks and interaction effect between condition and side.

The maximal foot height during the swing phase was not different among conditions, between sides, and there was no interaction between condition and side.

Discussion

The major finding of this study was that biomimetic-designed shoes have a smaller impact than regular shoes on spatial-temporal parameters and walking kinematics in healthy young children. This study compared the walking characteristics of young children in three conditions: biomimetic shoes, daily used regular shoes, and barefoot. There is limited and fair quality evidence that children's footwear alters biomechanical gait parameters.[20,21] The current work indicated that biomimetic-designed shoes have a minor impact on younger children's walking patterns, and it is similar to barefoot walking.

As a global walking measure, spatial-temporal parameters can provide insight into the differences among the three walking conditions. Significant differences with a large effect size were found among conditions in walking speed and step length. Previous studies reported that shod walking results in increased walking speed compared to barefoot.[2,22] On the other hand, others did not find this difference.[3,7,20,23] In the current study, the gait speed with the biomimetic shoe was not different from barefoot; however, the biomimetic condition differed from the regular shoe condition. The biomimetic midsole provides an irregular contact surface to the plantar foot region. This challenge may have contributed to reducing children's gait speed. Shkuratova et al.[24] described that slower walking speed might improve walking stability. When walking speed was directly manipulated in younger adults, slower speeds decreased local dynamic instability, despite increased variability.[24] Thus, reducing velocity could be an adaptation for the children to improve walking stability when using non-usual shoes that provide a softer contact surface for their feet.

Step length was longer in regular shoes compared with biomimetic shoes.The longer step length when wearing regular shoes agrees with the previous studies.[2,10,20,22,23] However, using a biomimetic shoe was not different from being barefoot. Furthermore, the mean vertical displacement of COM was also not affected by the biomimetic shoe compared to barefoot. The COM motion during gait can represent a summary indicator of the movement of the whole-body system.[25,26] This behavior can provide general information about the mechanics of walking concerning energy expenditure and mechanical efficiency. Our results indicated that the mean vertical displacement of COM with regular shoes was greater than the other two conditions. This result could be related to the higher velocity[26,27] in regular shoe condition, also presented in our data. Besides, this COM behavior difference may contribute to a higher metabolic cost of walking[28] with regular shoes than with biomimetic shoes and barefoot.

The knee flexion peak differed between shod conditions and barefoot (large effect size). Our results follow the literature[2] since a slight increase in the knee flexion peak was observed in the shod conditions compared to the barefoot condition. This change could be attributed to the added weight related to the shoes. Increased weight of shoes distally may increase knee flexion during the gait. Dominici et al.[29] concluded that a higher foot lift could be a safe, simple strategy for avoiding potential stumbling and falls and reducing the effect of involuntary foot drag and reduced dorsiflexion activity.

To our knowledge, no study investigated the impact of biomimetic-designed footwear on children. The current study did not track body segments three-dimensionally, limiting the results. Three-dimensional tracking requires more retro-reflective markers attached to children. During the pilot study, we found that some children do not tolerate multiple markers attached to their bodies. Besides, the anatomical markers used to define foot segment were placed over the shoes and not directly on the foot skin. Another limitation was that the participants used different regular shoes. Since they chose the most usual and comfortable, the characteristics of regular shoes differed across all participants. Moreover, the findings of this study were the result of short-term use. Thus, our research did not consider biomimetic shoes' impact on long-term management. Further research on biomimetic shoe design wearing for long periods could enhance understanding of this footwear effect.

Conclusion

The present study showed that biomimetic shoes' use resulted in speed, step length, stride width, and COM vertical displacement not different from barefoot walking in young children during gait onset. The knee flexion peak was affected by the biomimetic shoes like the regular shoes. The regular shoes resulted in greater COM vertical

displacement than biomimetic shoes and barefoot. Therefore, the biomimetic shoe design may provide a walking experience similar to barefoot, with less impact on the walking pattern.

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Conflict of Interests
Liria Akie Okai-Nóbrega and Ana Paula Lage work at Anamê Science and Technology in Child Health Products. The others authors do not have conflicts of interest.
Dr. Lage reports grants from Inovation award SESI/SENAI , during the conduct of the study; In addition, Dr. Lage has a patent Dynamic Insole (Brazil) pending, and a patent Biomimetic Shoe (Brazil, USA, India, Japan, UE) pending.

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Stoppa Intrapelvic Approach Provides Good Functional Clinical Outcomes: Prospective Study with a Minimum Follow-up of One Year and Comparison with the Literature

Acesso intrapélvico de Stoppa proporciona bons resultados clínicos funcionais: Estudo prospectivo com seguimento mínimo de um ano e comparação com a literatura

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Abstract

Objective To describe the clinical and radiographic outcomes of a cohort of patients with acetabular fractures treated with the modified Stoppa approach.

Methods We conducted a prospective analysis of adult patients with acetabular fractures treated using the modified Stoppa approach from June 2020 to June 2021, with a minimum follow-up period of 12 months. The analysis included demographic, epidemiological, and perioperative data, as well as postoperative radiographic and functional outcomes.

Results The study included 15 cases, with 14 men (93.3%) and 1 woman (6.67%). A postoperative tomographic evaluation revealed an anatomical reduction in 50%, an imperfect reduction in 13.6%, and a poor reduction in 36.4% of the subjects. Regarding the functional scores, the Harris Hip Score ranged from 56 to 100, with a mean value of 92.5. The Majeed Pelvic Score classified the functional outcome as excellent in 36.5%, good in 40.6%, moderate in 18.7%, and poor in 4.2% of the cases.

Conclusion The present case series study demonstrated positive statistical relevance between reduction quality and functional outcomes and between the time until surgery and the reduction quality. The functional outcomes at a one-year of follow-up demonstrate that this approach can be an excellent alternative for anterior acetabulum fractures.

Keywords
- acetabulum
- fracture fixation
- pelvis approach
- Stoppa

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Resumo

Objetivo Descrever os resultados clínicos e radiográficos de uma coorte de pacientes com fraturas de acetábulo tratados com o acesso de Stoppa modificado.

Métodos Foi realizada uma análise prospectiva de pacientes adultos com fraturas de acetábulo tratados pela via de Stoppa modificada de junho de 2020 a junho de 2021 e com seguimento mínimo de 12 meses. Foram analisados dados demográficos, epidemiológicos, perioperatórios e resultados radiográficos e funcionais pós-operatórios.

Resultados Foram estudados 15 casos, sendo 14 homens (93,3%) e 1 mulher (6,67%). Na avaliação tomográfica pós-operatória, redução anatômica foi observada em 50% dos casos, imperfeita, em 13,6%, e ruim, em 36,4%.

Nos escores funcionais, encontramos uma variação de 56 a 100, com média de 92,5 no Harris Hip Score. No Majeed Pelvic Score, o resultado funcional foi excelente em 36,5% dos casos, bom, em 40,6%, moderado, em 18,7%, e ruim, em 4,2%.

Conclusão O estudo da série de casos demonstrou relevância estatística positiva entre a qualidade da redução e os desfechos funcionais, assim como entre o tempo até a cirurgia e a qualidade da redução. Os resultados funcionais no seguimento de um ano demonstram que o uso dessa via pode ser uma excelente alternativa para as fraturas anteriores do acetábulo.

Palavras-chave

- abordagem pélvica
- acetábulo
- fixação de fratura
- Stoppa

Introduction

Since the study by Judet et al.[1] in the 1960s, with evidence later reinforced by Letournel and Judet[2] and Matta,[3] the fundamental principle for acetabular fracture treatment is its anatomical reduction with stable fixation, resulting in better short- and long-term functional outcomes.[1,3,4] Open reduction with internal fixation is the gold standard treatment.[5,6] Success largely depends on adequate exposure of the fracture focus[7,8] for better reduction and subsequent positioning of the synthesis materials.

Assessing alternative approaches, Cole and Bolhofner[9] and Hirvensalo et al.[10] developed[5,7,11,12] an intrapelvic route to assure a wide approach to the true pelvis.[5,7–9,13] After its development, the authors found similarities in the method proposed by Stoppa et al.[14] in 1984 to manage complicated inguinal hernias.[9,12] This method enables direct visualization of the acetabulum, including the quadrilateral lamina,[4–6,8] the body of the pubis, the superior ramus, the pubic root, and the medial aspect of the posterior and anterior columns of the sacroiliac joint.[5,7,8] This exposure also enables plate configurations not feasible with traditional approaches[7,9] (such as the infrapectineal plate[11]). However, this method may entail complications, such as obturator nerve damage, corona mortis, rectus abdominis atrophy, and peritoneal injury.[4,7]

Today, the modified Stoppa approach may be an alternative to manage anterior acetabular fractures. Even with broad visualization of the true pelvis, 60% to 83%[6] of the cases may require a combination with other approaches for adequate reduction and fixation of some types of fracture,[6,7,12] including the lateral window ilioinguinal[6,7] and the Kocher-Langenbeck approaches.[6,8]

The present study aimed to describe the clinical and radiographic outcomes of a cohort of patients with acetabular fractures treated with the modified Stoppa approach.

Materials and Methods

The institutional Ethics in Research Committee analyzed and approved the design of the present study under number CAAE 52764821.4.0000.5225. The prospective analysis included data from patients with acetabular fractures who underwent open reduction and internal fixation (ORIF) using the modified Stoppa approach in a university hospital from June 2020 to June 2021. The inclusion criteria were subjects over 18 years old with a minimum postoperative follow-up period of 12 months. The exclusion criteria were cases of osteoporotic/pathological fractures.

We selected the modified Stoppa approach for cases with acetabular anterior column involvement, either isolated or in combined fracture patterns. Thus, according to the Letournel and Judet classification,[2] fractures of the following types were included: anterior column, transverse, anterior column with posterior hemitransverse, T-shaped, and double-column fracture. For transverse fractures, we chose the anterior approach when the anterior column presented a higher deviation than the posterior column.

The data collected during the study included gender; age; trauma mechanism; preoperative Letournel[15] classification; postoperative reduction quality per the Matta criteria[3] (evaluated by two orthopedic doctors specialized in hips), through radiographs and computed tomography (CT) scans; days from admission to definitive approach; surgical time; blood loss; need for transfusion; other concomitant approaches; associated injuries; and peri- and postoperative

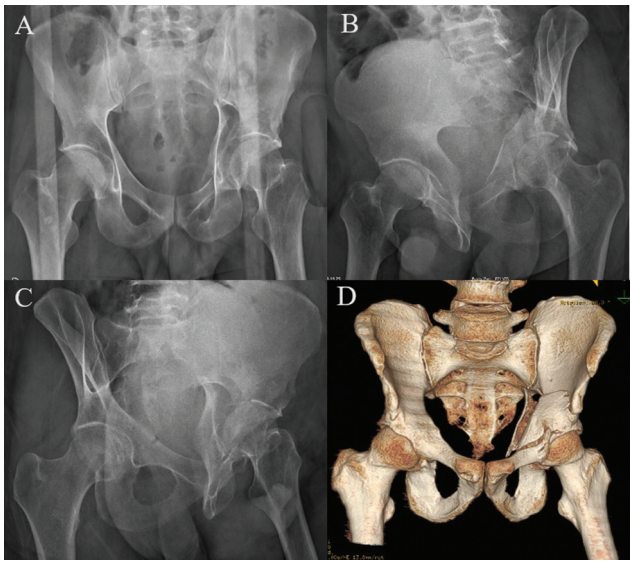


Fig. 1 (**A**) Anteroposterior (AP) radiograph. (**B**) Obturator oblique radiograph. (**C**) Alar radiograph. (**D**) Three-dimensional (3D) computed tomography showing double column fracture of the left acetabulum.

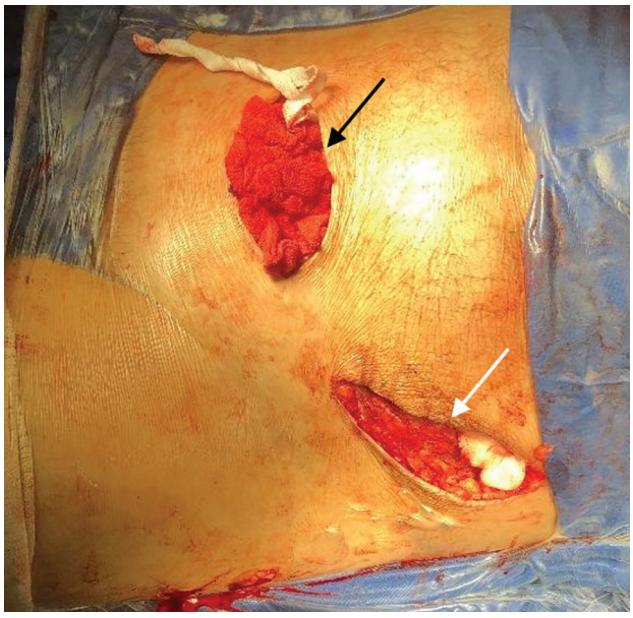


Fig. 2 Appearance of the approaches used in the study. **Black arrow:** Modified Stoppa approach. **White arrow:** Ilioinguinal lateral window.

complications. The categories of the Matta[3] classification were the following: 1 (anatomical reduction), 2 (imperfect reduction, ranging from 1 mm to 3 mm), and 3 (poor reduction, greater than 3 mm). The patients answered functional questionnaires at one year of outpatient follow-up: the modified Harris Hip Score (HHS) and the Majeed Pelvic Score (MPS).

The routine preoperative and postoperative examinations included pelvic radiographs in anteroposterior and Judet views, axial CT of the pelvis with three-dimensional reconstruction, and laboratory tests (►**Fig. 1**) In the surgical center, we always perform trichotomy and image checking with fluoroscopy on a radiolucent table before starting the procedure. We prepared the entire lower limb on the affected side to have free mobility for flexion and traction to assist in reduction maneuvers during surgery. The modified Stoppa approach was always the first to be performed. Other approaches were performed sequentially during the procedure according to need and preoperative planning (►**Fig. 2**).

Motor physical therapy started early with free range of motion. Next, the authors instructed the patients to only bear the proprioceptive load on the affected limb aided by a walker. Sequential outpatient return for weight progression occurred at 2 weeks, 8 weeks, 4 months, 6 months, and 1 year postoperatively.

The collected data were tabulated and statistically analyzed using the Pearson correlation coefficient for normally distributed continuous variables (confirmed by the Shapiro-Wilk test; p-value > 0.05) and Kendall tau correlations for other variables for inferences.

Results

After applying the inclusion and exclusion criteria, 15 cases were analyzed, including 14 men (93.3%) and 1 woman (6.67%). ►**Table 1** shows the age, operative time, and days until surgery. ►**Fig. 3** shows the frequency of fractures according to the Letorunel and Judet[2] classification.

The postoperative tomographic evaluation revealed an anatomical reduction in 50%, an imperfect reduction in 13.6%, and a poor reduction in 36.4% of the subjects. Regarding the functional scores, the HHS ranged from 56 to 100, with a mean value of 92.5. The MPS classified the functional outcome as excellent in 36.5%, good in 40.6%, moderate in 18.7%, and poor in 4.2% of the cases.

The correlation regarding time from admission to definitive surgery and reduction quality was statistically significant. The MPS and HHS positively correlated with reduction quality (►**Table 2**).

Of the 15 cases, some presented postoperative complications: 4 had obturator nerve praxis, and 1 had lateral

Table 1 Case profile

	Mean	Standard deviation	Minimum value	Maximum value
Age (years)	35.4	±11.879	20	55
Surgical time (minutes)	221	±77.78	90	390
Days until surgery	11.067	±8.093	4	33

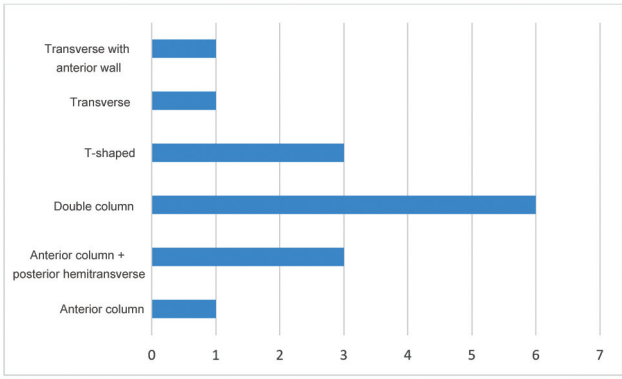


Fig. 3 Frequency of fractures according to the Letournel classification.

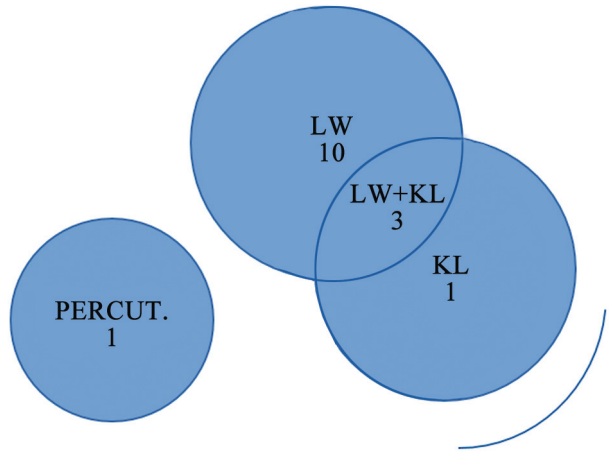


Fig. 4 Associated approaches.

cutaneous nerve praxis, which resolved during follow-up. In addition, there were four surgical site infections (one using the modified Stoppa approach, later progressing to septic arthritis), one corona mortis injury (requiring a joint approach with the service's vascular surgery team at the same operative time), and a case of late complication with incisional hernia. Soni et al.[16] reported obturator nerve injury as the most frequent complication, with complete resolution in 95% of THE cases within 3 to 6 months. Among late complications, osteoarthritis was the most common. In the present series, 27.7% of the patients presented obturator nerve praxis, all resolving completely during the 1-year follow-up.

In total, 13 out of the 15 cases required a lateral window, and 4, a Kocher-Langenbeck approach (including 3 associated with a lateral window). One case used a percutaneous approach (►**Fig. 4**). Most studies reported treatment with a single Stoppa approach in most cases. Guo et al.[8] used a single Stoppa approach in 59% of the patients and the Stoppa plus the posterior Kocher Langenbeck approach in 40% of the patients.

The estimated procedural average bleeding was of 1,411 mL (range: 400 mL to 3,525 mL), consistent with the average value of 1,376 mL reported by Laflamme et al.[17] Six cases required an intraoperative blood transfusion, and one patient received a postoperative transfusion. There were no severe hemorrhage-related complications in the present case series.

Finally, eight cases presented associated injuries, including three non-orthopedic injuries (aortic injury, epidural hematoma, and tension hemothorax). Orthopedic injuries to the upper limbs were more frequent and observed in five cases.

Surgery time and intraoperative bleeding presented a positive correlation (Pearson r = 0.712; $p = 0.003$; 95% confidence interval [95%CI] = 0.314 to 0.897). There was no correlation between surgery and reduction quality (Kendall τ; $p = 0.283$) (►**Table 2**) or time until surgery (Kendall τ; $p = 0.126$). However, longer times until surgery had a statistical significance with lower reduction quality ($p = 0.007$). The MPS and HHS correlated with the reduction quality (Kendall τ; $p < 0.006$ for both scores).

Discussion

The modified Stoppa approach enabled a good attack angle for maneuvers to reduce the quadrilateral blade and fixation (►**Fig. 5**) either with interfragmentary screws or anti-shear plates. (►**Fig. 6**). Lateral femoral traction also helps fracture reduction with this approach, and a Schanz pin in the femoral neck decreases pressure on the blade and enables its reduction.

The present study had a relatively low number of cases using exclusively the Stoppa approach. The lateral window of

Table 2 Kendall correlations

	Kendall τ-B	*p*
Time until surgery *versus* surgical time	0.311	0.126
Surgical time *versus* reduction quality	0.241	0.283
HHS *versus* MPS (1 year)	0.404	0.036
Reduction quality *versus* HHS	**−0.602**	**0.006**
Reduction quality *versus* MPS	**−0.577**	**0.006**
Reduction quality *versus* time until surgery	**0.544**	**0.007**

Abbreviations: HHS, Harris Hip Score; MPS, Majeed Pelvic Score.

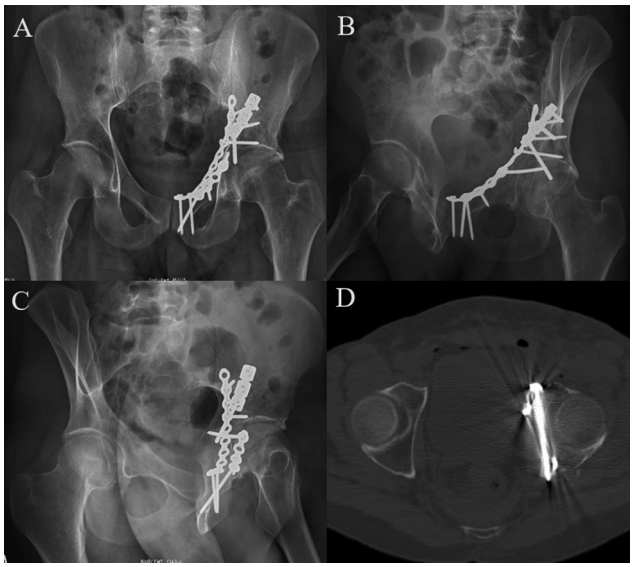


Fig. 5 (**A**) Postoperative AP radiograph. (**B**) Postoperative oblique obturator radiograph. (**C**) Postoperative alar radiograph. (**D**) Axial section of the postoperative computed tomography scan demonstrating the angle of attack and positioning of the interfragmentary screw fixing the anterior column to the posterior column.

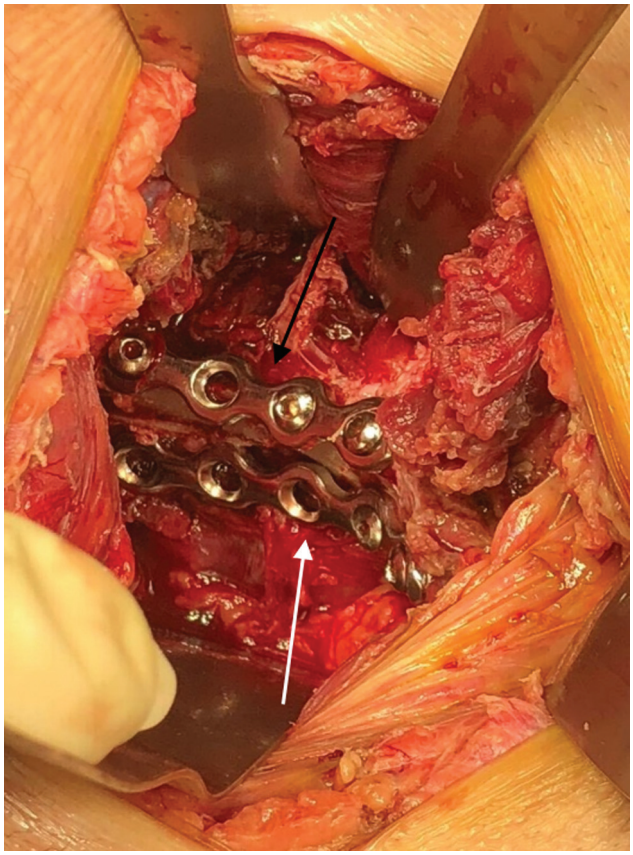


Fig. 6 Intraoperative appearance. **Black arrow:** Suprapectineal plate. **White arrow:** Infrapectineal plate.

the associated ilioinguinal approach seems a good concomitant option. The increasing learning curve will probably result in lower use of the posterior Kocher-Langenbeck approach at the same time, since studies with larger samples present a lower percentage of concomitant use of this route with the modified Stoppa approach.

We believe that maintaining the integrity of the inguinal canal results in lower rates of dissection of soft tissues and, consequently, a lower chance of infection. The time between trauma and the definitive surgical approach is a significant factor because fractures older than 15 days tend to present lower levels of mobilization and, as a result, difficult reduction. Sometimes, these injuries require more than two approaches, with increased surgical time and worse functional outcomes.

Conclusion

We concluded that the modified Stoppa approach provided good functional and clinical outcomes, demonstrated by an average HHS of 92.5 and 77.1% of excellent or good results on the MPS. The case series study demonstrated positive statistical relevance between the reduction quality and functional outcomes and between the time until surgery and the reduction quality. At the one-year follow-up, this approach can be an excellent alternative for anterior acetabular fractures.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Analysis of the Accuracy of CAM-type Deformity Resection on a Low-cost Arthroscopic Simulator in a Training Scenario

Análise da acurácia da ressecção de deformidades tipo CAME em simulador artroscópico de baixo custo em um cenário de treinamento

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Abstract

Objective To evaluate surgeons' performance in resecting CAM-type deformities using a realistic arthroscopic surgery simulator.

Methods An arthroscopic simulator was created using low-cost materials with the help of a GTMax Core A1 3D printer and the programs Invesalius and Meshmixer 2017, which were used to develop femoral head parts in ABS material, with the presence of a CAM-type deformity, to mimic a femoroacetabular impact situation. After the operations were performed by 16 surgeons, the femurs were compared to a previous model with deformity and another without, using Cloudcompare, and parameters such as the volumetric difference between the operated femurs, with and without deformity, the minimum and maximum distance between them, the percentage of the deformity resected, the estimated time for total resection of the deformity, as well as a qualitative analysis based on the images and graphs provided by the program representing the areas of the parts resected, were evaluated at the end.

Keywords
- arthroscopy
- femoroacetabular impingement
- hip
- simulation training

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Results The average resection speed was 34.66 mm^3/min (SD = 46 mm^3/min, max = 147.33; min = -2.66). The average resection rate was 26.2% (SD = 34.7%, max = 111; min = -2). Qualitative analysis showed hyporesection of deformities and sometimes hyperresection of nondeformed areas. The simulator was highly rated by the surgeons, with a tactile sensation very similar to real surgery, according to them.
Conclusion Arthroscopic simulators have proved very useful in training less experienced surgeons.

Resumo

Objetivo Avaliar o desempenho de cirurgiões na ressecção de deformidades tipo CAME fazendo uso de um simulador realista de cirurgia artroscópica.
Métodos Um simulador artroscópico foi criado a partir de materiais de baixo custo com auxílio de uma impressora 3D GTMax Core A1 e dos programas Invesalius e Meshmixer 2017, que foram utilizados para criar peças de cabeça de fêmur em material ABS, com a presença de uma deformidade tipo CAME, a fim de mimetizar uma situação de impacto femoroacetabular. Após as operações serem realizadas por 16 cirurgiões, os fêmures foram comparados a um modelo prévio com e outro sem deformidade pelo programa Cloudcompare, sendo avaliados ao final parâmetros como diferença volumétrica entre os fêmures operados, com e sem deformidade, distância mínima e máxima entre eles, porcentagem da deformidade ressecada, tempo estimado para ressecção total da deformidade, além de uma análise qualitativa feita com base nas imagens e gráficos fornecidos pelo programa representando as áreas das peças efetivamente ressecadas.
Resultados A velocidade média de resseção foi de 34,66mm^3/minuto (DP = 46 mm^3/min, max = 147,33 mm^3/min; min = -2,66 mm^3/min). A média de ressecção obtida foi de 26,2% (DP = 34,7%, max = 111%; min = -2%). A análise qualitativa demonstrou uma hiporresecção das deformidades e, por vezes, hiperresecção de áreas não deformadas. O simulador foi muito bem avaliado pelos cirurgiões, tendo uma sensação tátil bem semelhante à cirurgia real segundo os mesmos.
Conclusão Simuladores artroscópicos se mostraram muito úteis no treinamento de cirurgiões menos experientes.

Palavras-chave
- artroscopia
- impacto femoroacetabular
- quadril
- treinamento por simulação

Introduction

Training surgeons to acquire complex motor skills is a decisive factor in the outcome of orthopedic surgery. A greater volume of cases has been strongly associated with improved post-operative recovery time, lower mortality, and lower costs in hospital settings.[1] The volume of training increases surgeons' efficiency in the operating room and patient safety.[2] Various surgical skills can be obtained through simulator training.[3,4]

Femoroacetabular impingement (FAI) syndrome arises from abnormal contact between the rim of the acetabulum and the femoral neck during the range of motion, and the deformity most involved in this syndrome is the anomalous bulging in the anterosuperior portion of the femoral neck, known as the CAM.[5] The most common treatment currently used to correct this deformity is arthroscopic resection. Arthroscopic surgery is effective and correlated with good clinical results in various populations.[6,7] However, the most common cause of persistent symptoms and the need for revisions is incomplete resection of the deformity.[8,9] Additionally, there are reports in the literature that exaggerated or localized bone resection in inappropriate topographies, which would be related to persistent symptoms and risk of fractures.[10,11]

Hip arthroscopy is known for having a steep learning curve,[12] and complications can be reduced with surgeons' experience.[13] Recently, several strategies have been implemented to increase the expertise of surgeons and decrease their difficulty in obtaining the skills needed to perform hip arthroscopies.[14]

One of these is low-fidelity arthroscopic simulators, using models printed by additive manufacturing (3D printing). This study describes a realistic, low-fidelity arthroscopic simulator produced in Brazil with affordable materials. We also assess the ability of surgeons with different levels of experience to reproduce the desired correction.

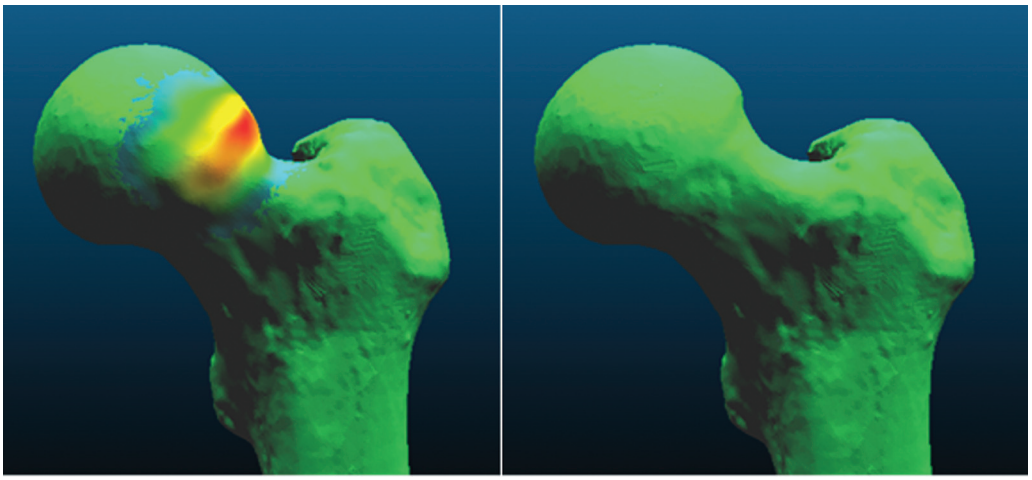


Fig. 1 Images of femurs without (right) and with (left) deformity. Color highlight generated by the volumetric difference according to the CloudCompare software. **Source:** Photo by the author, December 2022.

Methods

This is a comparative experimental study on realistic plastic models, three dimensional (3D) printed from medical images of a hip without bone deformities, in which surgeons' skills at different levels of experience in arthroscopic surgery for femoral CAM resection were evaluated.

A Digital Imaging and Communications in Medicine (DICOM) file stored in a medical image bank derived from a CT scan of a patient with a normal femur was obtained after consent and approval by the Research Ethics Committee.

The image of the patient's proximal femur was converted into a 3D mesh file (.stl) using the Invesalius software (Department of Computer Science at the Universidade Federal de Juiz de Fora). This file was called "femur without deformity." The volume of the femur image without deformity was 128,073 $mm^{3,}$ and the surface area was 16,654.90 mm^2. The image was then manipulated in the computer-aided design (CAD) program Meshmixer 2017 (Autodesk Inc., San Francisco, CA, USA), using extrusion and smoothing tools to create an image volumetrically like the typical deformity found in cam-type femoroacetabular impingement syndrome. This image was saved as "femur with deformity" (►**Fig. 1**). The volume of the deformed femur image was 130,601 $mm^{3,}$ and the surface area was 16,466.50 mm^2. Therefore, the difference in volume between the femur with and without deformity was 1.988 mm^3 (i.e., 1.988 milliliters), and the difference in surface area was 188.4 mm^2.

The files of the deformed femur were printed on a cast plastic injection printer using the rapid prototyping technique (3D printing) GTMax Core A1 (GTMax LTDA., Americana, SP, Brazil) (►**Fig. 2**).

The Simulator

The surgery was performed using a customized simulator created by the researchers. The simulator table consists of a flat wooden surface, a sergeant clamp, two PVC pipes (one 15 cm and the other 10 cm in diameter), two styrofoam cylinders (10 cm in diameter and 5 cm high), as well as medium-density foam (to simulate subcutaneous tissue) and a sheet of EVA (to simulate skin). To fix the plastic femurs in the simulator cavity, 5.5 mm Schanz pins were used (►**Fig. 3**).



Fig. 2 Femurs with deformities printed on ABS plastic. **Source:** Author, December 2022.

The Experiment

The 16 orthopedic doctors who had participated in an immersive hip arthroscopy course with practice on human cadavers, with different levels of experience in arthroscopic surgery, were invited to participate in the experiment, in which they performed simulated surgery to resect the deformity in plastic models. All participants agreed to take part, and there were no exclusions.

Participants answered a preparticipation questionnaire that recorded characteristics of their previous experience and degree of subspecialization.

Each participant was instructed on performing the procedure through a 30-minute lecture on the subject, with specific instructions on using the simulator. The simulated femoral osteoplasty procedure, using an arthroscopic simulation device, was carried out in a training room, using an arthroscopic camera with 70° optics and a 5.5mm arthroscopic bone resection blade (burr type). The researchers previously made two arthroscopic portals (anterolateral

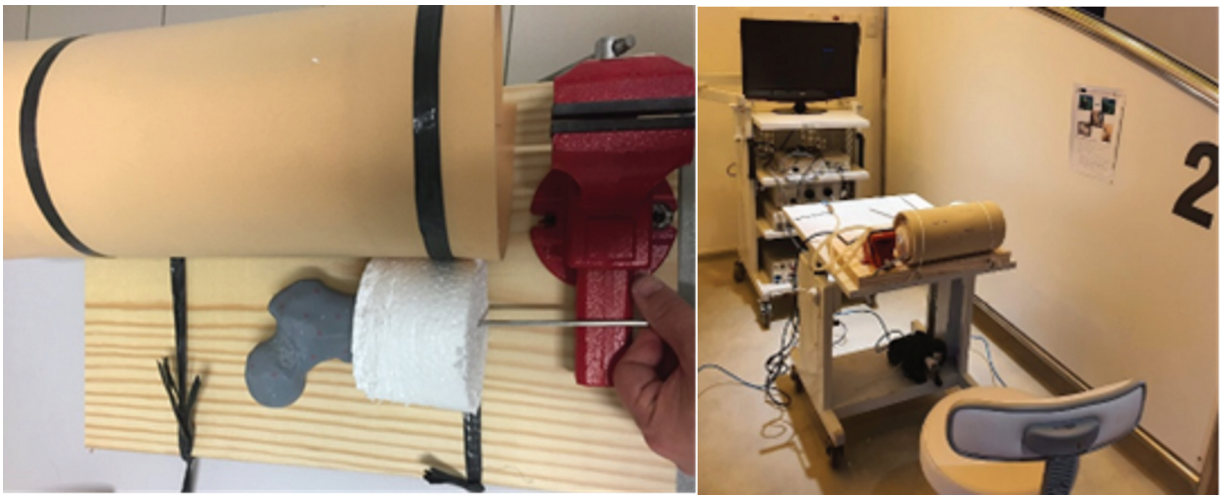


Fig. 3 Elements of the simulator and assembly of the training station. Source: Author, January 2023.

and distal medioanterior), and the instruments for performing the arthroscopic surgery were prepositioned. Each participant had 15 minutes to resect the deformity.

Immediately after the experiment, the participants answered a new questionnaire about their subjective perception of their abilities before and after the training and about their perceived experience of the simulator.

The specimens submitted to surgery on the simulator were optically scanned with a Desktop 3D Scanner HD (NextEngine, Santa Monica, CA, EUA) to assess the accuracy of the resection. The images from the optical scan were converted into stl-type digital files with 3D meshes and named "operated femur."

The images of the operated femur were compared in the computer program CloudCompare (EDF S.A, Paris, França) v.2.10.2, with the images of the femur with and without deformity.

Comparisons made of the femur with deformity provided parameters on the volume of bone removed, speed of correction, and location of the correction. Comparisons of the femur without deformity were used to assess the ability to restore anatomy through bone resection (including the proportion of resection compared to what was expected and the presence or absence of overcorrection).

All comparisons were made by an evaluator blinded to the surgeons' experience.

We analyzed the maximum distance from the surface of the operated part to the one with and without deformity, the average absolute distance (includes only absolute values, not taking into account whether the surface is deeper or more externalized than the other), the average relative distance (contains both positive and negative values), the standard deviation (SD), the difference in volume and the total work done (obtained by subtracting the volume of the deformed part from the operated one and then dividing this number by the subtraction of the deformed part from the standard).

The 3D color maps provided images that allowed qualitative analysis of the resections.

Results

Comparison Between Deformed and Operated Femurs

The average difference in volume between the operated femurs and the femurs with deformities (resected volume) was of 0.52 ml (SD = 0.69 ml; max = 2.21; min = -0.04) (►**Table 1**).

Proportionally, the average resection obtained was 26.2% (SD = 34.7%; max = 111; min = -2).

Data generated by the author from comparisons in the computer software CloudCompare.

Considering that the time available for the task was 15 minutes, the average resection speed was 34.66 mm^3/minute

Table 1 Metric and volumetric ratios between operated and deformed femurs

	Average	Deviation standard	Value Maximum	Value Minimum
Maximum distance (mm)	2,86	1,55	7,59	1
Average absolute distance (mm)	0,07	0,03	0,11	0,04
Maximum error (mm)	0,35	0	0,36	0,35
Relative distance (mm)	-0,03	0,04	0,03	-0,1
Volumetric difference (ml)	-0,52	0,69	-2,21	0,04

Source: Data generated by the author, based on comparisons in the CloudCompare software.

Table 2 Metric and volumetric differences between operated and non-deformed femurs

	Average	Deviation Standard	Value Maximum	Value Minimum
Maximum distance (mm)	5,15	0,72	7,46	4,54
Average absolute distance (mm)	0,23	0,06	0,39	0,14
Maximum error (mm)	0,35	0	0,36	0,35
Relative distance (mm)	0,17	0,05	0,23	0,09
Volumetric difference (ml)	1,9	0,68	2,72	0,26

Source: Data generated by the author, based on comparisons in the CloudCompare software.

(SD = 46 mm^3/min, max = 147.33; min = -2.66). Therefore, the estimated time for resection of the entire deformity volume (if there were 100% accuracy) would be 57.35 minutes on average (SD = 43.21 min; min = 13.49; max = 747.36).

Comparison of Non-deformed and Operated Femurs

The maximum distance between the operated and normal femurs, representing the residual deformity, was 5.15 mm on average (SD = 0.72 mm; max = 7.46; min = 4.54).

Regarding volume, the difference between operated femurs and those without deformity, which also expresses residual deformity, was of 1.9 ml (SD = 0.68 ml; max = 2.72; min = 0.26) (►**Table 2**).

Qualitative Analysis

In addition to insufficient resection (average resection of 26.2%), qualitative analysis using 3D color maps showed a predominance of hypocorrection at the deformity site (►**Fig. 4**).

Even in cases with a greater volume of correction, this occurred at the expense of resectioning areas unaffected by deformity to the detriment of the target areas with deformity (►**Fig. 5**).

Answers to the Questionnaire (►Table 3)

The study population included surgeons with different levels of previous experience: 20% were general orthopedic surgeons, 12.1% had a specialty in an area other than the hip, 6.6% were 1st year residents, 6.6% were advanced hip surgeons (R4), and 53% were specialists in hip surgery according to the SBQ.

Concerning previous experience in arthroscopic surgery, 93.3% said they had never performed hip arthroscopy on human patients, and 93.3% had performed less than 30 arthroscopies in general. Concerning previous training, 60% said they had previously interacted with an arthroscopic simulator, and 40% had performed hip arthroscopies on human cadavers.

Regarding self-assessment of experience, 80% rated their level of expertise in arthroscopy as novice, 12% as intermediate, and 6% as advanced.

The users' perception of the simulator used in this study is of an easy to use tool (87.5%), reproducing the clinical deformity of the CAM in FAI (93.7%), which should be used as part of the training of hip arthroscopists in training (93.3%).

Discussion

Femoroacetabular impingement repair surgery has many technical challenges, and various strategies have been proposed to overcome this steep learning curve.[15,16] Among surgeons, motor cognition skills are recognized as the most

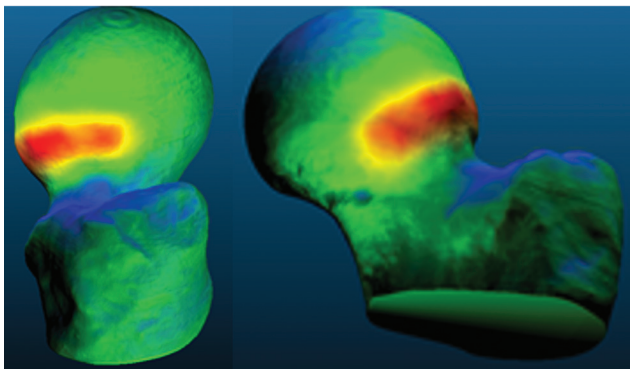


Fig. 4 Example of insufficient correction in which the deformity (represented by the warm colors) has hardly been removed. **Source:** Author, based on comparisons in the CloudCompare software.

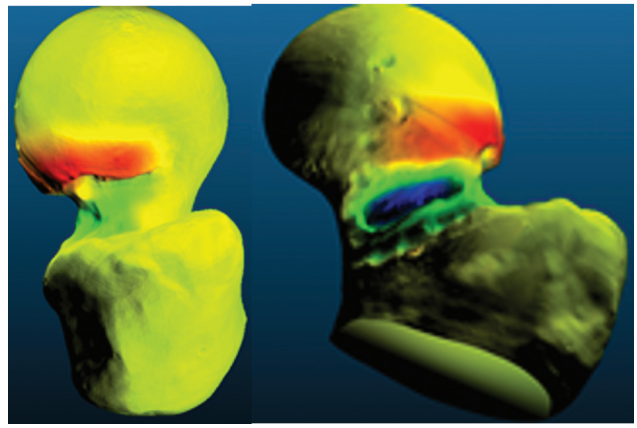


Fig. 5 Case of inadequate resection shown by the excessively deep and distal area of bone resection (represented by the blue color) associated with the persistence of the deformity (represented by the red color). **Source:** Author, based on comparisons in the CloudCompare software.

Table 3 Answers to the simulator evaluation questionnaire

	Disagree	Disagree	No	I agree	Agree, partially agree Agree, partially agree
	no disagree				
The simulator is easy to use	0	1(6,6%)	0	3(20%)	10(66,6%)
The simulator reproduces the clinical condition from the FAI	0	0	0	13(86,6%)	1(6,6%)
The simulator requires the use of special arthroscopic skills	0	0	2(12,12%)	8(53,3%)	3(20%)
The simulator reproduces feeling tactile bone resection	1(6,6%)	2(12,12%)	1(6,6%)	10(66,6%)	0
The simulator is useful increasing surgical skills	0	0	0	2(12,12%)	13(86,6%)
The simulator could have been useful in the early stages of training	0	0	0	1(6,6%)	13(86,6%)
The simulator reproduces the spacial feeling of bone resection	0	0	0	9(60%)	5(33,3%)
This simulator should be part of the training of hip arthroscopists' in training	0	0	0	0	14(93,3%)

Abbreviation: FAI, femoroacetabular impingement.

important for doctors in training to achieve competence.[14] Indeed, although training on cadavers seems to be the more favorable method for developing surgical skills, constraints of availability, time, and resources limit its frequent applicability.[14] Therefore, virtual reality simulators and high- and low-fidelity physical models have proved to be valuable alternatives for acquiring the complex motor skills required to learn hip arthroscopy.[14,16] The simulator presented in this study was developed in Brazil at an affordable cost and showed highly acceptable results among surgeons exposed to the training. In the literature, the most frequently reported parameters for evaluating the characteristics of simulator training were the ability to visualize and palpate joint structures with an arthroscopic probe (82%), average time to perform the task (73%), frequency of unwanted contact with cartilage and soft tissue (73%), and number of manual movements performed (73%).[16] In this study, we introduced additional objective parameters, namely the speed and volume of bone resection. The advantage of measuring these parameters is that they are directly related to the ability to accurately correct the deformity, which appears to be an essential element in the procedure's success in several studies.

Alter et al.[17] reported strong positive correlations between postoperative alpha angle measurements and the three-dimensional surface subtraction method, which is similar to the comparisons made in our study. In that study, the mean resected bone volume was $10{,}192 \pm 486.2\ mm^3$, which is close to the target resection values in our research and helps validate the verisimilitude of our model. Similarly, in that study, the maximum depth of bone resection measured was an average of 3.6 ± 1.0 mm, while in our series, we obtained values of 2.86 ± 1.55 mm. These values seem fully compatible, considering that, in our case, the participants only had 15 minutes to complete the task and, on average, only 26.2% of the expected volume was resected.

Inadequate resection of the deformity, whether in-depth, extent, or location, can increase the likelihood of postsurgical complications, including the risk of fractures and lip seal breakage.[10,11] An advantage of this simulator model is the possibility for the student to have instant feedback on the resection carried out, inspecting the operated part by simply removing it from the simulator after completing the task. Additionally, the quantitative and qualitative analysis carried out a posteriori with an optical scanner and computer programs can provide additional information to teachers and students in training.

Indeed, Uhl et al.[18] tested the use of 3D-printed simulators for cranioplasty training in patients with craniostenosis and found a significant improvement in the doctors' technique. In this study, 93.3% of the participants reported that they would have liked to have had access to the simulator at an earlier stage in their medical training, in addition to responding that training with the simulator should be applied while teaching the arthroscopic technique. The same observation was made by most of the surgeons involved in our study. Karam et al.,[19] in a survey carried out in conjunction with the American

Academy of Orthopedic Surgeons, found that 80% of orthopedic residency directors believe that the use of surgical simulations is essential for training residents in basic skills, and 87% say that the most significant barrier to instituting this training for their students is the lack of funds to pay for the simulators' high cost. Regarding residents, 66% say there is a need to implement a laboratory in all residencies in the country.[4]

The present study has several limitations. The lack of a control group with expert surgeons limits the validation of our model. However, as it was a pilot study, it made estimating the time allocated to complete the task (up to 60 min) possible. It also allowed us to identify the potential of the optical scanning method associated with 3D printing as a research and teaching tool. Printing errors are reported in the literature and can account for up to 1.1% of printed volumes.[20] This explains the negative values found in some linear and volumetric comparisons. Although this may impact the reliability of the measurements, this limitation does not affect the qualitative analysis or prevent the simulator's application. In future research, it would be advisable to scan the printed part optically before the procedure rather than compare it to the original digital model. This measure would eliminate potential bias due to dimensional printing errors.

Conclusion

Arthroscopic simulators produced by 3D printing are helpful in training surgeons to resect cam deformities in hip arthroscopy. The average speed of CAM deformity resection in this study was 34.66 mm^3/minute, and the estimated time for complete resection was of 57.35 minutes.

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

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Use of Three-dimensional Printing for Tibial Pilon Fracture Diagnosis and Treatment

Uso da impressão 3D para auxílio diagnóstico e terapêutico das fraturas de pilão tibial

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Abstract

Objective To evaluate whether three-dimensional (3D) printing increases agreement in the classification of tibial pilon fractures.

Methods Orthopedists and traumatologists reviewed radiographs, computed tomography scans with 3D reconstruction, and prototyping 3D printing, and classified the fractures based on the Rüedi-Allgöwer and Arbeitsgemeinschaft für Osteosynthesefragen (AO, Association for the Study of Internal Fixation) Foundation/Orthopedic Trauma Association (AO/OTA) classification systems. Next, data evaluation used Kappa agreement coefficients.

Results The use of the 3D model did not improve agreement for tibial pilon fractures regarding the treatment proposed by the groups. Regarding the classification systems, the agreement only improved concerning the AO/OTA classification when the 3D model was used in the assessment by the foot and ankle specialists.

Conclusion Although 3D printing is statistically relevant for surgeons specializing in foot and ankle, its values remain lower than optimal.

Keywords
- fractures, bone
- printing, three-dimensional
- tibial fractures

Resumo

Objetivo Avaliar se a impressão tridimensional (3D) aumenta a concordância na classificação de fraturas do pilão tibial.

Métodos Foram selecionadas radiografias, tomografias com reconstrução 3D e impressão de prototipagem em impressora 3D. Os exames foram apresentados a profissionais da área de Ortopedia e Traumatologia que classificaram as fraturas com base nas classificações da Arbeitsgemeinschaft für Osteosynthesefragen (AO, Associação para o Estudo da Fixação Interna) Foundation/Orthopedic Trauma Association

Palavras-chave
- fraturas da tíbia
- fraturas ósseas
- impressão tridimensional

Work developed at the Hospital da Santa Casa de Curitiba, Curitiba, Paraná, Brazil.

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(AO/OTA) e de Rüedi-Allgöwer. Posteriormente, os dados foram avaliados pelos coeficientes de concordância de Kappa.

Resultados O uso do modelo 3D não melhorou a concordância na fratura do pilão tibial quanto ao tratamento proposto pelos grupos. Em relação aos sistemas de classificação, somente a concordância na classificação AO/OTA melhorou quando foi utilizado o modelo 3D na avaliação pelos especialistas em pé e tornozelo.

Conclusão Apesar de o uso da impressão 3D ter relevância estatística para os cirurgiões especialistas em pé e tornozelo, ainda apresenta valores menores do que os ideais.

Introduction

Pilon fractures represent 1% of lower limb fractures and approximately 5% to 10% of tibial fractures.[1] Furthermore, 20% to 40% of these fractures are open.[2] Pilon fractures are more common in the fourth decade of life and in male subjects[3] They often result from high-energy trauma with axial load and shear force,[4] such as in falls and traffic accidents.[5] These fractures can also occur due to rotational trauma, such as in injuries due to sporting activities.[6] In this case, the fracture results from low-energy trauma and consequently causes less damage to soft tissues and less comminution. Foot position at impact, as well as the direction and amplitude of the force account for the several fracture patterns and degrees of comminution.[7]

Classification systems are helpful in the clinical practice to assess injury severity, guide surgical treatment, and facilitate communication and comparison for academic purposes. The most commonly used classifications for tibial pilon fractures include the Rüedi-Allgöwer and the Arbeitsgemeinschaft für Osteosynthesefragen (AO, Association for the Study of Internal Fixation) Foundation/Orthopedic Trauma Association (AO/OTA) classifications. The AO/OTA classification considers the extent of joint involvement and comminution,[8] dividing pilon fractures into 3 groups: 43-A (extra-articular fracture), 43-B (partial articular fracture), and 43-C (complete joint fracture)[9] These groups are divided into three subgroups each, with increasing complexity and progressively worse prognosis.[6] The Rüedi-Allgöwer classification divides fractures into three types per comminution degree and joint displacement. Type I is a simple articular fracture with no displacement, type II is a simple articular fracture with displacement of the articular surface but no comminution, and type III is a comminuted articular fracture with displacement.[10]

The surgical indication for the fixation of pilon fractures includes open fractures with 2 mm of joint displacement, talar subluxation, or misalignment greater than 5°.[10] The main therapeutic goals are to protect the soft tissues, ensure adequate alignment, restore the joint surface,[3] and enable early rehabilitation and mobilization.[10]

The conduct and surgical time depend on the patient's general health status, the condition of adjacent soft tissues, fracture comminution, and the surgeon's experience.[11] The literature reports several treatment options for tibial pilon fractures, including open reduction and internal fixation, external fixation, and several combinations and modifications of these techniques.[12] External fixation often occurs first to improve adjacent soft tissue damage,[13] reducing the rates of infection, dehiscence, and osteomyelitis.[12] This two-stage procedure is popular worldwide to treat tibial pilon fractures.[14] On the other hand, when the soft tissue is in good condition, open reduction and internal fixation are initially performed.[15] The general sequence to treat tibial pilon fractures includes length and alignment reestablishment, articular surface restoration, metaphyseal defect filling, and reconnection to the diaphysis.[10]

Three-dimensional (3D) printing is a rapid prototyping technology that uses a 3D digital model to build an object. It has developed quickly and gained good visibility in orthopedics because the printed model enables fracture visualization and the creation of a precise, customized plan for patients. In addition, the model enables procedural simulation due to preoperative visualization of fracture anatomy and improves the communication between doctor and patient.[16]

The present study aims to evaluate the agreement of tibial pilon fracture classification and proposed treatment based on imaging exams and comparison with 3D printing.

Materials and Methods

The Ethics Committee approved the current study, which was registered on Plataforma Brasil under CAAE number 52795321.0.0000.5225.

The present observational, cross-sectional, retrospective study included 16 professionals in the field of Orthopedics and Traumatology, namely 8 resident physicians, 4 orthopedist, and 4 orthopedist specializing in the foot and ankle.

The study was conducted in the Orthopedics and Traumatology Sector of a specialized hospital in Curitiba, Paraná, Brazil.

Through a retrospective analysis, we collected imaging tests from six patients diagnosed with tibial pilon fracture, including radiographs in the anteroposterior (AP) and lateral (L) views, computed tomography (CT) scans of the ankle, and 3D computed tomography reconstructions. No data regarding the patient or trauma was provided.

Supplementary tests for each patient included 4 groups: radiographs, CT scans, 3D reconstruction, and prototyping (3D printing). All 24 tests were randomized and numbered to avoid bias. Only the researchers knew which tests corresponded to the same patient.

The participants answered a questionnaire with images to classify the fractures according to the Rüedi-Allgöwer and AO/OTA systems and propose a treatment.

The interview occurred a single time after the participant signed an informed consent form, and there was no time limit for answering.

Initially, we assessed the interobserver agreement in each group (residents, orthopedists, and foot specialists) considering the four types of images (radiographs, CT, 3D CT, and 3D Model). Then, also for each medical group, we evaluated the agreement between the results of the four images. To assess the level of agreement among evaluators and image types, we estimated the Kappa agreement coefficients and their confidence intervals. Furthermore, we tested the significance of each Kappa coefficient and presented the *p*-values. The evaluation of the internal consistency of the questionnaire was carried out by estimating Cronbach alpha coefficients considering each group of evaluators and each image type. The bootstrap method (400 replications) was used to calculate 95% confidence intervals (95%CIs) for these coefficients. For the statistical tests, *p*-values < 0.05 were deemed significant, and for the intervals presented, we considered a 95% confidence level. Data were organized in an Excel (Microsoft Corp., Redmond, WA, United States) spreadsheet and analyzed using the IBM SPSS Statistics for Windows (IBM Corp., Armonk, NY, United States) software.

Results

We analyzed the answers to the questionnaires about fracture classification and the proposed treatment considering radiographs, CT, 3D CT, and 3D models. We estimated Kappa agreement coefficients to assess the agreement level among residents, orthopedists, and foot specialists for each image (radiographs, CT, 3D CT, and 3D model). The tables present the percentages of agreement, the Kappa agreement coefficients (with 95% confidence intervals), and the *p*-values corresponding to the significance of the coefficients.

The agreement coefficient analysis used Landis and Koch interpretation of Kappa values. Kappa values above 0.8 indicate excellent agreement, while those ranging from 0.60 to 0.79 show substantial agreement, 0.40 to 0.59, moderate agreement, 0.20 to 0.39, low agreement, 0 to 0.19, poor agreement, and negative values indicate disagreement.

Interobserver agreement in the AO/OTA classification was low ($k = 0.245$) for radiographs but improved to moderate ($k = 0.450$) for the 3D model.

Interobserver agreement in the Rüedi-Allgöwer classification was moderate ($k = 0.415$) for radiographs but low for the 3D model ($k = 0.329$) (►**Table 1**).

Interobserver agreement in the Rüedi-Allgöwer classification was moderate ($k = 0.415$) for radiographs but low for the 3D model ($k = 0.329$) (►**Table 2**).

Table 1 Agreement among residents, orthopedists, and specialists regarding imaging exams and 3D-printed models according to the AO/OTA classification

Image	Physicians	Agreement among physicians (%)	Kappa coefficient	95% confidence interval	*p*-value
Radiograph	General	43.9%	0.307	0–0.697	0.141
	Residents	47.0%	0.340	0–0.841	0.310
	Orthopedists	33.3%	0.176	0–0.576	0.211
	Foot specialists	38.9%	0.245	0–0.683	0.019
Computed tomography	General	31.3%	0.154	0.039–0.269	0.007
	Residents	24.4%	0.049	0.021–0.078	0.135
	Orthopedists	44.4%	0.256	0–0.625	0.055
	Foot specialists	50.0%	0.348	0–0.709	0.015
3D computed tomography	General	34.9%	0.208	0.060–0.356	0.062
	Residents	30.4%	0.158	0–0.327	0.087
	Orthopedists	41.7%	0.266	0–0.589	0.016
	Foot specialists	36.1%	0.200	0.055–0.345	0.063
3D model	General	43.6%	0.282	0–0.586	0.150
	Residents	41.1%	0.267	0–0.670	0.062
	Orthopedists	47.2%	0.306	0–0.634	0.017
	Foot specialists	63.9%	0.450	0.122–0.778	0.098

Abbreviations: 3D, tridimensional; AO/OTA, Arbeitsgemeinschaft für Osteosynthesefragen (AO, Association for the Study of Internal Fixation) Foundation/Orthopedic Trauma Association.

Table 2 Agreement among residents, orthopedists, and specialists regarding imaging exams and 3D-printed models according to the Rüedi-Allgöwer classification

Image	Physicians	Agreement among physicians (%)	Kappa coefficient	95% confidence interval	*p*-value
Radiograph	General	61.3%	0.415	0–0.892	0.076
	Residents	57.1%	0.347	0–0.840	0.130
	Orthopedists	55.6%	0.323	0–0.955	0.247
	Foot specialists	72.2%	0.556	0–1	0.064
Computed tomography	General	52.2%	0.196	0–0.430	0.083
	Residents	48.8%	0.094	0–0.328	0.348
	Orthopedists	52.8%	0.186	0–0.685	0.383
	Foot specialists	69.4%	0.385	0–1	0.216
3D computed tomography	General	49.3%	0.204	0–0.432	0.070
	Residents	46.4%	0.176	0–0.40	0.100
	Orthopedists	50.0%	0.168	0–0.559	0.321
	Foot specialists	50.0%	0.127	0–0.587	0.509
3D model	General	56.8%	0.304	0.004–0.605	0.048
	Residents	58.3%	0.369	0–0.831	0.095
	Orthopedists	63.9%	0.329	0–0.841	0.159
	Foot specialists	66.7%	0.329	0–0.706	0.076

Abbreviation: 3D, tridimensional.

Interobserver agreement regarding management was poor ($k = 0.168$) for the 3D model and low for radiographs ($k = 0.311$) (►**Table 3**).

A surprising finding was that CT images did not increase agreement for both classifications compared to plain radiographs. In the AO/OTA classification, residents presented a low agreement for radiographs ($k = 0.340$) and a poor agreement for CT ($k = 0.049$). Using the Rüedi-Allgöwer classification, foot specialists presented moderate agreement for radiographs ($k = 0.556$) but poor agreement for CT ($k = 0.385$), and low agreement for 3D CT reconstruction ($k = 0.127$).

Discussion

A fracture classification system must be reliable, reproducible, logical, and clinically useful; its purpose is to help in clinical decision-making, facilitate communication among professionals, and enable comparisons in research.[17,18]

In the present study, the Rüedi-Allgöwer and AO/OTA classification systems showed low to moderate agreement when using the 3D model. In the AO/OTA classification, agreement improved to moderate when experts evaluated the 3D model. Our hypothesis was corroborated with an increase in agreement only when 3D printing was evaluated by specialists in foot surgery using the AO/OTA classification. The other groups did not show statistical improvement. Byun et al.[19] evaluated the use of 3D CT regarding the same classifications, and they did not show an improved agreement between specialists and residents.

Computed tomography reportedly enables a better interpretation of the characteristics of each fracture and its joint fragments when compared with radiography.[17,20,21] However, the agreement with CT scans was not better than the one with radiographs in this study, which is consistent with similar studies, such as those by Ramappa et al.,[22] Keiler et al.,[23] and Martin et al.[20]

The 3D model did not improve agreement regarding treatment recommendations, which is consistent with the study by Byun et al.,[19] in which 3D CT did not improve agreement regarding treatment.

Keiler et al.[23] used the surgical procedure as a reference and evaluated the observers on the approach and implant positioning through 3D CT. These authors observed that the correlation improved significantly, especially in observers with less experience, suggesting that the 3D visualization of the injury may more beneficial for less-experienced surgeons.

Conclusion

Tibial pilon fractures are complex joint injuries, usually secondary to high-energy trauma. The correct interpretation of the injury and subsequent management is essential to avoid sequelae for the patient. Imaging exams are critical for the surgeon's decision-making. Therefore, articles like the present have great value in maintaining scientific growth and improving orthopedic protocols.

In the current study, the use of the 3D model did not improve agreement regarding the treatment proposed by the

Table 3 Agreement among residents, orthopedists, and specialists regarding imaging exams and 3D-printed models according to the treatment proposed

Image	Physicians	Agreement among physicians (%)	Kappa coefficient	95% confidence interval	*p*-value
Radiograph	General	78.6%	0.311	0.216–0.406	< 0.001
	Residents	76.9%	0.233	0.115–0.351	< 0.001
	Orthopedists	79.9%	0.371	0.219–0.522	< 0.001
	Foot specialists	80.6%	0.390	0.212–0.569	< 0.001
Computed tomography	General	72.9%	0.181	0.109–0.254	< 0.001
	Residents	73.1%	0.133	0.063–0.203	< 0.001
	Orthopedists	72.5%	0.238	0.090–0.387	0.002
	Foot specialists	79.3%	0.393	0.227–0.558	< 0.001
3D computed tomography	General	74.0%	0.167	0.106–0.228	< 0.001
	Residents	72.9%	0.084	0.018–0.149	0.014
	Orthopedists	77.2%	0.271	0.157–0.384	< 0.001
	Foot specialists	73.2%	0.211	0.054–0.369	0.009
3D model	General	72.6%	0.168	0.091–0.246	< 0.001
	Residents	70.8%	0.093	0.001–0.186	0.048
	Orthopedists	76.5%	0.277	0.116–0.438	0.001
	Foot specialists	73.2%	0.234	0.083–0.386	0.003

Abbreviation: 3D, tridimensional.

groups for tibial pilon fractures. Concerning the classification systems, it only improved agreement in the AO/OTA classification when compared with the foot and ankle specialist group.

We also emphasize that the results obtained in the present study did not demonstrate a higher agreement with the use of CT scans compared with simple tibial pilon radiographs.

However, we should not rule out the potential use of 3D printing to interpret tibial pilon fractures. Further studies with larger sample sizes are required.

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

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Mirror Foot: Surgical Approach for Esthetic and Functional Improvement

Pé em espelho: Abordagem cirúrgica para melhora estética e funcional

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Abstract

Mirror foot is a rare congenital anomaly within the spectrum of complex polydactyly of the foot. It can occur alone or with other malformations or genetic syndromes. It is a little described topic in the literature, with few publications on its treatment. We report the case of a 4-year-old female patient who presented eight fingers on her left foot and no other associated deformities. Her complaints included the impossibility of wearing closed shoes and social stigma. Radiography revealed eight metatarsals with their respective phalanges, five cuneiform bones, and the absence of bone deformities in the hindfoot. We opted for a surgical approach aiming at functional and esthetic improvement, in addition to better adaptation to closed shoes, as desired by the patient and her family. We performed a dorsal and plantar "V" incision and resected three supernumerary rays, including three central metatarsals with their nine corresponding phalanges, two cuneiform bones, tendons, and excess digital nerves. Next, we sutured the intermetatarsal ligaments, preserving the fingers with a normal appearance, reducing the width of the foot, and preserving adequate support. Kirschner wires maintained the reduction by transmetatarsal fixation. During the postoperative period, the patient wore a boot splint with zero load with no complications. We removed the Kirschner wires and allowed load on the limb after 12 weeks.

Keywords
- congenital foot deformities
- bone wires
- polydactyly

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Resumo

O pé em espelho é uma anomalia congênita rara, pertencente ao espectro das polidactilias complexas dos pés. Pode ocorrer isoladamente ou associado a outras malformações ou síndromes genéticas. Trata-se de um tema pouco descrito na literatura, com escassas publicações acerca do seu tratamento. Relatamos o caso de uma paciente do sexo feminino, de 4 anos de idade, que apresentava pé esquerdo com 8 dedos, sem outras deformidades associadas, cuja queixa incluía impossibilidade do uso de calçados fechados e estigma social. Radiograficamente, verificou-se a presença de oito metatarsos com suas respectivas falanges, cinco ossos cuneiformes e ausência de deformidades ósseas no retropé. Optou-se pela abordagem cirúrgica visando uma melhoria funcional e estética, bem como melhor adaptação ao uso de calçados fechados, conforme desejo da paciente e de sua família. Foi realizada incisão em "V" dorsal e plantar com ressecção de três raios supranumerários, incluindo três metatarsos centrais com suas nove falanges correspondentes, dois ossos cuneiformes, tendões e nervos digitais excedentes, seguida da sutura dos ligamentos intermetatarsais, com preservação dos dedos com aparência normal, diminuição da largura do pé e manutenção do seu apoio adequado. A redução foi mantida por fixação transmetatarsal com fios de Kirschner. O pós-operatório seguiu com o uso de tala bota e carga zero, sem intercorrências; os fios de Kirschner foram retirados, e a carga no membro foi liberada após 12 semanas.

Palavras-chave

- deformidades congênitas do pé
- fios ortopédicos
- polidactilia

Introduction

Polydactyly is the most common congenital anomaly of the toes, with an incidence of 1.7 per every one thousand live births and a positive family history in around 30% of cases; in addition, it is up to 10 times more common among black people.[1] Polydactyly is postaxial when the extranumerary ray is on the lateral (peroneal) foot surface and pre-axial when located on the medial (tibial) region. Polydactyly is complex when there is a mirror, central, dorsal, or Haas-type duplication, and all fingers present cutaneous fusion, with an extranumerary ray that is either pre- or postaxial.[2]

Mirror foot is a rare subtype of polydactyly, and the literature has few reports on the best approach for the surgical treatment.[3,4] Patients with this complex deformity usually present seven to eight digits and duplication of the tarsal bones, but hindfoot bone involvement is rare.[3,5] Mirror foot can occur alone or with other malformations, commonly fibular hemimelia, tibial hypoplasia, mirror hand, and genetic syndromes, such as Laurin-Sandrow syndrome and Martin syndrome.[3,5]

There is no standardization to treat these patients. Planning of the surgical technique is tailored to improve gait function and provide adaptation to closed shoes and an esthetic appearance of the foot, which result from the excision of supernumerary rays, tendon transfers, and skin flap placement.[3,5] The more normal-looking digits are usually preserved. In the central type of mirror foot, resection of the middle rays results in very functional feet with a good cosmetic appearance.[5]

The current paper presents the surgical treatment technique used in a patient with a central mirror foot treated at the Foot and Ankle Outpatient Clinic of the Musculoskeletal System Unit of our institution, and the postoperative outcomes. The study was submitted to and approved by the institutional Ethics Committee.

Case Report

A 4-year-old female patient treated at the Foot and Ankle Surgery Outpatient Clinic of our hospital presented a deformity in her left foot, resulting in pain and the impossibility of wearing closed shoes. She had no pain when wearing open sandals or walking barefoot. Her neuropsychomotor development was age-appropriate. There were no other malformations or similar cases in the family. Her mother was healthy, a non-smoker, and had no complications during pregnancy. The parents had no consanguinity.

The physical examination revealed eight fingers with a medialized hallux and central syndactyly (►**Fig. 1**), as well as the absence of tibial or fibular deformity or left lower limb shortening. Her gait was atypical, but with no limping.

Radiology showed the presence of eight rays, with hypoplasia of the third and hypertrophy of the fourth metatarsal, five cuneiform bones, and no bone fusions in the phalanges or hindfoot deformities (►**Fig. 2**).

Therapeutic Planning

After diagnosing the mirror foot, we decided on surgical correction with the family and the patient, considering the social repercussions and stigmas, the possibility of using closed shoes, and the esthetic improvement of the foot.

The surgical planning included the removal of three central supernumerary rays, including three metatarsals



Fig. 1 Preoperative clinical appearance of the mirror foot.

with the nine corresponding phalanges, two cuneiform bones, and the corresponding tendons and digital nerves, preserving the fingers with an appearance closest to normal.



Fig. 2 Preoperative radiological appearance of the mirror foot.

Technical Description

The procedure occurred in a surgical center, with the patient in the supine position, under spinal anesthesia, a lateral cushion, and a pneumatic tourniquet at the thigh level inflated to 300 mmHg. We performed a "V"-shaped dorsal and plantar skin incision centered on the middle of the foot (►**Fig. 3**), followed by dissection in planes and resection of the second, third, and fourth metatarsals and their phalanges, and the second and third cuneiforms. Next, we placed a wedge flap. Removal of the second toe on the medial side led to an inevitable rupture of the Lisfranc ligament. After hemostasis, we reduced the width of the forefoot by approximating the metatarsal bones and fixation with 2 parallel 1.5-mm Kirschner wires inserted 90° degrees from the first metatarsal bone, avoiding transfixing the growth plate. We checked the positioning of the Kirschner wires (►**Fig. 4**) and sutured the intermetatarsal ligaments with absorbable thread. We placed a suction drain and performed synthesis in layers using absorbable sutures in the subcutaneous tissue and 4.0 mononylon for skin closure (►**Fig. 5**). We removed the drain after 12 hours, with a blood flow of 50 mL.

Intraoperatively, cuneiform bone duplication is a challenge, as it requires deciding how many cuneiform bones to remove and the influence of the number of metatarsal bones. This bone wedge removal must occur à la carte and forefoot closure, with the resulting width reduction, must be the main reference parameter for the number of cuneiform bones to be removed.

The postoperative period was uneventful, and the patient wore a boot splint with zero load. Suture removal occurred after 18 days, and Kirschner wire removal happened after 3 months, when we allowed full load on the limb.

Discussion

In a literature survey from 2017, Lalé et al.[6] found 78 patients, totaling 118 mirror feet, including only 3 cases with a normal talus. These studies reported few cases, some undergoing surgical treatment but with no standardized approaches. The strategies adopted in most cases aimed at a functional foot with a satisfactory esthetic presentation.

The central mirror foot is the most uncommon form of this rare deformity, comprising only 6% of the cases.[4] To date, we have not found case reports or descriptions of published treatments for this malformation in the Brazilian literature.

Papamerkouriou et al.[4] described the surgical treatment of a central mirror foot with a dorsal and plantar "V" incision

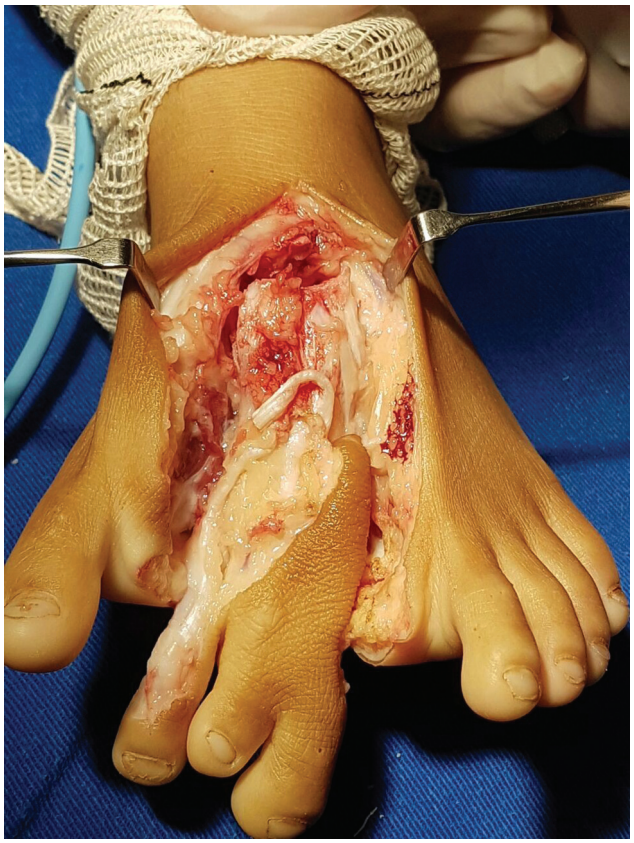


Fig. 3 Wedge resection of supernumerary rays and bones.



Fig. 4 Immediate postoperative radiological appearance.

in the center of the foot, removing excessive skin, three central rays, and extra tendons and digital nerves, consistent with the case herein reported.

Shahcheraghi et al.[5] reported treating two cases of central mirror foot by removing the central rays and excessive skin. In one of these cases, the approximation of the other metatarsals used cerclage with 1.0 steel wire and suture with absorbable thread. In the other case, ray approximation relied on a metal pin inserted with the lateral and medial ends bent to contain the enlargement of the forefoot. In the present study, after resecting the three central rays and the two excess wedges, we opted for transmetatarsal fixation of the first to fourth rays with Kirschner wires to stabilize them and heal the soft tissues.

Vlahovic et al.[8] described the surgical treatment of a patient with central polydactyly with nine fingers who underwent resection of the four supernumerary rays. They closed the space generated by fixing the first ray adjacent to the other rays with Kirchner wires, with no complications. However, after approximately 7.5 years, the patient required a new intervention due to progressive adduction of the tarsal bones and hallux abnormality. This new procedure removed the supernumerary cuneiform and corrected the alignment of the first metatarsal and the hallux varus with Kirschner wires.

All of these cases in the literature evolved with satisfactory functional and esthetic outcomes, which is consistent with the present study. Allen (1997, apud Osborn et al.[7]) described another central ray resection technique associated with dorsal and plantar advancement flaps to maintain the width of the foot, which demonstrated excellent radiographic and functional outcomes in a case series of cases with 22 patients and 27 feet with central polydactyly.

The technique used in the present case encompasses strategies described by these different authors, including wedge resection of the excess skin and supernumerary bones, closure of the resulting space, and alignment of the remaining rays, aiming for anatomy close to normal, which were fixed with Kirschner wires to maintain the intermetatarsal space reduction, and good esthetic and functional outcomes were achieved.[4,5,8]

Final Comments

Despite being a rare condition with scarce literature, the existing studies have shown good outcomes from the



Fig. 5 Postoperative clinical appearance.

surgical treatment of these patients, promoting better quality of life and resulting in patient satisfaction. Standardizing the most appropriate type of treatment is challenging due to the rarity and variability in the clinical presentation of mirror foot. Nevertheless, the need to master anatomy, knowledge of foot biomechanics, and concepts of operative technique for individualized planning is evident in the search for the functional and esthetic restoration of feet affected by this deformity. As a limitation of the present study, the patient was lost to follow-up, as she did not return to the outpatient clinic after we allowed the full load and could not be reached by telephone or the address registered in the medical record at the beginning of the follow-up.

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

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A Novel Method of Treatment of Small Osteolabral Avulsions Associated with Posterior Fracture-dislocation of the Hip

Um novo método de tratamento de pequenas avulsões osteolabrais associadas a fratura-luxação posterior do quadril

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Abstract

Small osteolabral avulsions of the hip can be easily missed, and postreduction stress testing and computed tomography (CT) scans of the hip should be performed to look for these injuries. The usual modality of treatment of these unstable osteolabral avulsions is suture anchors, Herbert screws or spring plates. But when the bony avulsion is small, the use of these implants becomes a tedious job. We present a novel technique to fix small osteochondral avulsion fractures not amenable to fixation using screws or spring plates.

We performed a retrospective analysis of 57 cases of patients who underwent open reduction and internal fixation for posterior fracture dislocation of the acetabulum, and we identified 6 cases of small posterior labral osteochondral fragments leading to instability. These injuries were fixed using a novel method. The mean Harris Hip Score at the final follow-up was of 92.5. Fixation of osteochondral avulsions associated with posterior hip fracture dislocation can be a difficult task if the bony fragment is small. Our technique is a simple, cost-effective and reliable way of fixing such avulsions with satisfactory outcomes.

Keywords

- acetabulum
- femur head
- fractures, bone
- hip dislocation

Resumo

Pequenas avulsões osteolabrais do quadril podem passar despercebidas, e testes de estresse pós-redução e tomografia computadorizada do quadril devem ser realizados para sua detecção. O tratamento dessas avulsões osteolabrais instáveis geralmente é feito com âncoras de sutura, parafusos de Herbert ou placas-molas. Em avulsões ósseas pequenas, porém, o uso desses implantes é um trabalho tedioso. Apresentamos uma nova técnica de fixação de pequenas fraturas com avulsões osteocondrais não passíveis de fixação com parafusos ou placas-molas.

Work developed at the Government Medical College and Hospital, Chandigarh, India.

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Palavras-chave
- acetábulo
- cabeça do fêmur
- fraturas ósseas
- luxação do quadril

Realizamos uma análise retrospectiva de 57 casos de pacientes submetidos à redução aberta e fixação interna de fratura-luxação posterior do acetábulo, e identificamos 6 casos em que um pequeno fragmento osteocondral labral posterior causava instabilidade. Essas lesões foram corrigidas com um novo método. A pontuação média no Harris Hip Score no último acompanhamento foi de 92,5. A fixação de avulsões osteocondrais associadas a fratura-luxação posterior do quadril pode ser difícil se o fragmento ósseo for pequeno. Nossa técnica é uma maneira simples, econômica e confiável de corrigir tais avulsões com resultados satisfatórios.

Introduction

Posttraumatic posterior hip dislocation is usually caused by high-energy trauma in young individuals involved in road traffic accidents (RTAs). The mechanism of injury is usually a dashboard injury in which there is an axially-directed force from the knee in a flexed hip, and, depending on the magnitude of the force and the position of the hip at the time of the injury, various other associated injuries can occur, such as osteochondral avulsion, posterior wall fracture, and transverse fracture with involvement of the posterior wall.[1] Reduction of a hip dislocation should be performed as an emergency procedure within twelve hours to decrease the risk of avascular necrosis (AVN) of the hip. Non-concentric reduction or persistent instability after reduction is usually caused by intra-articular loose bodies, incarcerated fragments or posterior osteolabral avulsion.[2] Addressing these injuries is paramount to achieve a stable and concentric reduction and decrease the risk of redislocation of hip, osteoarthritis, and hip AVN and enable early mobilization. Small osteolabral avulsions can be easily missed, and post-reduction stress testing and computed tomography (CT) scans of the hip should be performed to look for these injuries.[3] The usual modality of treatment of these unstable osteolabral avulsions is suture anchors, Herbert screws or spring plates.[4] But when the size of the bony avulsion is small, the use of these implants becomes a tedious job. We present a novel technique to fix small osteochondral avulison fractures not amenable to fixation using screws or spring plates.

Description of the Method

In the present study, we performed a retrospective analysis of 57 cases of patients who underwent open reduction and internal fixation for posterior fracture dislocation of the acetabulum by a single surgeon at a tertiary-level trauma center in Northern India from 2012 to 2018. We obtained approval from the institutional Ethics Committee, and written informed consent was taken from all patients for inclusion in the study and publication of data in a scientific journal without any disclosure of personal details.

We identified six cases of small posterior labral osteochondral fragments leading to instability, which were fixed using a novel method. All six patients were male, with a mean age of 36.1 (range: 21 to 54) years, and the right side was involved in 5 patients. The mechanism of injury in every case was motor vehicle accident, and all presented a concurrent posterior dislocation at the time of the injury. Three patients presented a transverse acetabular fracture with associated posterior osteolabral fracture, and the other three, only osteochondral fragments associated with posterior dislocation. In the latter three patients, posterior dislocation was reduced in the emergency department under sedation, but they presented persistent dynamic instability. Therefore, surgery was planned, and dynamic instability was confirmed by stress testing in the operation theater (OT) under C-arm and obturator view of the hip. Open reduction as per the Matta criteria[5] was planned for the patients with an associated transverse fracture, and the osteochondral fragment was addressed when persistent posterior instability was noted after fixation of the transverse fracture.

All patients were operated using the Kocher Langenbeck approach. Surgical dislocation of the hip was not performed in any of the cases. Trochanteric flip osteotomy was performed in two transverse fractures and one posterior wall injury. In every case, the ostechondral fragments were so small that they could not be fixed using routine methods such as screws or spring plates (►**Figs. 1**–**2**). The fragments were stabilized using Kirschner wires with the lateral ends bent over the retroacetabular area, and a buttress plate (3.5-mm reconstruction plate) was applied over the bent and cut hairpin loop of the Kirschner wires to secure the fixation (►**Fig. 3**). Intraoperative movements were assessed immediately after fixation, and the concentricity of the reduction was checked using diagnostic imaging techniques after dynamic stress testing under all views. All six hips were stable and reduced while the osteochondral fragments were also securely fixed throughout the complete range of motion of the hip.

Isometric quadriceps strengthening exercises were started immediately after the procedure. The patients were kept on toe-touch weight-bearing mobilization with a walker frame for about four weeks, followed by gradually-increasing weight-bearing as per tolerance approximately eight to ten weeks after surgery, depending on the degree of radiographic consolidation of the fracture. The clinical outcome was



Fig. 1 Preoperative X ray of the left hip in anteroposterior (AP) view of a patient with posterior-wall small osteochondral avulsion after reduction of the hip dislocation.

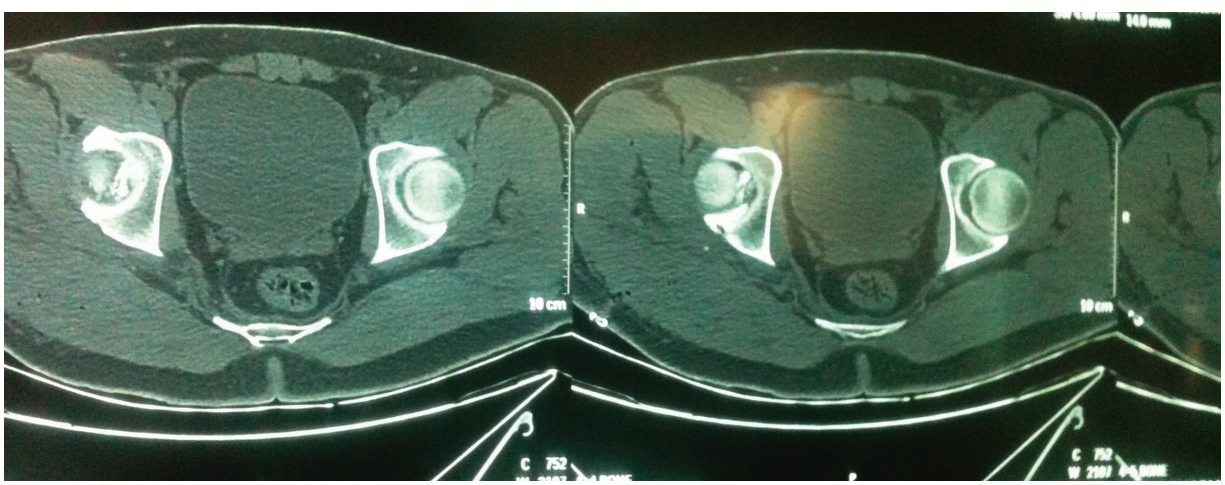


Fig. 2 Axial images of the preoperative computed tomography (CT) scan of the affected hip after reduction.

evaluated through the Harris Hip Score at 6 weeks, 3 months, 6 months, 1 year and at the final follow-up. The quality of the articular reduction and joint congruency were evaluated by postoperative plain radiographs using the Matta[5] classification (anatomic/imperfect/poor) and supplemented with three-dimensional (3D) CT scans. The radiological evaluation at the final follow-up was performed based on the Matta[5] criteria: excellent (hip joint with a normal appearance), good (mild changes with minimal sclerosis and joint narrowing < 1 mm), fair (intermediate changes with moderate sclerosis and joint narrowing $< 50\%$), and poor (advanced osteoarthritis changes). All patients were followed up for a minimum of 2 years (mean: 44 weeks; range: 24 to 66 weeks). There were no cases of surgical site infection, sciatic nerve injury, loss of reduction or non-union at the trochanteric osteotomy site**.** All acetabular fractures were united at the final follow-up, and the mean time until the union was of 6.4 (range: 4 to 10) months. The mean Harris Hip Score at the final follow-up was of 92.5 (range: 90.4 to 95.8). None of the patients developed features suggestive of hip AVN. The radiological outcome at the final follow-up was deemed excellent in four cases and good in two patients.

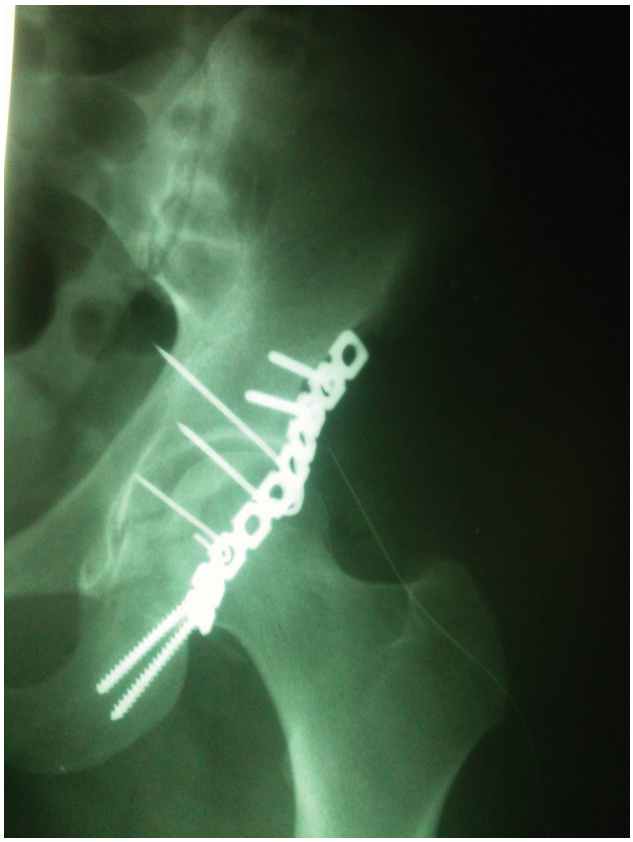


Fig. 3 Immediate postoperative hip X ray in AP view of the same patient.

Final Comments

Posterior dislocation of the hip with associated wall fracture is a common injury in high-energy RTAs. Persistent instability after reduction of the dislocation or fixation of the fracture should prompt physicians to look for any posterior osteolabral tears. Identification of a small acetabular "fleck sign" on hip radiographs in oblique view near the posterior wall, in the absence of any major acetabular fracture, is a marker of posterior labral avulsion, and it should be assessed thoroughly by stress testing using diagnostic imaging techniques to look for dynamic instability.[6] The choice of method of fixation in avulsions with small bony fragments remains arguable due to the fact that the fragment is not amenable to fixation with anchors, screws or plates, and the lack of stability when fixation is performed with Kirschner wires alone. In the present study, we described a novel technique to fix small osteochondral labral injuries using Kirschner wires and buttress plates over the bent wire ends. The buttress plates increased the stability of the Kirschner wire fixation and prevented pullout of the wires. The hips remained stable after fixation in the dynamic stress testing in the OT under imaging techniques and at all follow-ups. Our technique is a simple, cost-effective and reliable way to fix such avulsions with satisfactory outcomes.

Authors' Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by AS, SG, and RK. The first draft of the manuscript was written by AS, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Effects of Adipose-derived Stem Cells in the Treatment of Knee Osteoarthritis: A Case Report in Brazil's Unified Health System

Efeitos das células-tronco mesenquimais no tratamento da osteoartrite de joelho: Um relato de caso no Sistema Único de Saúde do Brasil

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Abstract

Osteoarthritis (OA) can incapacitate the individual to perform their activities of daily living due to pain. This is an important public health issue that worsens worldwide and in Brazil, since the population goes through an aging process, and has caused increased public spending on the monitoring and maintenance of treatments that can last for years and still not be resolutive. Thus, the search for innovative and effective therapies that can reduce costs becomes necessary. In this context, the present study reports the first application of cell therapy with adipose-derived stem cells in the treatment of cases of OA that are refractory to the conservative treatment, performed in the Brazilian Unified Health System (Sistema Único de Saúde, SUS). The evaluation was performed with the application of the Visual Analog Scale (VAS), the Short Form Health Survey (SF-36) and the Western Ontario and McMaster Universities (WOMAC), specifics for OA evaluation, and also an analysis of the synovial fluid (inflammatory cytokines). The cell therapy improved the scores on the WOMAC, SF-36 and EVA, and reduced the inflammatory process. We observed a decrease of 0.73x in the TNF, of 0,71x in IL-1b, of 0,68x in IL-8, and of 0,70x in IL-10. For IL-6, an increase of 1,48x was observed. Therefore, this cell therapy can be considered promising in aiding the

Keywords
- cell therapy
- inflammation
- joint pain
- orthopedics
- regenerative medicine
- Unified Health System

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management of this disease, since it improved the patient's pain, decrease inflammatory markers, and enabled the return to activities of daily living, which resulted in an improvement in their quality of life.

Resumo

A osteoartrite (OA) pode deixar o indivíduo incapacitado para realizar suas atividades da vida diária devido ao quadro álgico. Essa é uma importante questão de saúde pública que se agrava no mundo inteiro e no Brasil, uma vez que a população passa pelo processo de envelhecimento, e isso causa um aumento nos gastos públicos com o acompanhamento e manutenção dos tratamentos que podem perdurar por anos e mesmo assim não serem resolutivos. Assim, torna-se necessária a busca por terapias inovadoras e eficazes que possam reduzir esses custos. Nesse contexto, o presente estudo relata a primeira aplicação de terapia celular com células-tronco mesenquimais do tecido adiposo no tratamento de OA refratária ao tratamento conservador realizada no Sistema Único de Saúde (SUS). Na avaliação, foram usados os instrumentos Escala Visual Analógica (EVA), os questionários de qualidade de vida Short Form Health Survey (SF-36) e Western Ontario and McMaster Universities (WOMAC), específicos para avaliação da OA, e fez-se uma análise do líquido sinovial (citocinas inflamatórias). A terapia celular melhorou as pontuações no WOMAC, SF-36, e EVA, e reduziu o processo inflamatório. Observou-se redução de 0,73 × do TNF, de 0,71 × da IL-1b, de 0,68 × da IL-8, e de 0,70 × da IL-10. Já para a IL-6, observou-se aumento de 1,48 ×. Portanto, considera-se este tipo de terapia celular promissora no auxílio do manejo desta doença, pois melhorou o quadro álgico do paciente, reduziu os marcadores inflamatórios, e possibilitou o retorno às atividades da vida diária, o que resultou em uma melhora de sua qualidade de vida.

Palavras-chave
- dor articular
- inflamação
- medicina regenerativa
- ortopedia
- Sistema Único de Saúde
- terapia celular

Introduction

Adipose-derived stem cells (ADSCs) have interesting results in the treatment of osteoarthritis (OA).[1] Our preclinical results indicated that ADSCs, by paracrine effect and cell differentiation, can lead to improved repair and regeneration of cartilage.[2] These data were important to start a clinical study which will use ADSCs in the treatment of OA in humans, and to implement innovative therapies at the Cell Processing Center, in partnership with the Orthopedics Service at Universitary Hospital Maria Aparecida Pedrossian (HUMAP/EBSERH), in the city of Campo Grande, state of Mato Grosso do Sul (MS), Brazil.

The present study reports the results of the first cell therapy with ADSCs in a patient of the Brazilian Unified Health System (Sistema Único de Saúde, SUS).

Case report

A male patient, aged 66 years, weighing 93 kg, and 1,75m, with a diagnosis of medial meniscus rupture in the right knee, with grade III OA (in the Kellgreen and Lawrence classification through radiographic evaluation), and total prosthesis in the left knee. In the clinical evaluation, he reported intermittent pain in the right knee, presented joint cracking with movement, increased knee circumference, and decreased range of motion (ROM), only being able to flex the leg up to 95° without feeling pain. During the interview, we applied the Visual Analog Scale (VAS), the Short Form Health Survey (SF-36), and the Western Ontario and McMaster Universities (WOMAC) osteoarthritis index. The patient was then informed about the treatment with ADSCs and signed the free and informed consent form for the use of cell therapy.

The following week, a videoarthroscopy surgery was performed according to the routine of the Orthopedics Service (HUMAP/EBSERH) (►**Fig. 1C-D**), was performed only cleaning of the joint and light debridement of the affected cartilage. After one week, the patient returned to the hospital for the collection of adipose tissue, a procedure performed by liposuction.[3]

Regarding of the liposuction processing, extraction, culture, characterization (immunophenotyping: CD105, CD90, CD34 and CD133), and cell differentiation (adipogenic, chondrogenic and osteogenic) were performed according to Schweich et al.[4] (2017). The cultivation of ADSCs for transplantation occurred for 25 days (3rd passage), until reaching the necessary amount (►**Fig. 2**).[4] Bacteriological testing was performed before the cell therapy. Then, the patient returned and received an intra-articular injection containing 1×10^7 of ADSCs homogenized in 3 mL of saline solution (►**Fig. 2**). A bandage was applied around the treated knee to avoid limb flexion in the first 12 hours.

The collection of synovial fluid occurred in two moments: in the operating room, before the videoarthroscopy (►**Fig. 1B**), and after six months of cell therapy. For the analysis of the

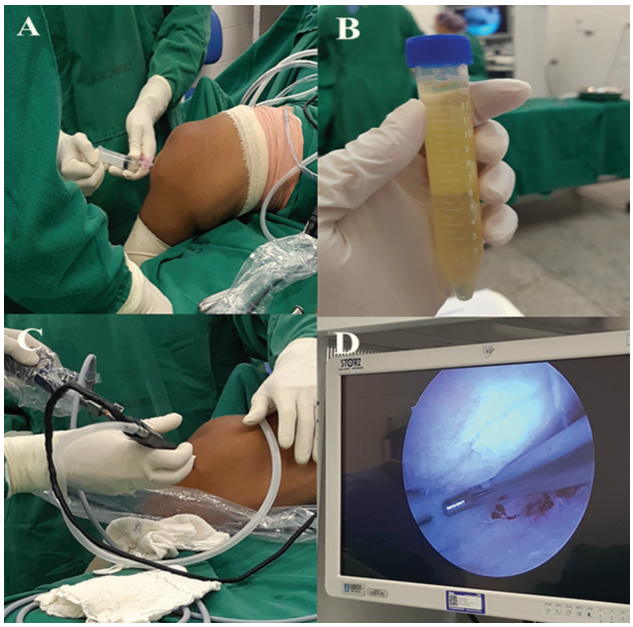


Fig. 1 Videoarthroscopy surgical procedure. (**A**) Arthrocentesis. (**B**) Collected synovial fluid. (**C**) Positioning of the surgical instruments and entry sites. (**D**) Visualization of articular cartilage to clean debris or areas without leveling.

inflammatory process, we used the CBA Human Inflammatory Cytokines KIT (BD Biosciences, Franklin Lakes, NJ, US), according to the manufacturer's instructions, by flow cytometry (Cytoflex, Beckman Coulter, Inc., Brea, CA, US).

Regarding the results of the cell therapy, we observed that, in the evaluation of the domains of the SF-36 questionnaire, functional capacity and limitation by physical aspects improved by 3x pain by 2,6x, social aspects by 2,5x, the emotional aspects by 2x, mental health by 1,4x and general health and vitality by 1.1x (►**Fig. 3A**).

The WOMAC questionnaire indicated a reduction in the score of the domains in both evaluations at three and six months after the cell therapy. In the second evaluation, in relation to the initial condition, the decrease was 0,55x in

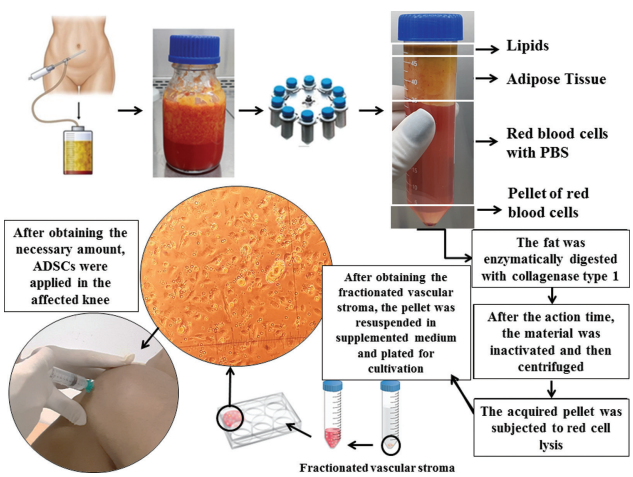


Fig. 2 Flowchart of the procedures to obtaining and process lipoaspirate, cultivation of adipose-derived stem cells, and application in the knee with osteoarthritis.

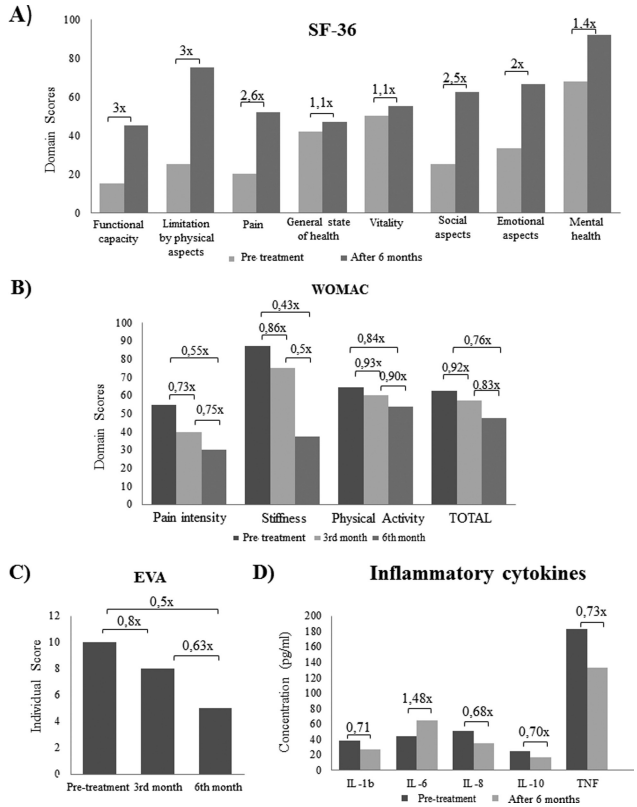


Fig. 3 Values acquired after proposed evaluations, in the period before and after treatment with ADSCs. (**A**) Score of the SF-36 questionnaire applied before the intervention and after 6 months. (**B**) WOMAC questionnaire scores before the intervention, at the 3rd month and at the 6th month. (**C**) EVA classification performed before the intervention, in the 3rd month and in the 6th month. (**D**) Quantification of inflammatory cytokines before intervention and at the 6th month.

pain intensity, 0,43x in stiffness, 0,84x for physical activity and 0,76x in the total score (►**Fig. 3B**).

The EVA scale showed a descrease of 0,8x and 0,63x for the first (3 months) and second (6 months) assessments, respectively (►**Fig. 3C**).

The macroscopic evaluation of the synovial fluid showed improved viscosity, reduction of opacity, and greater homogeneity. The evaluation of inflammatory cytokines showed a decrease of 0,73x of TNF, 0,71x of IL-1b, 0,68x of IL-8 and 0,70x of IL-10. In IL-6, an increase of 1.48x was observed (►**Fig. 3D**).

Discussion

The way of action of ADSCs in the treatment of OA occurs through three different biological effects: cell differentiation, inflammatory modulation (paracrine effect) and mediation of condroprotectors.[5] In the present report, the scores on the SF-36, WOMAC and EVA demonstrate that cell therapy can improve the condition of patients with OA, since it improves the functionality of the affected limb and the patient as a whole, which reflects in the return to activities of daily living and improvements in the overall quality of life, these results corroborate with the current literature.[6,7]

In the pathogenesis of OA, the predominance of the IL-6, IL-1b and TNF cytokines stands out. These cytokines have the

ability to activate multiple inflammatory pathways, and they may increase disease severity, joint swelling and cartilage destruction.[8] In the present case report, a decrease in the levels of IL-1b, IL-8, IL-10, and mainly TNF, was also observed. With the reduction in these cytokines, it can be suggested that there was a decrease in the local inflammatory process, which aided in the improvement of the degenerative picture of this joint. However, with the specific decrease of IL-10, which is an anti-inflammatory cytokine,[9] it is observed that there is a need for further studies that can describe/understand how ADSCs modulate the inflammatory process in this disease. The only cytokine that increased was IL-6, which is related to the activation of target genes involved in cell differentiation, proliferation and apoptosis.[8] Thus, we infer this increase due to the mild debridement performed during the videoarthroscopy surgery, since it stimulates proliferation/differentiation.

The reduction in the inflammatory process, suggested by the modulation of cytokines, may explain the improvement in the viscosity of the synovial fluid, as well as the reduction in opacity, since the inflammatory process causes an influx of cells into the joint cavity. Therefore, with the reduction in the number of cells, there is a reduction in opacity. In addition to this, and to the increased homogeneity, we observed a reduction in fibrin and remnants of cartilage wear that are also favored by the inflammatory process that has been reduced.[10] These facts are important, since the quality of the synovial liquid is an indicator of the quality of the articular cartilaginous tissue.

We conclude that cell therapy with ADSCs in patients with OA refractory to the conservative treatment can be considered a promising alternative in aiding in the management of this disease, since there is an improvement in pain, and return of the patient to their activities of daily living.

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

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Early Intraprosthetic Dislocation of Total Hip Arthroplasty with Double Mobility Implant: Case Report

Luxação intraprotética precoce de artroplastia total do quadril com implante de dupla mobilidade: Relato de caso

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Abstract

Total hip arthroplasty (THA) is a successful surgery in the treatment of hip pain, but there are potential complications, of which dislocation is one of the most common. Dislocation management is a challenging problem that requires a multimodal approach, and the use of dual mobility implants is an option. We present a patient with a history of femoral neck fracture who underwent THA with a double mobility implant. On the 18th postoperative day, after a fall to the ground, she developed prosthesis dislocation and had a complication after closed reduction, a subsequent intraprosthetic dislocation. After a radiographic diagnosis, the patient presented mechanical signs of hip flexion caused by a disassociated double mobility implant. The revision surgery was indicated, but the patient chose not to perform the necessary surgical procedure. A careful postoperative study of the radiographs revealed an eccentric femoral head and evidence of disassociated implantation in the surrounding soft tissues. Radiographs after closed reduction of intraprosthetic dislocations should be examined thoroughly.

Keywords
- arthroplasty, replacement, hip
- hip
- hip dislocation
- periprosthetic fractures

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Resumo

A artroplastia total do quadril (ATQ) é uma cirurgia bem-sucedida no tratamento da dor no quadril, mas existem complicações potenciais, das quais a luxação é uma das mais comuns. O gerenciamento das luxações é um problema desafiador que requer uma abordagem multimodal, e o uso de implantes de mobilidade dupla é uma opção. Apresentamos uma paciente com história de fratura do colo do fêmur que foi submetida a ATQ com um implante de dupla mobilidade. No 18° dia pós-operatório, após queda ao solo, a paciente evoluiu com luxação da prótese e teve uma complicação após redução fechada, uma luxação intraprotética subsequente. Após um diagnóstico radiográfico, a paciente apresentou sinais mecânicos na flexão do quadril causados por um implante de mobilidade dupla desassociado. A cirurgia de revisão foi indicada, mas a paciente optou por não realizar o procedimento cirúrgico necessário. O estudo pós-operatório cuidadoso das radiografias revelou uma cabeça femoral excêntrica e evidências do implante desassociado nos tecidos moles circundantes. As radiografias após a redução fechada das luxações intraprotéticas devem ser examinadas minunciosamente.

Palavras-chave

- artroplastia de quadril
- fraturas periprotéticas
- luxação do quadril
- quadril

Introduction

Instability is one of the most feared complications of hip arthroplasty, corresponding from between 0.2 and 7% of primary arthroplasties to 25% in review cases.[1]

In the 1970s, Giles Bousquet, aiming to reduce this index, developed the concept of double mobility. This consists of two joints, a larger one between the polyethylene liner and the metal acetabular cupula, and the other, smaller, between the femoral head and the polyethylene liner, increasing the radius between the head and the neck and the distance to impact between the neck and the acetabular edge, reducing dislocation rates in this type of prosthesis.[2]

In this implant, early intraprosthetic dislocation (dissociation between the femoral head and polyethylene) is extremely rare, with few cases described. The causes of early intraprosthetic dislocation are inadequate assembly of components and dislocation or forced reduction. Other causes are the extrinsic blockage of polyethylene coating or polyethylene wear (debris would compromise the coupling of the two bearings), which occurs years after the procedure, not being common in early dislocation.[3]

Radiographic recognition of intraprosthetic dislocation after reduction may be difficult, because the head of the femoral component may be located within the metallic acetabular cup, while the polyethylene component is displaced. Radiographic signs of an intraprosthetic dislocation include eccentricity of the femoral head inside the metallic acetabulum and the presence of a "bubble sign" on post-reduction radiography, representing polyethylene.[4] Immediate recognition is essential for planning open reduction and exchange of polyethylene liner.

Case Report

Female patient, 85 years old, with a history of fall to the ground. She was treated in the emergency room with hip pain, shortening and external rotation in the left lower limb. The radiographic examination revealed the diagnosis of fracture of the neck of the left femur, AO 31B1.1 (►**Fig. 1a-b**).

The patient underwent total arthroplasty of the left hip with double mobility implant (Medacta). A 48/28 double mobility polyethylene liner, size 1 uncemented femoral stem, a 28 mm metallic femoral head, and a 48 mm non-cemented acetabular dome were used. Posterolateral access was performed with capsular repair and short rotators.

The choice of the double mobility prosthesis occurred due to risk factors for instability: age $>$ 75 years, flexibility, hypermobility, active life, female gender.[5]

The polyethylene liner was properly coupled to the metal head with specific material and tested before being deployed. Stability tests and intraoperative control radiographs were performed, confirming good implant positioning and hip stability (►**Fig. 2a-b**).

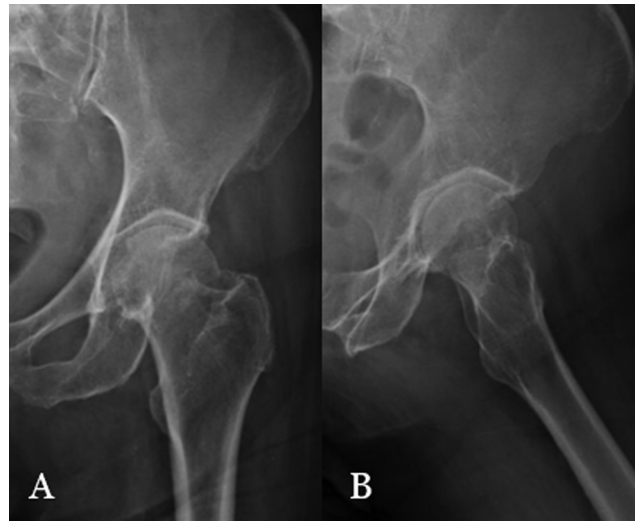


Fig. 1 Fracture of the neck of the left femur impacted in valgus, in AP (A) and profile (B).

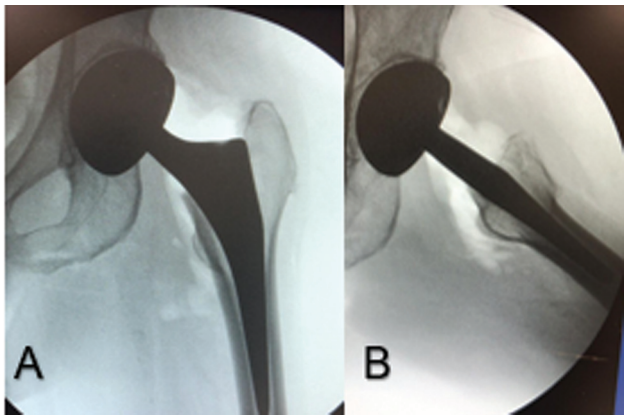


Fig. 2 Radiographic control in the immediate postoperative period showing reduction of components and concentricity of the metallic head (A) in AP and profile (B).

On the 18th postoperative day, after a fall to the ground, the patient was treated in the emergency room, complaining of pain in her left hip. Radiographs of the hip showed upper posterior dislocation of the prosthesis (►**Fig. 3**).

The closed reduction was performed with sedation (propofol), using the reduction maneuver of Allis apud Waddell et al.[6] and radiographic control. She returned to the outpatient clinic on the 7th day after reduction in good general



Fig. 4 X-ray 7 days after reduction. The larger arrow shows the "bubble sign", the polyethylene displaced in the soft parts. The smaller arrows show the eccentricity of the metal head in the acetabular dome.



Fig. 3 Panoramic radiography of the basin showing posterosuperior dislocation of the left hip prosthesis.

condition, without functional limitation, complaining only of crackling in the posterior region of the left hip. Radiographs after reduction show congruence between the femoral head and the acetabular dome, but femoral head eccentricity is observed in the acetabular metallic dome (►**Fig. 4**). A superolateral circular opacity (bubble sign) is also observed. Computed tomography (CT) reveals a polyethylene component in the posterosuperior aspect of the hip (►**Fig. 5**).

The patient underwent outpatient follow-up. She can perform all daily activities without functional limitation. The only complaint was polyethylene crackling which improved with ~ 60 days. She did not present other episodes of dislocation. Due to the absence of symptoms and high surgical risk (chronic renal failure and severe heart disease), both the patient and the responsible physician chose not to perform revision surgery.

Discussion

In our case, the patient presented complications after a single attempt at closed reduction, in which the maneuver strength resulted in intraprosthetic displacement of the polyethylene. This complication occurs when the polyethylene coating fits into the edge of the acetabular component, and the

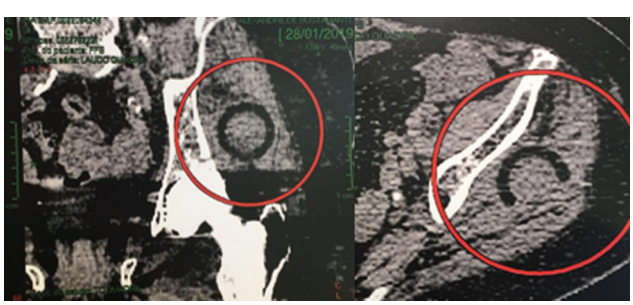


Fig. 5 (A) Coronal section of computed tomography. The red circle shows polyethylene component in soft tissues, (B) In the axial cut, a red circle evidencing polyethylene.

subsequent traction of the limb results in the dissociation of the metal head from the polyethylene coating, similar to a "bottle opener" effect, and polyethylene can migrate out of the acetabulum.

Intraprosthetic dislocation can be a diagnostic challenge, especially in postreduction radiographs, because the femoral head can give the false impression of being reduced in the dome.

When evaluating a dislocation after hip arthroplasty, it is necessary to differentiate a conventional prosthesis from a double mobility implant. The presence of crackling or noise associated with the request of the motion arc is a sign of direct contact between the head and the acetabular dome. The x-ray should be made with close attention to the eccentricity of the head in the acetabular component. The possible presence of an opaque radio halo in the periarticular region ("bubble sign"), which may represent dislocated polyethylene, should also be observed.

The reduction in these patients should be performed with general anesthesia or subarachnoid block, in order to facilitate it. The maneuver should be performed carefully and without axial traction to avoid or attenuate the "bottle opener" effect. Instead of applying direct axial traction, internal rotation should be coupled to axial traction, allowing the polyethylene coating to move away from the acetabulum, avoiding the collision of the acetabular component. Fluoroscopic imaging should be used to guide the reduction maneuver. Postreduction radiographs should be carefully evaluated for femoral head eccentricity and the presence of a bubble sign. Intraprosthetic dislocation requires surgical intervention, and anesthesia should be used for open reduction and eventual component replacement. Computed tomography may be requested in case of doubt. The suggestion would be to place a metallic marker on the polyethylene that would facilitate its detection on radiographs.

With the popularization of dual mobility prostheses in our country, training and information of orthopedists are needed in the emergency room for this possible complication that is easy to be neglected. The examining physician should question and know how to identify the implant model and evaluate the signs of this complication: femoral head eccentricity in the acetabular dome, "soft tissue bubble sign", crackling or deformity on joint palpation after reduction.

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

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Treatment of Two-column Acetabular Fractures by Double Extrapelvic Approach: Three Clinical Cases

Tratamento de fraturas acetabulares de duas colunas por dupla via extrapélvica: Três casos clínicos

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Abstract

Fractures of two columns of the acetabulum according to the Letournel classification are among the most common in frequency, indication and surgical complexity. These are mainly the result of lateral compression mechanisms and are characterized by originating a disconnected acetabulum from the axial skeleton. Its surgical treatment may include: isolated anterior or posterior approach; combined, at the same surgical time or not; or broad approaches. The authors present another surgical option with association of the Kocher-Langenbeck pathway with the iliac crest approach simultaneously and in the same positioning (lateral decubitus) based on the first three clinical cases performed and their clinical and imaging results. In addition to the presentation of the cases, a description of the three characteristic fragments of this type of acetabular fractures, the approach pathway, and the reduction sequence performed are made. From the results obtained and the associated advantages, the authors believe that the addition of the iliac crest approach to the Kocher-Langenbeck pathway may be a very attractive option to consider in the surgical treatment of properly selected fractures of two columns of the acetabula.

Keywords
- acetabulum
- fractures, bone
- pelvis

Resumo

As fraturas de duas colunas do acetábulo segundo a classificação de Letournel são das mais comuns em frequência, indicação e complexidade cirúrgica. Estas resultam essencialmente de mecanismos de compressão lateral e caracterizam-se por originarem um acetábulo desconectado do esqueleto axial. O seu tratamento cirúrgico pode incluir: abordagem anterior ou posterior isolada; combinadas, no mesmo tempo cirúrgico ou não; ou abordagens alargadas. Os autores apresentam outra opção

Palavras-chave
- acetábulo
- fraturas ósseas
- pelve

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cirúrgica com associação de via de Kocher-Langenbeck e abordagem da crista ilíaca simultânea e no mesmo posicionamento (decúbito lateral) com base nos três primeiros casos clínicos realizados e seus resultados clínicos e imagiológicos. Para além da apresentação dos casos, é feita uma descrição dos três fragmentos característicos deste tipo de fraturas acetabulares, da via de abordagem e da sequência de redução realizada. Pelos resultados obtidos e vantagens associadas, os autores acreditam que a adição da abordagem da crista ilíaca à via de Kocher-Langenbeck pode ser uma opção muito atrativa a ter em conta no tratamento cirúrgico de fraturas de duas colunas do acetábulo devidamente selecionadas.

Introduction

Acetabulum fractures constitute 2 to 8% of all fractures and result mostly from high-energy trauma.[1,2] Since 1964, with Judet and Letournel, osteosynthesis of deflected acetabulum fractures is believed to ensure better results than conservative treatment.[2] Fractures of two columns of the acetabulum, according to the Letournel classification, are one of the three most common types in frequency, indication, and surgical complexity, with the initial deviation and the presence of intra-articular fragments being the greatest predictors of a less favorable result, and the reduction closer to the anatomical the main predictor of good results.[1–7] These fractures result essentially from lateral compression mechanisms, being the only type of fracture that reaches the two columns whose fracture traces are above the acetabulum, causing a floating acetabulum, without any part connected to the axial skeleton.[1,4,8] Surgical options include: anterior approach with indirect reduction and fixation of the posterior spine; anterior approach followed by posterior approach, either at the same surgical time (which implies repositioning), or in different surgical times; posterior approach followed by an anterior approach, which is a rare approach, since it should usually start with the anterior route; extended iliofemoral approach, increasingly unadvised because of its high extent and aggressiveness; posterior approach with indirect reduction and fixation of the anterior spine.[2,4,6,8,9] In line with this latter option, the authors present a surgical option (double simultaneous and lateral decubitus approach: Kocher-Langenbeck approach and iliac crest approach) based on the first three clinical cases and their clinical and imaging results.

Case Report

Case 1

Female patient, 59 years old, victim of a hit-and-run, arrives at our center with trauma to the right hemi-hip. The imaging study allowed the diagnosis of a fracture of the two columns of the acetabulum with posterior iliac involvement and central dislocation of the femoral head. Skeletal traction was applied to the femoral condits with weight corresponding to 10% of the body weight, and the patient was hospitalized. After surgical planning, progress was made for definitive treatment: reduction and osteosynthesis of the iliac with two plaques and reduction of the posterior spine fracture, and osteosynthesis with plaque via the Kocher-Langenbeck route combined with the iliac crest approach. For better access to the anterior fracture component, fixed with two plates, osteotomy of the large trochanter was required. The postoperative protocol was one commonly used in the institution for this type of lesions and common to the following cases: early initiation of mobilization and muscle strengthening according to scar evolution, discharge of the operated limb during the first 6 weeks and progressive partial load during the following 6 weeks, with total autonomous load allowed at 3 months. With 3 years of evolution, the patient is satisfied, without pain, with autonomous gait and joint mobility similar to the contralateral pelvis, with a Harris Hip Score of 84 points (►**Fig. 1**).

Case 2

A 49-year-old male patient was admitted to the emergency department after a 7-meter-high fall with trauma to the right hemi-hip and thoracic trauma, resulting in costal arches fractures with associated pneumothorax and fracture of the two columns of the acetabulum with high extension to the iliac and with central dislocation of the head. After evaluation and multidisciplinary stabilization, we opted for a closed reduction of the central dislocation under anesthesia with fluoroscopic control and application of skeletal traction in the distal femur. After clinical stabilization, definitive surgical treatment was performed: open reduction and osteosynthesis via the Kocher-Langenbeck route combined with the iliac crest approach. The patient complied with the rehabilitation protocol and, at 9 months of evolution, the patient is satisfied and walking without support or limitation in daily life activities, with a Harris Hip Score of 95 points (►**Fig. 2**).

Case 3

A 69-year-old male patient referred from another institution after a 3-meter-high fall that resulted in a fracture of the two columns of the left acetabulum with high extension to the iliac. After clinical stabilization, complete imaging study and planning, definitive surgical treatment was performed: open reduction and osteosynthesis with posterior spine plate, indirect reduction of the anterior spine and open reduction of iliac fracture, and fixation with two plates and screw in compression via the Kocher-Langenbeck route combined

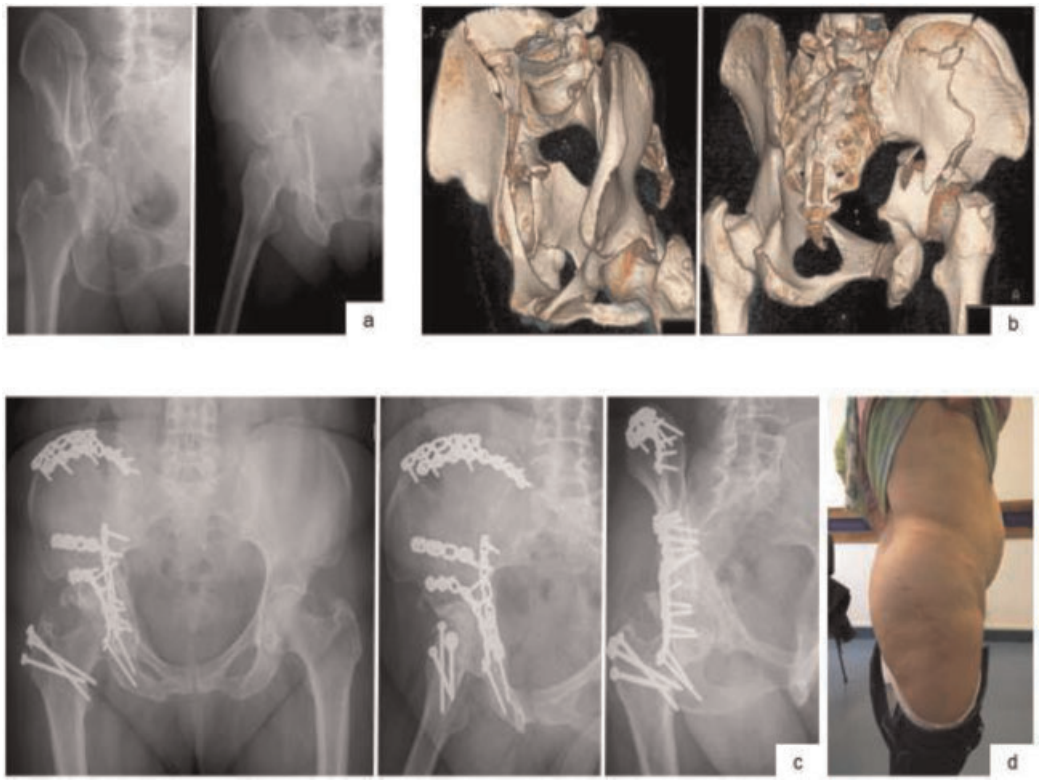


Fig. 1 X-ray images at obturator oblique and oblique acetabular views, with typical spur sign on the first image (**a**) 3D reconstructions (**b**) Radiological control *in inlet, alar* and obturator at the 3rd postoperative year (**c**) Photograph of the patient with scars of the routes used (**d**).

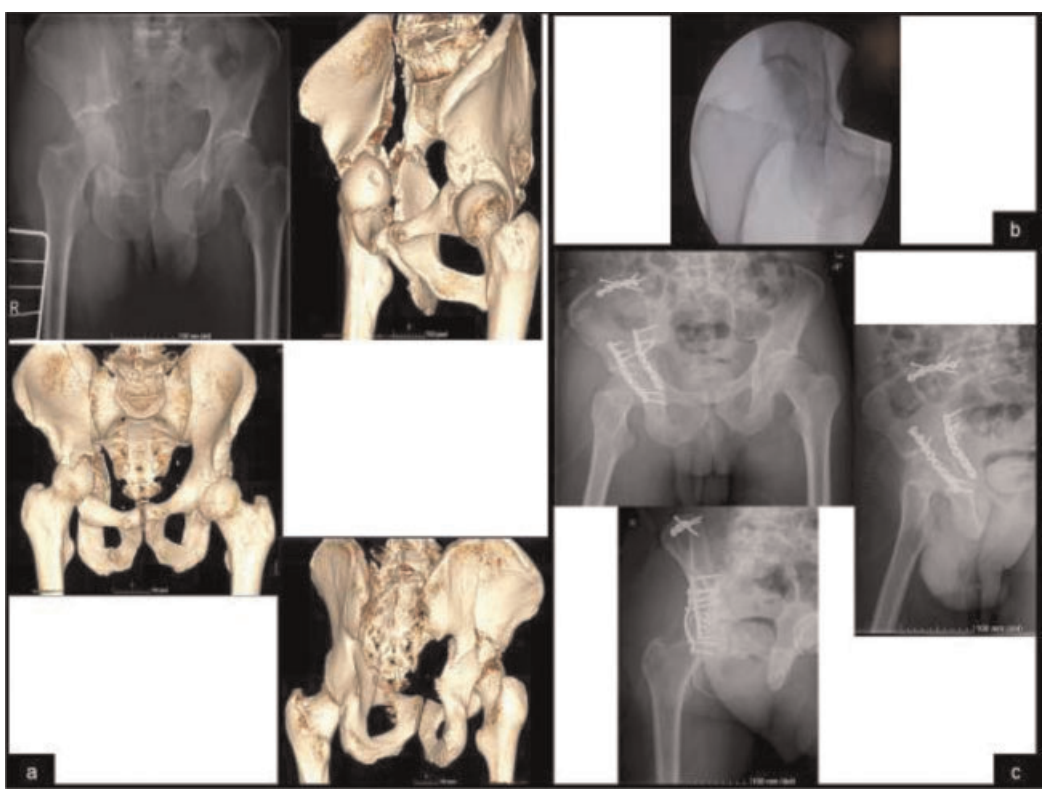


Fig. 2 Images of anteroposterior radiography of the pelvis and 3D ACT images for better characterization of the fracture of two columns of the right acetabulum with high extension to the iliac (**a**) Intraoperative image after maneuvers to reduce central dislocation (**b**) Radiological control in the anteroposterior view of the right pelvis, obturator oblique and oblique acetabular view of the right pelvis in the postoperative period, with acceptable reduction and absence of intra-articular screws.

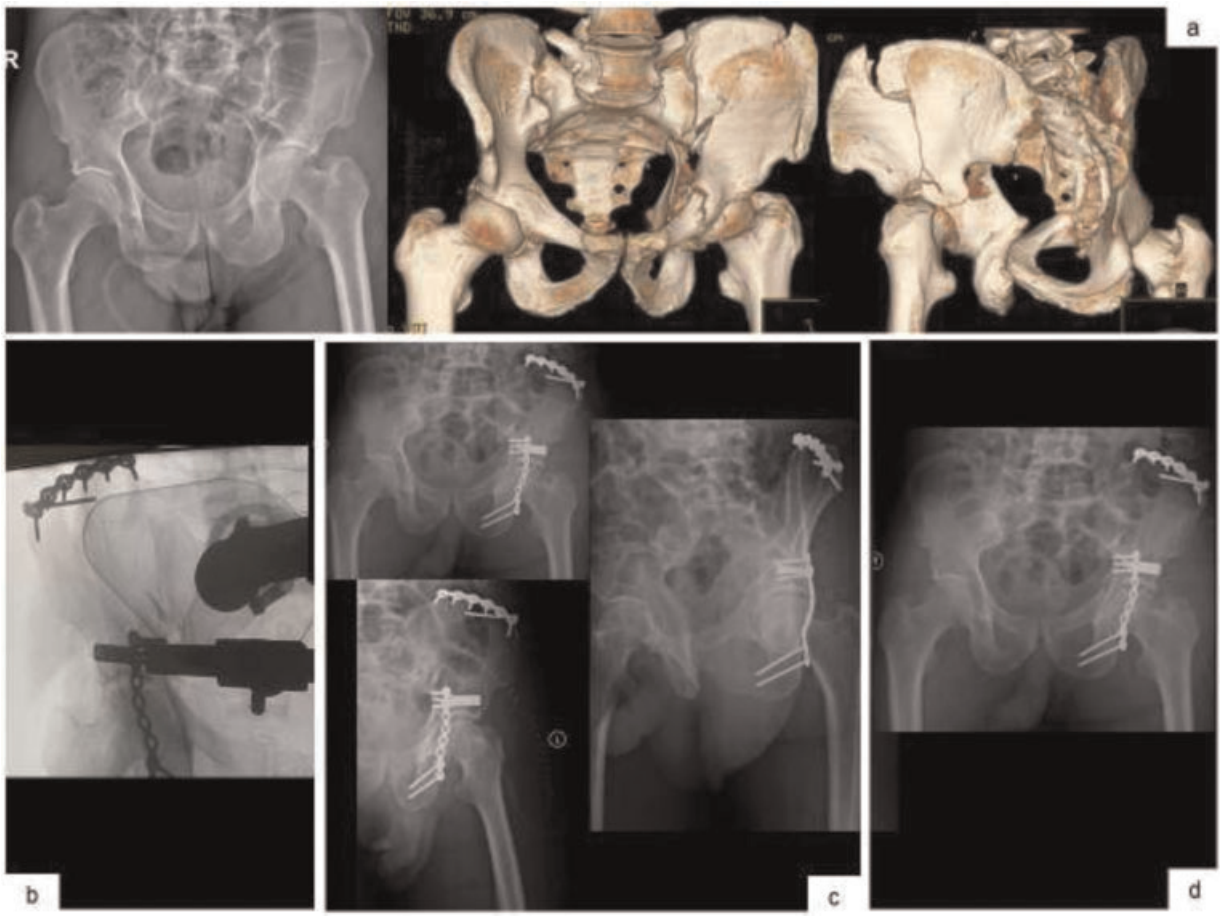


Fig. 3 Images of anteroposterior radiography of the pelvis and 3D ACT images for better characterization of the fracture of two columns of the left acetabulum with high extension to the iliac (**a**) Intraoperative control image (**b**) Radiological control in the anteroposterior view of the pelvis, obturator oblique and oblique acetabular view of the left pelvis in the immediate postoperative period (**c**) Anteroposterior radiograph of the pelvis at the 3rd month (**d**).

with the iliac crest approach. With 7 months of evolution, the patient presents autonomous gait and is without pain, with a Harris Hip Score of 91 points (►**Fig. 3**).

Discussion

Two-column fractures are among the most common acetabular fractures and are characterized as complex and surgically challenging.[1–5,7] The three clinical cases presented in the present case report represent much of what characterizes them: mechanisms of high energy injury, essentially lateral energy vector, and junction of fracture traces above the acetabulum, which is disconnected from the axial skeleton. The surgical decision and planning for patients with this type of lesion requires experience in the different acetabular approaches and implies a deep understanding of the mechanism of injury and diversion of fragments. A detailed evaluation of the patient and of the associated lesions, and a complete imaging study including 3D computed tomography (CT) reconstructions is essential. This planning is the most important step for global success. The authors present three clinical cases in which the characteristics of the lesion dictated the option taken. ►**Fig. 4** shows the positioning and the approach, and ►**Fig. 5** is representative of the suggested reduction and fixation sequence. In the opinion of the authors, the main advantages of this option are: extrapelvic surgery, performed in a single surgical time



Fig. 4 Positioning of the patient in lateral decubitus and prior marking of the incisions (a) Posterior view of the positioning, and the image intensifier enters in this plane (**b**).

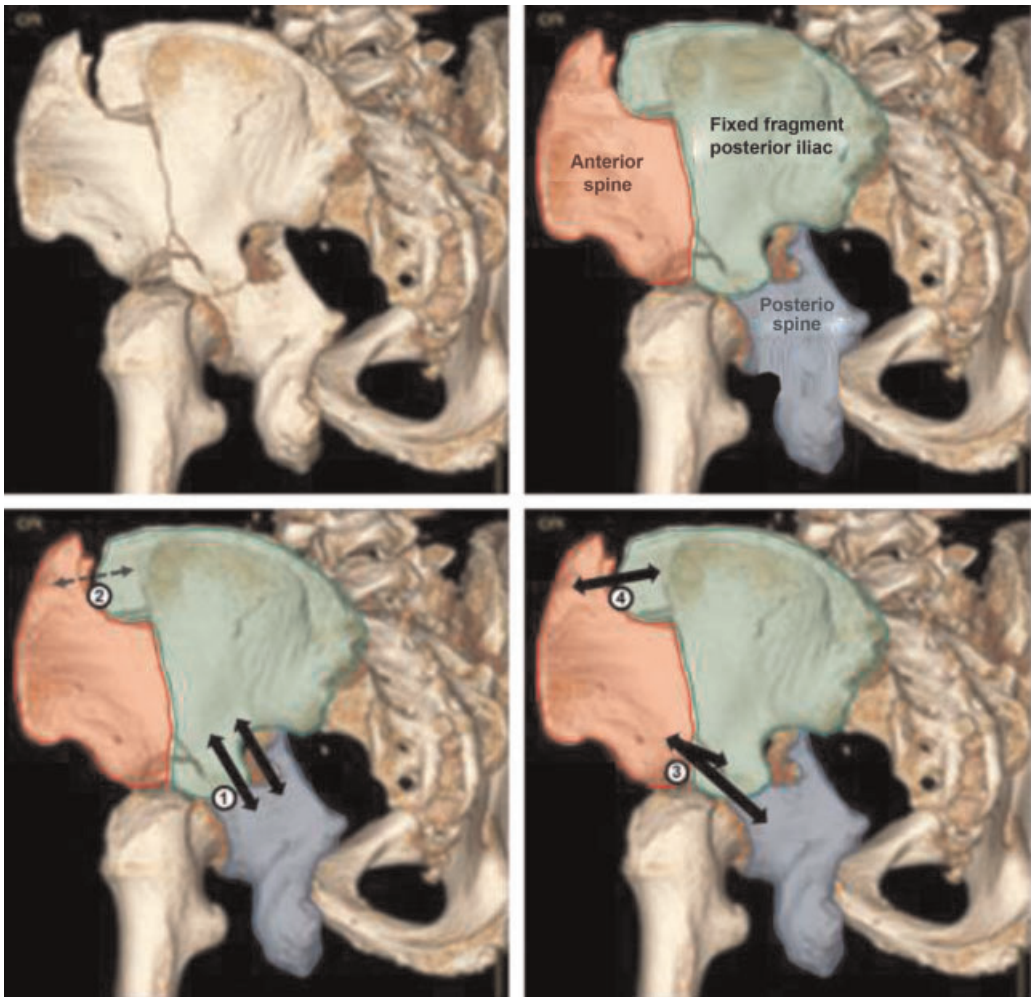


Fig. 5 Above: The three main fragments of fractures of two columns of the acetabulum: anterior column, posterior column, and posterior iliac. The latter is connected to the axial skeleton and encompasses the sciatica chamfering; the anterior column (with essentially medial deviation) and the posterior column (with medial and posterior deviation) are free, with their deviation more easily noticeable in the obturator oblique view, where the sciatic chamfering in situ laterally and the medial deviation of the columns and acetabulum (spur sign) are visualized. (6) Below: suggested order of reduction and osteosynthesis of fragments by simultaneous approaches (Kocher-Langenbeck route and iliac crest approach): 1st – reduction and fixation of the posterior column to the posterior iliac; 2nd – temporary reduction of the upper portion of the anterior spine to the posterior iliac; 3rd – reduction of the distal part of the anterior column and its fixation to the posterior iliac and/or posterior column; 4th – definitive fixation of the upper portion of the anterior column to the posterior iliac.

and positioning, without a potential for complications similar to that of an extended approach. Additionally, in case of intra-articular fragments or associated fractures of the femoral head, it is possible to associate safe pelvis dislocation. In conclusion, despite the need for more forward-looking, randomized, and comparative studies, with relevant samples and follow-up time, the authors believe that the addition of the iliac crest approach to the Kocher-Langenbeck route may be a very attractive option to take into account in the surgical treatment of fractures of two acetabulum columns with greater posterior spine deviation and high extension to the iliac pathway.

Free and Informed Consent

The free and informed consent form was obtained from the patients for the publication of data regarding the cases.

Conflict of Interests

The authors have no conflicts of interests to declare.

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Strategy for the Conservative Treatment of Type-III Camptodactyly in Children with Beals-Hecht Syndrome

Estratégia para o tratamento conservador da camptodactilia de tipo III em criança com síndrome de Beals-Hecht

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Abstract

The authors present a successful case in the conservative treatment of type-III camptodactyly in a patient with Beals-Hecht syndrome. Camptodactyly is a flexion deformity of the proximal interphalangeal (PIP) joint, in the anteroposterior direction, painless and bilateral in 2/3 of the cases. Type-III is the most severe and disabling form, as it usually affects several fingers and is associated with syndromes and other malformations. The case herein reported had the correction achieved with the systematic use of static orthoses started at 7 months of age and completed after 23 and a half months of the intervention.

Keywords
- congenital hand deformities
- finger joints
- orthoses
- rehabilitation

Resumo

Os autores apresentam um caso bem-sucedido no tratamento conservador da camptodactilia de tipo III em paciente com síndrome de Beals-Hecht. A camptodactilia é uma deformidade em flexão da articulação interfalangeana proximal (IFP), no sentido anteroposterior, indolor, e bilateral em 2/3 dos casos. A de tipo III é a forma mais grave e incapacitante, pois geralmente acomete vários dedos e está associada a síndromes e outras malformações. O caso apresentado teve a correção alcançada com o uso sistemático de órteses estáticas iniciado aos 7 meses de idade e concluído após 23 meses e meio de intervenção.

Palavras-chave
- articulações dos dedos
- deformidades congênitas da mão
- órteses
- reabilitação

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Introduction

Camptodactyly is a flexion deformity of the proximal interphalangeal (PIP) joint of congenital and non-traumatic origin. It is a rare condition, with a prevalence of approximately 1%, with the fifth finger being the most affected.[1] It is classified into types I, II and III. Type I: infantile camptodactyily, which usually affects the little finger in isolation. Type II: adolescent camptodactyl, which has a rapid evolution with the growth spurt. Type III: present at birth, it affects several fingers, and is associated with other syndromes. Camptodactyly affects structures that cross the joint, and they are implicated as one of the possible causes. Changes in the skin, aponeurosis, tendons, lumbrical muscle, superficial flexor muscle of the fingers and ligaments can be found.[1] The initial treatment is conservative, with the use of orthoses and passive stretching, or surgical stretching.[2] In cases in which flexion of the PIP joint is $\geq$ 60°, surgery is the choice procedure.[3,4]

Beals-Hecht syndrome is a rare syndrome diagnosed in less than 1 in 10 thousand patients worldwide.[5,6] The clinical picture consists of congenital contractures of multiple joints,[7] long and slender limbs, congenital contratural arachnodactyly, kyphoscoliosis, and anomalies of the auricular pavilions.[3] The contractures may reduce in severity, but the camptodactyly present in the fingers persists.[7]

Case Report

A 6-month-old white male patient cared for at the Hand Surgery Outpatient Clinic of our institution for the first time in October 2013. The presence of some clinical signs was observed: PIP joint flexion of the middle, ring and little fingers, flexion of the wrists and hyperextension of the metacarphalangeal (MCP) joints bilaterally, changes in the auricular pavilion, and pectus excavatum. All the contractures present were rigid. He was diagnosed with type-III camptodactyily, and we opted for the conservative treatment with orthotization in November 2013. The initial goniometry of the patient was not performed due to the difficulty in execution, and a photographic record was made (►**Fig. 1A-E**). The flexion contractures of the PIP joint presented more than 90°. The use of static orthoses was initially uninterrupted,[8] and the follow-up visits occurred every three months for adjustments in the orthoses or to change them.

The orthotization process began at seven months of age. The initial objective was to reach the neutral position of the

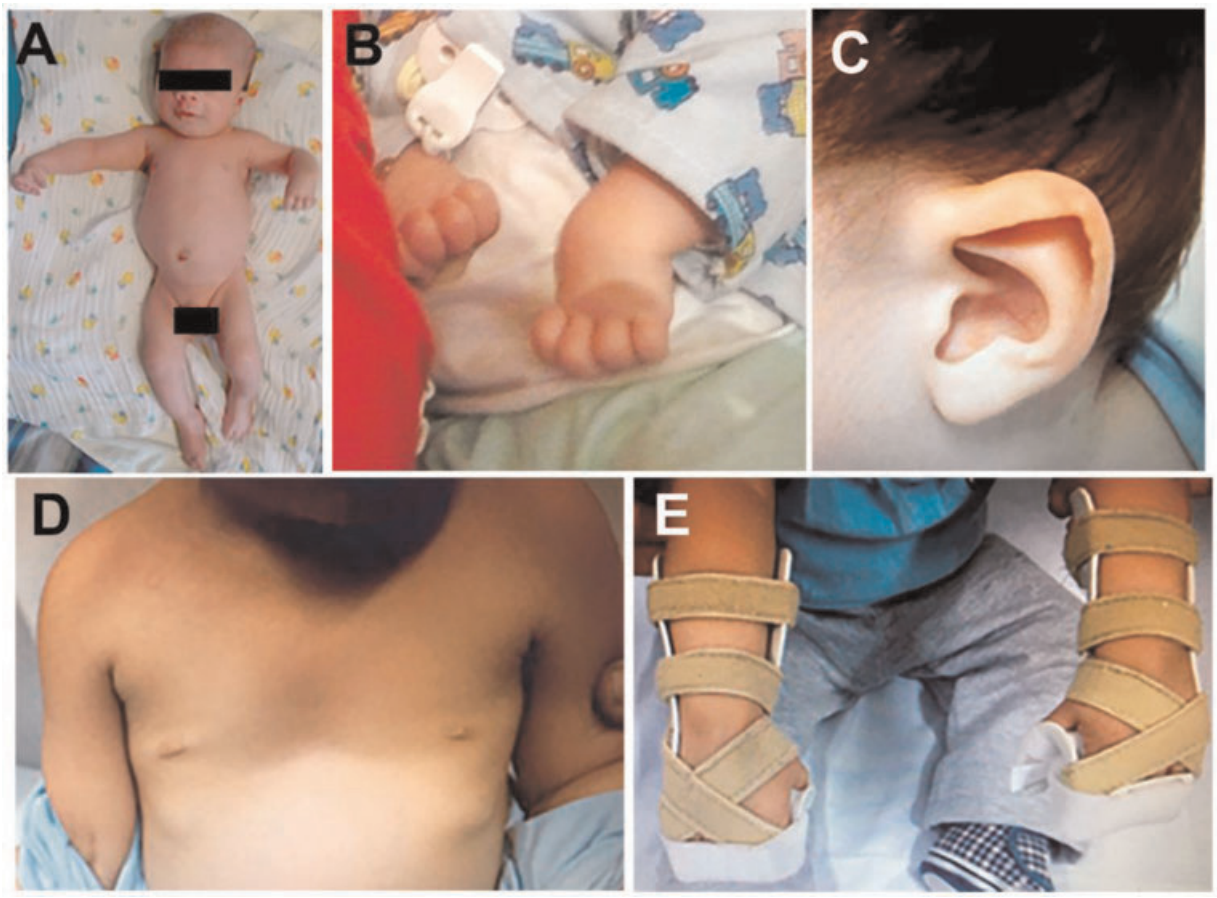


Fig. 1 Phenotypic features of the patient with Beals-Heacht syndrome. Two-month-old patient (**A**) with deformities in the wrist and metacarpophalangeal and proximal interphalangeal joints (**B**), anomalies in the auricular pavilion (**C**), pectus excavatum (**D**), and positioning orthosis with dorsal support (**E**).



Fig. 2 Demonstration of the evolution of the conservative treatment of the patient with camptodactyly. Beginning of the correction (**A**), positioning orthosis with maintenance of the dorsal support (**B**), nocturnal orthosis with free thumbs and ethylene-vinyl acetate (EVA) plate in the dorsal region of the fingers (**C**), nightly use of orthosis in lateral view (**D**) and complete extension of fingers (**E**).

PIP joint flexion, wrist flexion and MCP joint hyperextension, achieved in February 2015 (►**Fig. 2 A-E**).

After reaching the neutral position, the orthosis was modified, starting with a slight flexion of the MCP joint and dorsal support device following the angulation of the orthosis to exert pressure on the fingers against the orthosis, thus maintaining the position besides assisting the flexion of the MCP. From July 2015, already at 26 months, the orthosis began to be made with free thumbs, flexed MCP joint, and wrist in extension (►**Fig. 2, A-D**).

The orthoses started to be used only at night, around 8 p. m., since June 2016. Correction of the camptodactyly was achieved (►**Fig. 2E** and ►**Fig. 3A-C)**.

Discussion

In this case of rigid type-III camptodactyly in children with Beals-Heacht syndrome, early intervention[9] with static orthoses provided a satisfactory outcome with the regression of the deformity and the achievement of functional use of the

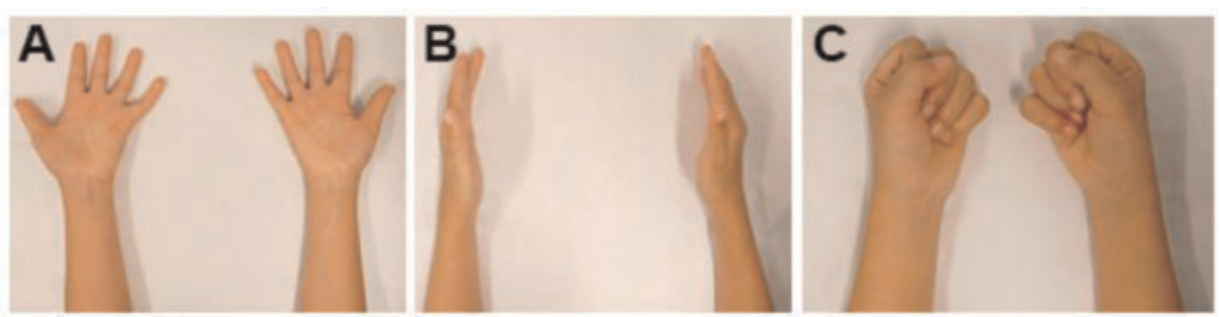


Fig. 3 Morphology of the upper limb after conservative treatment for 23 and a half months. Supine position with the fingers in extension (**A**), side view (**B**), fingers in flexion (**C**).

hands. The use of orthoses should be the first choice for the beginning of the treatment, even syndromic cases.[9]

The multiplicity of structures involved in camptodactyly that are responsible for joint imbalance can reach balance with tissue remodeling using orthoses.[9]

The use of orthoses to remodel musculoskeletal tissue is a low-complexity option, but there is a need for a relatively long period of use for the remodeling to occur.[10]

The use of the dorsal support device optimized the elongation of the structures responsible for flexion contracture in the PIP joint.

Clinical follow-up of the patient in question will be maintained until the end of the skeletal growth to avoid possible recurrence of soft-tissue contractures.[4,8]

The involvement of the family and their collaboration made a difference in the conservative treatment. The intervention is relatively long and exhaustive, but necessary.[10]

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

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7. Citing a symposium article:
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