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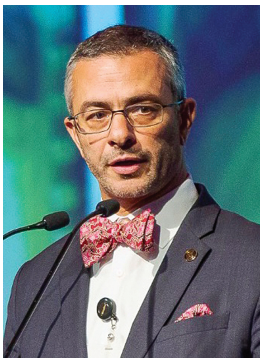
Fabio Ferri de Barros: A Life Dedicated to the Treatment of Pediatric Scoliosis in Underprivileged Children

Fabio Ferri de Barros: Vida dedicada ao tratamento da escoliose pediátrica aos menos favorecidos

Robert Meves[1]

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Rev Bras Ortop 2023;58(4):e543.



Fabio Ferri de Barros

Fabio Ferri de Barros was born on November 3, 1970, in São Paulo, Brazil. Dr. Barros obtained his medical degree from the Faculty of Medical Sciences at Santa Casa de São Paulo and his Medical Residency in Orthopedics and Traumatology at Pavilhão Fernandinho Simonsen at Santa Casa de São Paulo. After that, he worked in Ilhabela for five years, enjoying what he loved most: family, tropical beauty, and sports: surfing, long-distance swimming in the sea, and diving. Dr. Barros took on new challenges on a training journey to several locations in the United States, Australia, and Switzerland with top mentors in his field.

In 2006, Dr. Barros applied the knowledge he acquired at the University of Toronto in treating pediatric deformities, especially in the spine. He perfected his specialization in Pediatric Orthopedics and Spine Surgery at the Hospital for Sick Children and completed a Master's in Bioethics in Health Sciences. Dr. Barros found his mission in studying evidence-based resources and interventions allocation to assist people with spinal deformities, especially within public health systems. In 2010, Dr. Barros joined the Alberta Children's Hospital in Calgary, where he worked tirelessly to improve surgical outcomes and care for the pediatric scoliosis population. Soon, he became the Director of the Pediatric-Spine Fellowship program at this renowned institution. Due to his professional dedication, Dr. Barros became President of the Canadian Pediatric Spine Society. Dr. Barros received numerous international recognitions as an Honorary Member of the Brazilian Society of Pediatric Orthopedics and the Brazilian Spine Society. His publications made extensive contributions to the literature.

Dr. Barros was an active member of the RBO Consultant Board for many years.

Fabio Ferri de Barros prematurely left his family, who loved him so much - his wife Natalia Marangoni Ferri de Barros and three children - and all his friends captivated by his companionship and knowledge.

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Comparative Analysis of the Tibial Component Migration After Cemented and Uncemented Total Knee Arthroplasty with a Hydroxyapatite Coating in Two, Five, and Ten Years: A Meta-Analysis*

Análise comparativa da migração do componente tibial da artroplastia total do joelho cimentada versus não cimentada versus não cimentada com revestimento de hidroxapatita por dois, cinco e dez anos: uma metanálise

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Abstract

Objective This study evaluated and compared the tibial component migration in cemented and uncemented total knee arthroplasty (TKA) with no hydroxyapatite coating 2, 5, and 10 years after surgery.

Methods This meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) based on PubMed and MeSH database queries from June to July 2022.

Results The meta-analysis included eight randomized clinical studies evaluating 668 knees undergoing TKA. The maximum total point motion (MTPM) in cemented TKAs was higher in 5 years, with a mean value of 0.67 mm (95% confidence interval [CI], 0.52 to 0.87). Uncemented TKAs also presented higher mean MTPM in 5 years (1 mm; 95% CI, 0.82 to 1.22). Uncemented coated ATKs had a higher mean MTPM in 10 years (1.30 mm; 95% CI, 0.70 to 2.39). MTPM was statistically similar in the short- and long-term for cemented and uncemented techniques, with a standardized mean difference of -0.65 (95% CI, -1.65 to 0.35).

Conclusion Tibial component migration in TKA was statistically similar at 2, 5, and 10 years in cemented and uncemented techniques, either with or without coating. However, due to the scarce literature, further studies are required with a longer follow-up time.

Keywords
- arthroplasty, replacement, Knee
- durapatite
- bone cements
- prognostic

* *Work developed at Hospital Porto Dias, Serviço de Ortopedia e Traumatologia, Belém, Pará, Brazil.*

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Resumo

Objetivo Avaliar e comparar a migração obtida pelo componente tibial na Artroplastia Total de Joelho (ATJ) cimentada, não cimentada sem revestimento e não cimentada com revestimento de hidroxapatita aos 2, 5 e 10 anos pós operatório.

Métodos Esta metanálise foi conduzida de acordo com o Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Foi realizada busca a partir das bases de dados PubMed e MeSH no período de junho a julho de 2022.

Resultados Oito ensaios clínicos randomizados foram incluídos. Um total de 668 joelhos submetidos a ATJ foram avaliados. Observou-se que a média de *Maximun Total Point Motion* (MTPM) nas ATJ cimentada foi maior em experimentos com cinco anos com média de 0,67 mm (IC95% - 0,52 a 0,87), as ATJ não cimentadas com revestimento de hidroxapatita também obtiveram maior média neste período (1mm; IC95% - 0,82 a 1,22). Em ATJ não cimentada sem revestimento o maior MTPM médio ocorreu no período de 10 anos (1,30mm; IC95% - 0,70 a 2,39). O MTPM foi estatisticamente semelhante no curto e longo prazo ao comparar as técnicas cimentada e não cimentada, com diferença média padronizada -0,65 (IC95%, -1,65 a 0,35).

Conclusão A migração obtida pelo componente tibial na artroplastia total de joelho (ATJ) foi estatisticamente semelhante em 2 5 e 10 anos ao comparar as técnicas cimentada e não cimentada (com e sem revestimento). Entretanto devido ao pequeno número de artigos existentes são necessários mais estudos clínicos sobre tais técnicas e com maior tempo de acompanhamento.

Palavras-chave

- artroplastia do joelho
- durapatita
- cimentos ósseos
- prognóstico

Introduction

The demand for arthroplasties is growing all over the world. Indication for these procedures is increasing, especially in younger subjects. Kurtz et al.[1] predicted that by 2030, 55% of total knee arthroplasties (TKA) will occur in patients younger than 65. In addition, the scientific community is searching for surgical methods and strategies to increase implant longevity and stability.

The ideal fixation method for TKA remains uncertain. Although bone cement is the most accepted and used method by knee surgeons, a growing number of studies show better, or equivalent outcomes compared with uncemented components.

Bercovy et al.[2] include the lack of toxicity at the bone-implant interface, reduced surgical time, and decrease risk of polyethylene wear as advantages of uncemented components. On the other hand, theoretically, uncemented fixation is more vulnerable because it allows more micromotion in the immediate postoperative period.

A hydroxyapatite coating around the porous surface of the component may improve uncemented TKA fixation. Freitas et al.[3] highlighted that thanks to its biocompatibility and bioactivity properties, hydroxyapatite has a notorious application in implant areas and bone grafts, increasing biological fixation and prosthetic stability.

The most investigated factor in TKA is tibial component migration since it directly influences prosthetic longevity, loosening rates, the need for revision, and, consequently, the clinical success of the procedure. Therefore, this meta-analysis of randomized clinical studies published in the last 10 years is an effective and necessary tool to determine the benefits or indifferences among the three available fixation methods. Previous similar papers did not group these fixation methods in a meta-analysis. Thus, this study aimed to quantitatively evaluate and compare the tibial component migration in cemented TKA, uncemented TKA with no coating, and uncemented TKA with hydroxyapatite coating.

Materials and Method

This meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA methodology).

Query Strategy

We performed a systematic search in the literature on the PubMed and MeSH databases from June to July 2022. An advanced search employed the Medical Subject Headings (MeSH) tool with the keywords "randomized controls trial" AND ("hydroxyapatite" OR "durapatite") AND ("knee arthroplasty" OR "Arthroplasty, Replacement, Knee"). In addition, a PubMed search used free terms not found in the Health Sciences Descriptors (DeCS) or MeSH: "knee cemented uncemented" OR "knee cemented uncemented rsa."

Eligibility Criteria

We retrieved randomized clinical trials published in the last 10 years analyzing tibial component migration through

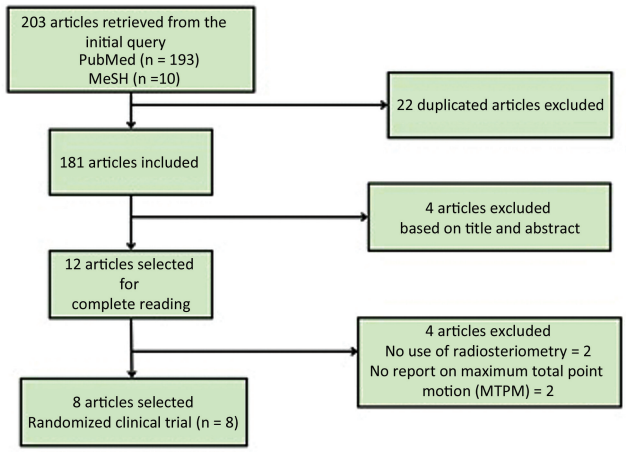


Fig. 1 Flowchart of articles identification and selection.

radiosteriometry in cemented, uncemented, and uncemented TKAs with hydroxyapatite coating over time. No language limitations were applied.

We excluded animal studies and papers analyzing revision prostheses or not incorporating the maximum total point motion (MTPM) in their results.

Article Selection

Papers were downloaded in the Mozilla Firefox browser. Two different authors individually selected the files. Discordances in paper selection were set in common agreement.

Statistical Analysis

After study selection and compilation of sample number, mean MPTM, and MPTM standard deviation (mm), we estimated the difference in weighted means with a 95% confidence interval (CI) between two exposures: cemented and uncemented TKA with no coating. We used the random effects model and tested the heterogeneity between studies per I^2 and the chi-square test.

We established three categories regarding the time after TKA: 2, 5, and 10 years.

One study[4] estimated the standard deviation based on the upper and lower limits of the confidence interval. The three other studies [5–7] calculated the standard deviation from the mean values reported in other publications (Cochrane Handbook).

We prepared a spreadsheet in Excel software and processed the data in R software version 4.1.2 with the Rstudio interface. We did forest plots for meta-analysis and funnel plots to evaluate publication bias (►**Fig. 1**).

Results

Eight randomized clinical trials met the eligibility criteria for this meta-analysis. Among them, six compared cemented TKA with uncoated uncemented TKA; one compared cemented TKA with uncemented TKA with hydroxyapatite coating, and another compared uncemented uncoated TKA with uncemented TKA with hydroxyapatite coating. All these studies comprised 668 knees (►**Table 1**).

Six studies in the meta-analysis compared cemented TKA and uncoated uncemented TKA techniques. The standardized mean difference was -1.20 (95% CI, -1.39 to -1.02) with the common model effect and -0.55 (95% CI, -1.26 to 0.17) with the random effect model. Although this result favored the cemented technique, there was no significant difference (►**Fig. 2**). The funnel plot (►**Fig. 3**) and I^2 estimate revealed high heterogeneity at 97% (p-value < 0.01).

Next, we analyzed mean MTPM values for each technique type and follow-up time. The cemented TKA presented higher mean MTPM (0.67 mm [95% CI, 0.52 to 0.87]) at 5 years of follow-up. On the other hand, the mean MTPM was lower in the 2-year follow-up (0.28 mm [95% CI, 0.10 to 0.79]). Despite the differences in mean MTPM, there was no statistical significance. In the 10-year follow-up, MTPM values were intermediate, with a mean of 0.41 mm (95% CI, 0.16 to 1.04) (►**Fig. 4**).

Mean MTPM in uncemented and uncoated TKAs was higher in the 10-year follow-up (1.30 mm [95% CI, 0.70 to 2.39]). The lowest mean occurred in the 2-year follow-up (0.70 mm [95% CI, 0.30 to 1.60). MPTM was intermediate in

Table 1 Characteristics of the included studies

Author	Samples	Technique	N	Follow-up (months)
Laend et al. (2019) [8]	222/138	CEM x UCWNC	360	12 e 24
Henricson & Nilsson (2016) [5]	21/26	CEM x UCWNC	47	3, 24 e 60
Henricson, Rõsmar, & Nilsson (2013) [11]	21/26	CEM x UCWNC	47	120
Pijls (2012) [6]	24/20	CEM x UCWNC	44	120
Wilson et al. (2012) [4]	18/27	CEM x UCWNC	45	6, 12, 24 e 60
Heesterbeek et al. (2016) [7]	16/17	CEM x UCWNC	33	24
van Hamersveld et al. (2017) [9]	30/30	CEM x UCWC	60	3, 12, 24 e 60
van Hamersveld et al. (2018) [10]	17/16	UCWNC x UCWC	33	12, 24 e 120
		Total	669	

Abbreviations: CEM, Cemented; UCWC, uncemented with coating; UCWNC, uncemented with no coating.

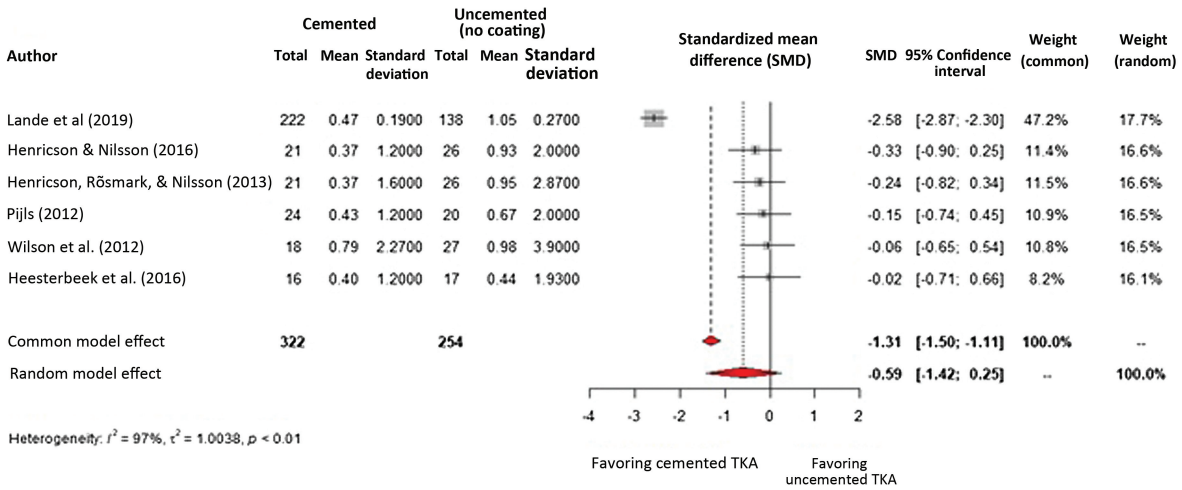


Fig. 2 Maximum total point motion (MTPM) forest plot comparing cemented total knee arthroplasty (TKA) and uncemented TKA with no coating.

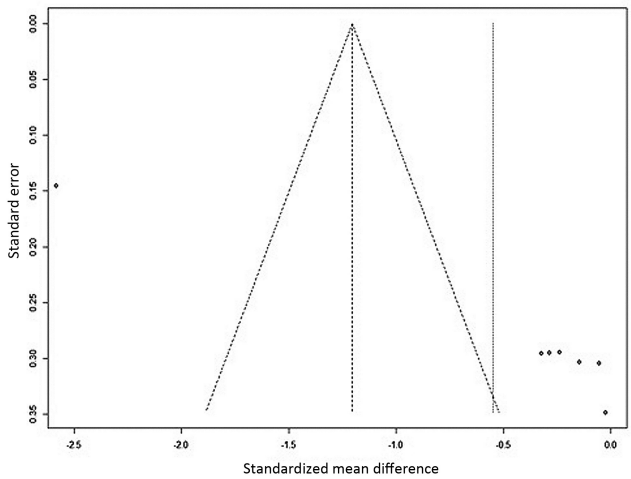


Fig. 3 Funnel plot with standard error and weighted mean difference in cemented total knee arthroplasty and uncemented total knee arthroplasty with no coating.

the 5-year follow-up, presenting a mean value of 0.96 mm. Despite the numerical differences in mean MTPM, there was no statistical significance (►**Fig. 5**).

►**Fig. 6** shows studies measuring MTPM in uncemented TKA with hydroxyapatite coating. The lowest mean value occurred at the 10-year follow-up (0.90 mm [95% CI, 0.69 to 1.18]), while the highest mean value occurred at the 5-year follow-up (1 mm [95% CI, 0.82 to 1.22]). Despite numerical differences in mean MTPM values, there was no statistical significance.

►**Fig. 6**: Forest plot of mean MTPM values of uncemented total knee arthroplasty with hydroxyapatite coating by time period in years.

Discussion

The primary objective of this study was to quantitatively evaluate and compare the tibial component migration in cemented TKA, uncemented TKA with no coating, and uncemented TKA with hydroxyapatite coating. The results favor cemented TKA (standardized mean difference, 0.65) over uncemented TKA. However, there is no significant difference (95% CI, -1.65 to 0.35), probably because of the high heterogeneity of the studies ($I^2 = 97\%$; $p < 0.01$). The study with the largest sample size and a 2-year follow-up reported significantly better results for cemented TKA.[8]

Only two studies by the same author analyzed uncemented TKA with hydroxyapatite coating.[9,10] Therefore, we cannot reach conclusive results comparing this technique with those using cemented TKA or uncemented TKA with no coating. In general, uncemented TKA with hydroxyapatite coating had the highest mean MTPM (0.94 mm), followed by uncoated TKA (0.81 mm) and cemented TKA (0.40 mm). However, van Hamersveld et al.[10] reported that the higher mean MTPM of uncemented TKA with hydroxyapatite coating results from the greater migration of coated components in the first postoperative weeks, which decreases after 3 months. Our study found a lower mean MTPM for uncemented TKA with hydroxyapatite coating (0.9 mm) compared with uncemented TKA with no coating (1.7 mm) in 10 years. Nevertheless, a single study analyzed TKAs with hydroxyapatite coating for 10 years. We did not include a study about TKA with coating in our meta-analysis because of the lack of absolute MTPM data; still, it reports a reduced tibial component migration with hydroxyapatite coating compared with the uncemented TKA and TKA with no coating.[6]

We analyzed the mean MTPM for each technique (cemented TKA, uncemented TKA with no coating, and uncemented TKA with hydroxyapatite coating) and each follow-up period. We observed a higher mean MTPM for cemented TKAs and uncemented TKAs with hydroxyapatite coating in the 5-year follow-up and uncemented TKAs with no coating in the 2-year follow-up. However, the difference in mean values was not statistically significant.

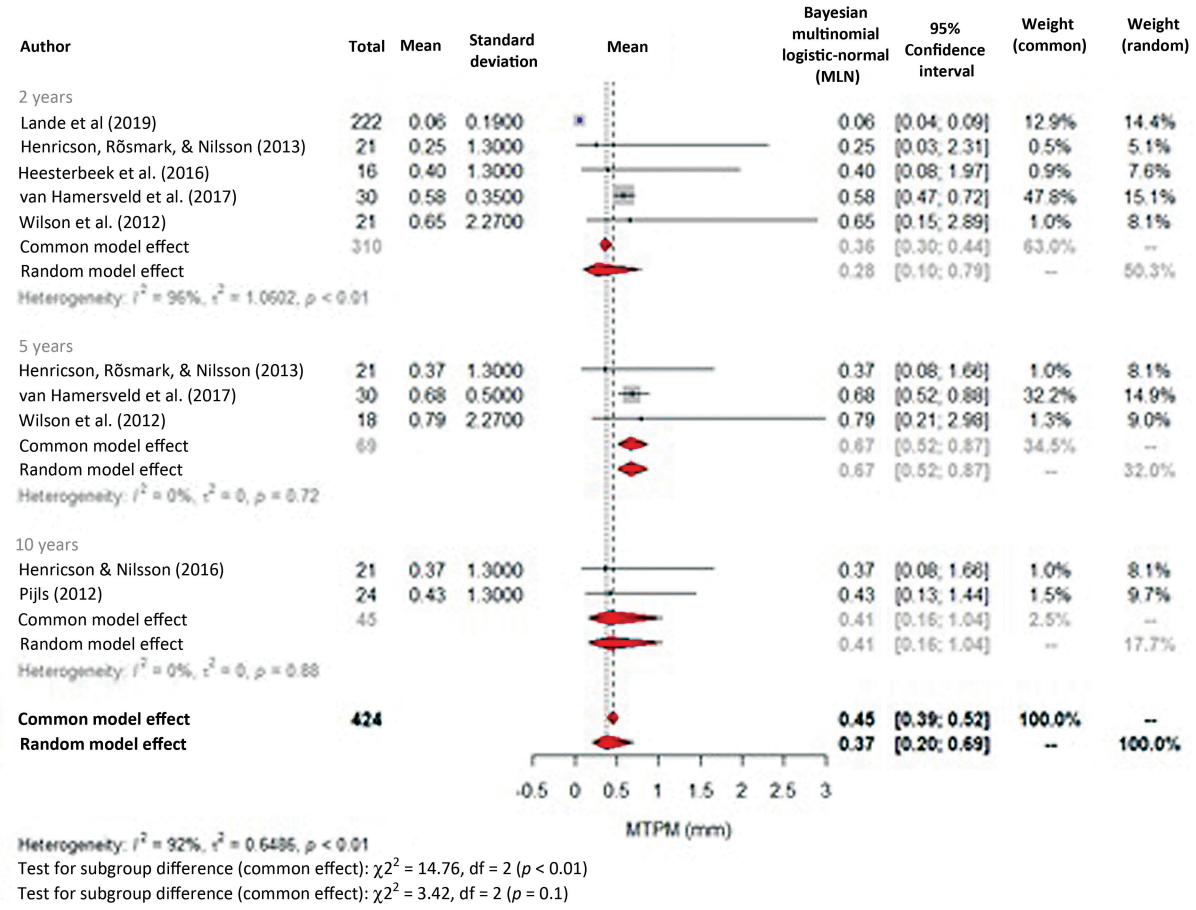


Fig. 4 Forest plot of mean maximum total point motion (MTPM) for cemented total knee arthroplasty by period and time in years.

The use of cemented or uncemented components with different designs in the study groups may interfere with migration. The retrieved studies were not homogeneous regarding designs for fixation. Laende et al.[8] analyzed eight different implant designs, including five uncemented devices. These authors reported less favorable migration outcomes for modular implants. Migration was significantly higher in 1 year and between 1 and 2 years, indicating that the modular implant design has a greater risk of poor long-term survival. The two studies from van Hamersveld et al.[9,10] used the Triathlon implant in its cemented and uncemented with hydroxyapatite coating versions. Henricson e Nilsson[5,11] used trabecular metal monoblock (TM) tibial components for uncemented TKAs and NextGen devices in cemented TKAs. These authors reported a good prognosis for uncemented TM components for 10 years, with stabilization from 3 months after the initial early migration. Wilson et al.[4] also used TM tibial components in uncemented TKAs and NextGen devices in cemented TKAs, reporting similar outcomes in a 5-year follow-up period.

Regarding the high heterogeneity of the studies, a potential explanation for the relative variability of outcomes from studies on TKA fixation is the variety of designs used and the lack of a method to blind the analyses. In addition, due to the scarcity of articles on the subject, there were no population demographic limits, which may influence our findings.

Orthopedists still prefer cemented TKAs. However, the demand for TKA is increasing, especially in younger subjects. Recent trials have shown that uncemented TKAs have longer survival and better functional results than cemented prostheses.[12,13] However, further prospective randomized studies are required to delineate any differences between these three fixation options. It is necessary to emphasize the need for a follow-up time greater than 10 years and an improved serialization within the first year of the study. Blinding would also add value to future studies, eliminating biases such as surgeon preferences and peculiarities of surgical techniques.

Conclusion

Tibial component migration in TKA was statistically similar at 2, 5, and 10 years when comparing cemented and uncemented techniques (with and without coating). However, the scarce literature requires further clinical studies on such techniques with longer follow-up periods.

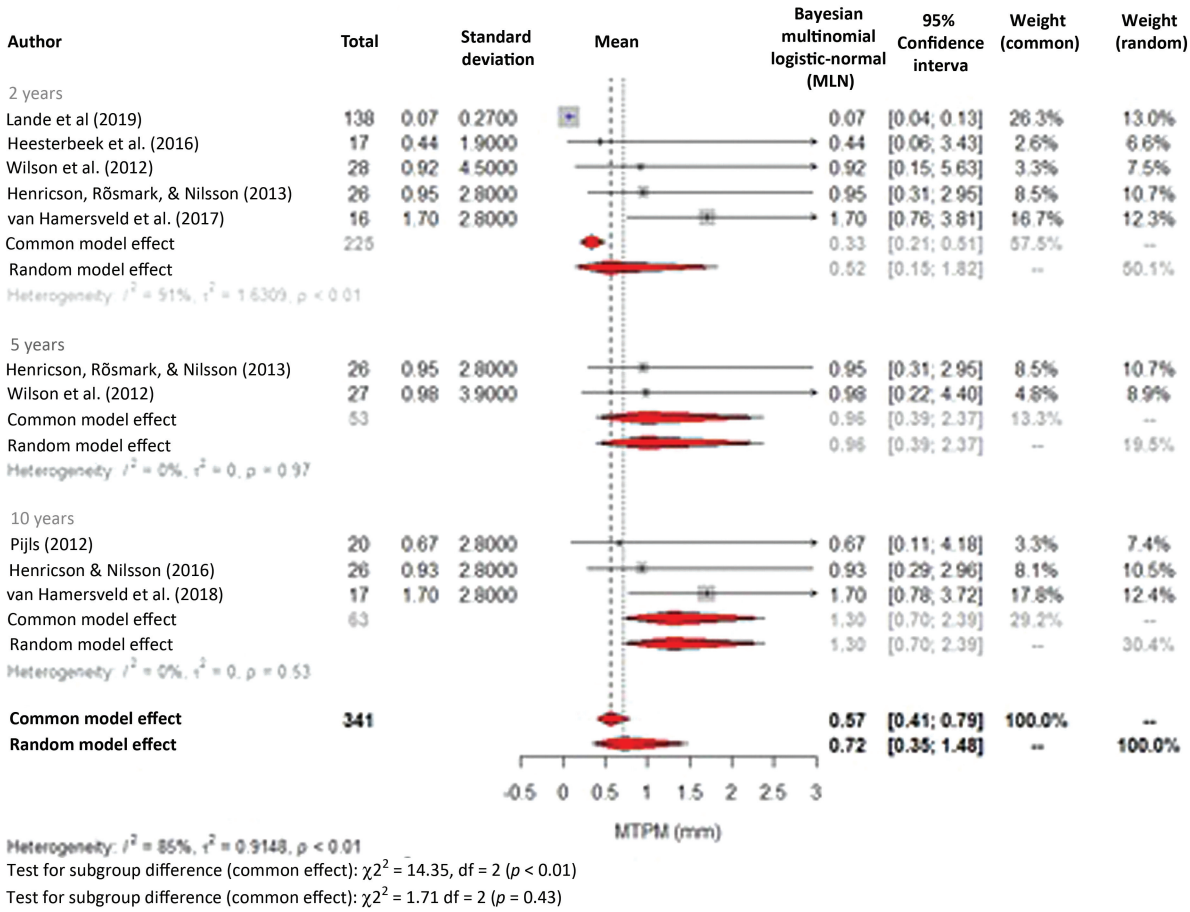


Fig. 5 Forest plot of mean maximum total point motion (MTPM) for uncemented total knee arthroplasty with no coating by period and time in years.

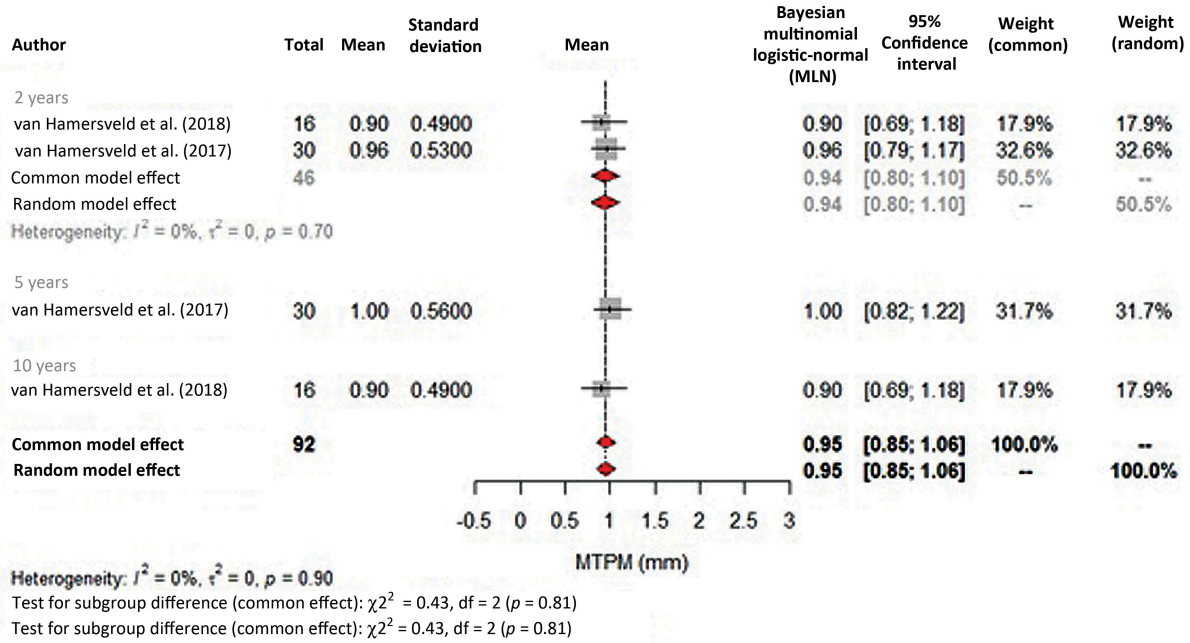


Fig. 6 Forest plot of mean maximum total point motion (MTPM) for uncemented total knee arthroplasty with hydroxyapatite coating by period and time in years.

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Conflict of Interests
The authors declare no conflict of interest.

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Treatment of Chondral Lesions in the Knee

Tratamento das lesões condrais no joelho

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Abstract

Articular cartilage injuries are common and lead to early joint deterioration and osteoarthritis. Articular cartilage repair techniques aim at forming a cartilaginous neo-tissue to support the articular load and prevent progressive degeneration. Several techniques are available for this purpose, such as microfracture and chondrocyte transplantation. However, the procedural outcome is often fibrocartilage, which does not have the same mechanical resistance as cartilaginous tissue. Procedures with autologous osteochondral graft have a morbidity risk, and tissue availability limits their use. As such, larger lesions undergo osteochondral transplantation using fresh or frozen grafts. New techniques using minced or particulate cartilage fragments or mesenchymal stem cells are promising. This paper aims to update the procedures for treating chondral lesions of the knee.

Keywords
- cell transplantation
- cartilage, articular
- knee injuries
- microfracture
- chondrocytes

Resumo

As lesões da cartilagem articular são comuns e levam à deterioração precoce da articulação e ao desenvolvimento da osteoartrite. As técnicas de reparo da cartilagem articular visam a formação de um neo-tecido cartilaginoso capaz de suportar carga articular e evitar a progressão da degeneração. Há várias técnicas disponíveis para esse fim, como a microfratura e o transplante de condrócitos. Entretanto muitas vezes o desfecho do procedimento é a formação de fibrocartilagem, que não possui a mesma resistência mecânica do tecido cartilaginoso. Em outros procedimentos, nos quais é realizado enxerto osteocondral autólogo, há risco de morbidade associada ao procedimento, além da disponibilidade limitada de tecido. Por esse motivo, o transplante osteocondral, utilizando enxertos a fresco ou congelados tem sido utilizado para lesões de maior volume. Por fim, novas técnicas utilizando fragmentos de cartilagem picada ou particulada, assim como o uso de células tronco mesenquimais se apresentam como promissores. O objetivo desse artigo é realizar uma atualização dos procedimentos para tratamento das lesões condrais do joelho.

Palavras-chave
- transplantes de células
- cartilagem articular
- traumatismos do joelho
- microfratura
- condrócitos

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Introduction

Articular cartilage is a specialized avascular, non-neural tissue covering the bony ends in synovial joints. It provides a surface for frictionless gliding, absorbing and supporting mechanical loads.[1] It consists of chondrocytes, which contribute to about 1 to 2% of tissue volume, embedded in a highly-organized dense extracellular matrix of collagen and proteoglycans.[2–4] Type II collagen is the main collagen fiber of mature articular cartilage, constituting about 90 to 95% of the total collagen weight and 10% of the dry cartilage weight.[2]

Studies on case series of knee arthroscopies show that the incidence of these injuries ranges from 19%[5] to 66%.[6] The treatment of articular cartilage injuries is difficult because of their limited intrinsic repair ability, generating high economic and social impacts.[7] The major concern is the progression of osteochondral defects to osteoarthritis.[8]

Diagnosis

The first assessment step involves a thorough history and physical examination to investigate when the injury occurred and the symptoms present. Common symptoms of articular cartilage damage include joint swelling, activity-related pain, lameness, and joint locking or an instability sensation. However, these symptoms are not specific.[9]

Screening for several clinical conditions is required before the specific treatment of chondral lesions of the knee, such as the evaluation of the cruciate and collateral ligaments, the patellofemoral joint, and the menisci. One also needs to investigate previous treatments, including surgery.[9,10] Ligament reconstruction should occur before or during the treatment of the articular cartilage lesion. Lower limb alignment evaluation rules out dynamic varus or valgus overload in the orthostatic position. All patients must undergo panoramic radiographs of the lower limbs to assess the need for corrective osteotomy. The menisci must undergo magnetic resonance imaging (MRI) and arthroscopic examination; in addition, the menisci should be preserved as much as possible. Patellofemoral joint assessment involves careful physical examination, radiographs, MRI, and, sometimes, computed tomography (CT). This allows the surgical treatment of any anatomical abnormality placing the patient at risk of recurrent dislocation or increased stress on the patellar facets.[9–11]

The investigation of variables specific to the chondral defect, including location, size, depth, defect geometry and number, subchondral bone quality, surrounding cartilage quality, and degree of defect containment, is critical before choosing a surgical procedure.[9,12] Outerbridge[13,14] classified the macroscopic alterations of the articular cartilage (►**Table 1**). However, the use of the International Cartilage Regeneration and Joint Preservation Society (ICRS) classification[15] in studies on chondral lesion treatment became more frequent (►**Table 2**).

Table 1 Outerbridge classification

Grade	Description
Grade 0	Normal
Grade I	Cartilage softening
Grade II	Fragmentation and fissure $\leq$ 0.5 inch in diameter
Grade III	Fragmentation and fissure $>$ 0.5 inch in diameter
Grade IV	Cartilage erosion with subchondral bone exposure

Table 2 International Cartilage Regeneration and Joint Preservation Society (ICRS) classification

Normal	Grade 0
Almost normal	Grade 1a – Superficial lesions/softening Grade 1b - Superficial lesions/softening and/or fissures or artificial gaps
Abnormal	Grade 2–Extension $<$ 50% thickness
Severe lesion	Grade 3a – Extension $>$ 50% thickness Grade 3b – Up to the calcified layer Grade 3c – Up to the subchondral bone surface (with no penetration) Grade 3d – Includes cartilage bulging around the lesion
Very severe lesion	Grade 4a – Subchondral bone penetration but not in the total diameter of the defect Grade 4b – Penetration in the whole diameter of the defect

Treatment

Recently, some authors suggested an algorithm to divide surgical strategies for treating joint cartilage injuries into three "Rs": repair, restoration, and regeneration.[1] Cartilage repair techniques aim to induce tissue formation at the chondral or osteochondral defect site by stimulating local cells and/or implanting cells, biological agents, and/or scaffolds in the defect. The most common among these techniques are microfracture and autologous chondrocyte transplantation.[1] Restoration techniques replace a chondral or osteochondral defect with functional hyaline cartilage and subchondral bone, such as autologous osteochondral grafting and allogeneic osteochondral transplantation.[1] Regeneration techniques comprise intervention methods resulting in the recapitulation of functional hyaline cartilage and subchondral bone.[1]

Cartilage repair techniques

Microfracture

Microfracture is a bone marrow stimulation technique introduced in the late 1980s and indicated for small Outerbridge III to IV chondral defects ($<$ 2 to 4 cm^2). It consists of subchondral bone perforations to allow the migration of mesenchymal progenitor cells and growth factors from the bone marrow. These elements form a cell-rich clot that proliferates and differentiates, originating a repair tissue to fill the chondral defect.[16–18] It demands checking the

outflow of blood and fat through the perforations with a deflated tourniquet to ensure sufficient penetration of the subchondral surface. This check must occur at the end of the procedure to not impair the arthroscopic view and allow clot formation at the cartilage defect site.[10]

Microfracture is the first line of treatment for small defects of the articular cartilage of the knee, improving function and providing medium-term pain.[19] However, it often results in a fibrocartilaginous tissue biomechanically and biochemically inferior to hyaline cartilage, vulnerable to mechanical trauma, and deteriorating 18 to 24 months after the procedure.[7,18]

A recently published systematic review reports that patients with the best prognosis after microfracture are young, present preoperative symptoms for a short time, and have a non-degenerative mechanism of injury, with small injuries or a single lesion.[20] On the other hand, subjects with a high body mass index ($> 30\,kg/m^2$), a defect bigger than 2 to $4\,cm^2$, located in the patellofemoral compartment or tibial plateau, and aged over 40 years have a worse prognosis.[21] Contraindications to microfracture include deviation of the lower limb axis, partial-thickness defects, uncontained cartilage defects, osteoarthritis, immune-mediated systemic arthritis, and inability to comply with the postoperative rehabilitation protocol.[22]

The main complications include incomplete defect filling, when the clot fills or adheres to only a portion of the lesion, bone overgrowth due to the formation of an intralesional osteophyte or elevation of the subchondral bone plate, and deterioration over time.[23]

Autologous chondrocyte implantation

Autologous chondrocyte implantation (ACI) is a recommended procedure for defects larger than 3 or $4\,cm^2$. ACI occurs in two stages.[17,18] The first stage consists of a diagnostic arthroscopic procedure and biopsy to obtain a cartilage fragment for in vitro culture and expansion for 4 to 6 weeks. The second stage is the implantation of the differentiated cells in the defect and its coverage with a periosteal flap.[9] However, it has the disadvantages of requiring two surgeries and having high costs.[18] In addition, ACI requires a longer recovery period for neotissue maturation, ranging from 6 to 12 months.[7]

Over time, ACI underwent modifications, and there are four generations of ACI to date. The first generation (P-ACI) consisted of a chondrocyte suspension injection under a periosteal flap. The second generation (C-ACI) injected a chondrocyte suspension under a collagen membrane. In the third generation, chondrocyte culture used a carrier surface or a porous matrix/scaffold. In the fourth generation, chondrocytes implant occurred in a one-step procedure.[24]

The third ACI was called MACI (matrix-assisted chondrocyte implantation) and used a type I/III collagen membrane for chondrocyte culture, followed by cell implantation in the defect.[25,26] The membrane acts as a cell carrier, distributing them at a density of 500,000 to 1,000,000 cells per cm^2, and it is easy to implant.[10] Other products have been developed and are commercially available, such as Hyalograft® C (Fidia Advanced Biopolymers, Abano Terme, Italy), which uses hyaluronic acid as a scaffold, ChondroGide (Geistlich Biomaterials, Wolhusen, Switzerland), a porcine collagen I/III membrane, and NeoCart® (Histogenics Corporation, Waltham, United States), a type I collagen scaffold.[27,28]

An observational case series analyzed outcomes from 15 patients treated with autologous matrix-induced chondrogenesis (AMIC) based on a porcine membrane of type I/III collagens. AMIC had a greater benefit in patients with larger chondral lesions evaluated per subjective clinical scores and magnetic resonance observation of cartilage repair tissue (MOCART).[29] Another study with 56 patients presenting single chondral or osteochondral lesions demonstrated that chondrocyte culture in fibrin could provide a favorable microenvironment for matrix synthesis, improving their clinical condition and activity after 1 year of follow-up.[30]

The most common complications of ACI are graft hypertrophy, commonly associated with the periosteal flap, with an incidence of 28% to 36%; insufficient cartilage regeneration, more frequent in repairs with periosteum coverage (3.8%) and using matrix (3.7%); delamination, i.e., the separation of cartilage from the underlying bone, occurring in 22.1% of cases; and inadequate/insufficient fusion, when the graft fails to incorporate itself into the adjacent cartilage, which occurs in approximately 23.1% of cases.[23]

Cartilage restoration techniques

Autologous osteochondral graft

An autologous osteochondral graft transfers osteochondral cylinders containing the patient's mature cartilage and bone from regions with relatively lower loads to those with higher joint loads. The procedure can occur through an open or arthroscopic approach.[26] It is indicated for full-thickness cartilage or larger ($> 3\,cm^2$) osteochondral defects.[17]

The retrieved cylinders must be contoured to fit the lesion site and have 6 to 10 mm in diameter. Numerous cylinders can form a mosaic to treat larger defects ($>3\,cm^2$).[10,31,32] However, using more than two large cylinders is not recommended due to morbidity at the donor site.[26] The retrieved cylinder must have 10 to 15 mm deep; this measurement requires confirmation after extraction.[26]

Cylinder fixation uses press-fit, not requiring materials. Fixation must be careful to maintain perpendicularity to the receptor site and reproduce the articular surface curvature.[9,10,26]

Its main advantages include being a single-stage procedure, cheaper than osteochondral grafting, capable of treating lesions with subchondral involvement,[10] and the lack of risk of disease transmission.[24] Its disadvantages are the self-limiting tissue amount and the morbidity at the donor site. This is why it is indicated for smaller lesions ($< 2\,cm^2$).[9,18] In addition, there is concern about fibrocartilage formation between the cylinders, resulting in mixed repair outcomes.[33] One study stated that when properly used, the mosaicplasty technique can produce excellent outcomes with good durability and functional impact, low morbidity rates, and low costs.[34]

A recently published technique described harvesting an osteochondral graft from the proximal tibiofibular joint.[35]

Osteochondral transplantation

Osteochondral transplantation involves the transplantation of a cadaver graft with viable articular cartilage and its underlying subchondral bone. It is a treatment option for lesions larger than 2.5 cm^2. It may provide a hyaline cartilage surface for deep chondral defects and fill any associated bone defects.[12]

Osteochondral transplantation is indicated for patients with symptomatic, large ($\geq 2\ cm^2$) cartilage defects secondary to trauma, intra-articular fractures, osteonecrosis, osteochondritis dissecans, and revision of previously failed cartilage procedures.[36,37] It may consist of osteochondral cylinders such as those used in mosaicplasty or larger grafts with surgical instrumentation to ascertain size compatibility to the recipient's defect.[26]

The graft storage method (e.g., frozen, cryopreserved, fresh) plays a decisive role in chondrocyte viability and immunogenicity, and time for transplantation.[38–40] Typical storage uses a specific medium between 4 °C and 37 °C.[36] Fresh grafts have the highest degree of cell viability. However, this viability starts to decrease after 14 days under 4 °C,[38] reaching 70% of viable chondrocytes up to 28 days.[41] Viability is deleterious after this period.[37]

The size compatibility between the donor and the recipient is also critical to guarantee the optimal superficial congruence, curvature, and shape to minimize the formation of joint step, load on the edge of the graft, and risk of graft failure.[37]

Its advantages include the possibility of performance in a single procedure,[9] achieving precise joint architecture, and treating large defects without morbidity to the donor site.[42] However, its disadvantages are the more difficult operative learning curve, the high cost of materials, the high rate of early reoperation (30% in two years), the availability of knee grafts with similar dimensions, and chondrocyte death by excessive handling.[36]

The technique demonstrates favorable outcomes, with radiographic consolidation in 86% of cases and good to excellent outcomes in 86 to 89% of the patients 2 years after the procedure. However, patients aged over 30 who underwent three or more previous procedures have worse outcomes.[33] In Brazil, one study reported that osteochondral transplantation was a safe procedure, resulting in short and medium-term good clinical outcomes for treating osteochondral lesions of the knee ($> 4\ cm^2$).[43] However, another study warned that lesions caused by corticosteroids, bipolar lesions, and degenerative disease present inferior long-term outcomes when using fresh grafts.[44]

Treatment perspectives

Minced or particulate cartilage

The principle of using minced or particulate autologous cartilage ("minced cartilage," "particulate cartilage," or "cartilage chips") is based on cutting healthy, viable hyaline cartilage into pieces as small as possible ($< 1\ mm^3$) until obtaining a pasty appearance. Next, the cartilage is directly implanted into the chondral or osteochondral lesion.[45,46]

Fragmentation induces repair by activating chondrocytes in migration, proliferation, and differentiation.[46] It must be performed quickly, with precise cuts (using a scalpel, shaver, or perforator), avoiding cartilage crushing, which would reduce cell viability.[45,46] The smaller the fragment, the greater the potential for chondrocyte proliferation and differentiation.[46]

The procedure, either open[47] or arthroscopically,[48] is indicated for all types of lesions (contained, isolated and unipolar), including osteochondral injuries. The fixation techniques described involve platelet-rich plasma, fibrin glue, membranes, or a combination of them.[46] Its advantages are a one-stage procedure for chondrocyte and extracellular matrix transplantation and the possibility of arthroscopy, which is quick and economically attractive. However, its limitation is the defect size.[48]

A recently described technique uses intact allogeneic juvenile joint cartilage, particulate, with fragments adhesion to the defect with fibrin adhesive. The advantage of juvenile cartilage (<13 years) is the higher chondrogenic potential compared with adult cartilage. Moreover, in laboratory conditions, it forms hyaline-like cartilage with cell viability of 40 to 45 days from collection and grafting.[49]

In the United States of America, minced autologous cartilage (Cartilage Autograft Implantation System [CAIS; DePuy/Mitek]) and allogeneic particulate juvenile cartilage (DeNovo Natural Tissue [NT]; Zimmer Inc, Warsaw, United States) techniques have been described. For CAIS, the hyaline cartilage is arthroscopically removed from an area under little load (lateral wall of the intercondylar node or trochlear margin) with an instrument that chops it into 1 to 2 mm fragments and then disperses the chopped cartilage in a biodegradable scaffold. The DeNovo NT graft implant occurs after defect preparation and dimension determination (one package for 2.5 cm^2 of defect size). Both procedures are promising, but studies suggest that further research is required to define their indications and contraindications.[17,50]

Wodzig et al.[51] had promising results when treating 18 patients with CAIS, reporting a significant improvement in joint function, quality of life, and pain in a 12-month follow-up. In addition, the radiological evaluation showed good cartilage quality in the same period per the MOCART score.

Bone marrow aspirate and bone marrow aspirate concentrate

Bone marrow aspirate is a complex mixture of cellular components, including platelets, white cells, red cells, hematopoietic precursors, and non-hematopoietic precursors.[52,53] Bone marrow aspirate concentrate (BMAC) is a mixture of bone marrow elements with mesenchymal stem cells isolated from the bone marrow obtained by one or multiple centrifugations of a bone marrow aspirate.[52,53] BMAC was investigated alone or associated with cartilage repair procedures with good clinical efficacy. However, some questions remain regarding its use, including cell source, expansion requirements, treatment timing, and amount.[53]

Microfragmented adipose tissue aspirate

The micro-fragmented adipose tissue aspirate is an innovative and safe procedure[54] deemed simple, sustainable,

minimally invasive, fast, and requiring a single stage.[55] Available methods in Brazil include Lipogems®, a non-enzymatic process using mechanical force. In this method, adipose tissue from abdominal or flank fat undergoes washing, emulsification, and microfragmention, removing blood and residues without jeopardizing the integrity of the vascular stromal niche.[56]

Expanded mesenchymal stem cells

Expanded mesenchymal stem cells in the clinical setting may be safe since there are no short and medium-term reports of major adverse events related to the treatment or the cell-retrieving process. In addition, clinical improvement and positive histological and imaging findings from some studies indicate its effectiveness.[57] However, the path may be long due to chondrogenesis and joint cartilage repair complexity.[58]

Final considerations

The treatment of articular cartilage injuries is difficult due to their limited repair capacity. Several techniques are available for treatment, ranging from bone marrow stimulation to osteochondral cylinder transplantation. All present inherent advantages and disadvantages. New procedures, including cell therapy, have shown promising potential. However, we advise caution as some methods still require further studies and approval by regulatory agencies for use in the country.

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Conflict of Interests

The authors declare no conflict of interest.

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Radial Nerve Supracondylar Block Versus Fracture Hematoma Block. Comparison of Their Efficacy in Cases of Fractures of the Distal Third of the Radius*

Bloqueio supracondilar de nervo radial versus bloqueio de hematoma de fratura. Comparativo de sua eficácia em casos de fraturas do terço distal do rádio

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Abstract

Objective The present study compares the analgesic efficacy of two techniques to perform non-surgical reduction: fracture hematoma block and radial nerve supracondylar block.

Methods Forty patients with fractures of the distal third of the radius, who required reduction, were selected in a quasi-randomized clinical trial to receive one of the anesthetic techniques. All patients signed the informed consent form, except for those who did not wish to participate in the study, had neurological injury, had contraindication to the procedure in the emergency room, or with contraindication to the use of lidocaine. To measure analgesia, the numerical pain rate scale was used at four different moments: preblock, postblock, during reduction, and after reduction; then three differences were calculated: the first between before and after blocking; the second between during reduction and after blockade; and the third between before blocking and after reduction.

Keywords
- anesthesia, local
- closed fracture reduction
- nerve block
- radius fractures
- pain measurement

* *Study developed at Santa Casa de Ribeirão Preto, Ribeirão Preto, São Paulo, Brazil.*

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Results The fracture hematoma and supracondylar block groups showed the following mean values, respectively: 3.90 (1–10) and 3.50 (-6–10) in difference 1; 4.35 (-5–10) and 5.00 (-3–10) in difference 2; and 4.65 (1–10) and 3.80 (-3–10) in difference 3.
Conclusion Both techniques proved to be efficient for analgesia, with mild superiority of hematoma block, but without statistical significance.

Resumo

Objetivo O estudo compara a eficácia analgésica de duas técnicas para realizar redução incruenta: o bloqueio de hematoma da fratura e o bloqueio supracondilar de nervo radial.
Métodos Quarenta pacientes com fraturas do terço distal do rádio, que necessitassem redução, foram selecionados em um ensaio clínico quasi-randomizado, para receber uma das técnicas anestésicas. Todos os pacientes assinaram o termo de consentimento ou assentimento, com exceção daqueles que não desejassem participar do estudo, tivessem lesão neurológica, com contraindicação ao procedimento na sala de emergências, ou com contraindicação ao uso da lidocaína. Para aferir a analgesia foi utilizada a escala numérica da dor em quatro momentos distintos: pré-bloqueio, pós-bloqueio, durante a redução e após a redução; em seguida, foram calculadas três diferenças: a primeira entre antes e após o bloqueio; a segunda entre durante a redução e após o bloqueio; e a terceira entre antes do bloqueio e após a redução.
Resultados Os grupos do bloqueio de hematoma de fratura e bloqueio supracondilar apresentaram respectivamente os seguintes valores médios: 3.90 (1–10) e 3.50 (-6–10) na diferença 1; 4.35 (-5–10) e 5.00 (-3–10) na diferença 2; e 4.65 (1–10) e 3.80 (-3–10) na diferença 3.
Conclusão As duas técnicas se provaram eficientes para analgesia, com discreta superioridade do bloqueio de hematoma, mas sem significância estatística.

Palavras-chave
- anestesia local
- bloqueio nervoso
- fraturas do rádio
- medição da dor
- redução fechada

Introduction

Fractures of the distal third of the radius occur very frequently, being the most prevalent in the upper limbs.[1] Studies indicate an estimated 600,000 cases annually,[2] with an incidence in children of approximately 1.5 forearm fractures in every 100 emergency room visits.[3]

Despite happening in patients of all ages, fractures of the distal third of the radius have a great distinction regarding the mechanism of trauma, as it may vary according to age range.[1,2] In young adults, it is usually related to high-energy trauma, and in the elderly to low-energy trauma.[1,2] It is also important to highlight that studies indicate that the number of cases in the elderly should increase due to the increasing life expectancy of the population; and in children due to increased body mass index (BMI), and increasingly early onset of sports activities and risk.[3]

The treatment of distalic fractures of the radius can range from immobilization with orthosis to surgical treatment with internal fixation.[1–3] In addition, part of the fractures requires a non-surgical reduction early on admission, either for definitive treatment, or for improvement of bone alignment to preserve soft tissues and to provide pain relief while awaiting definitive surgical treatment.[1,2] Thus, analgesia planning is necessary to perform these procedures.[4–7]

In the medical literature, several techniques have been described with the purpose of analgesia to aid in the non-surgical reduction of the radius' distal fractures.[8] Among them, some stand out: fracture hematoma block,[6] Bier block,[9] sedation with venous drugs,[10] brachial plexus block,[11] and supracondylar block of the radial nerve.[7]

It is possible to find several studies in the medical literature in which different analgesia techniques are described, but there are few that are comparative, and none was found to compare two techniques which was possible to perform easily outside the operating room.

The present study aimed to compare the results of analgesia of fracture hematoma block with that of the supracondylar block (SCB) of the radial nerve in non-surgical treatment in patients with radius distal fracture.

Materials and Methods

The work followed the determinations of the declaration of Helsinki with the guidelines for studies with human beings, being submitted and approved by the research ethics committee (CAAE 37896620.8.0000.5378). All participants agreed to their participation by signing a free and informed consent form (TCLE) or consent form.

The study consisted of a near-randomized clinical trial, which compared two analgesia techniques used to aid in the non-surgical reduction of fractures of the distal third of the radius. The inclusion criteria in the study were: patients diagnosed with fracture of the distal third of the radius with

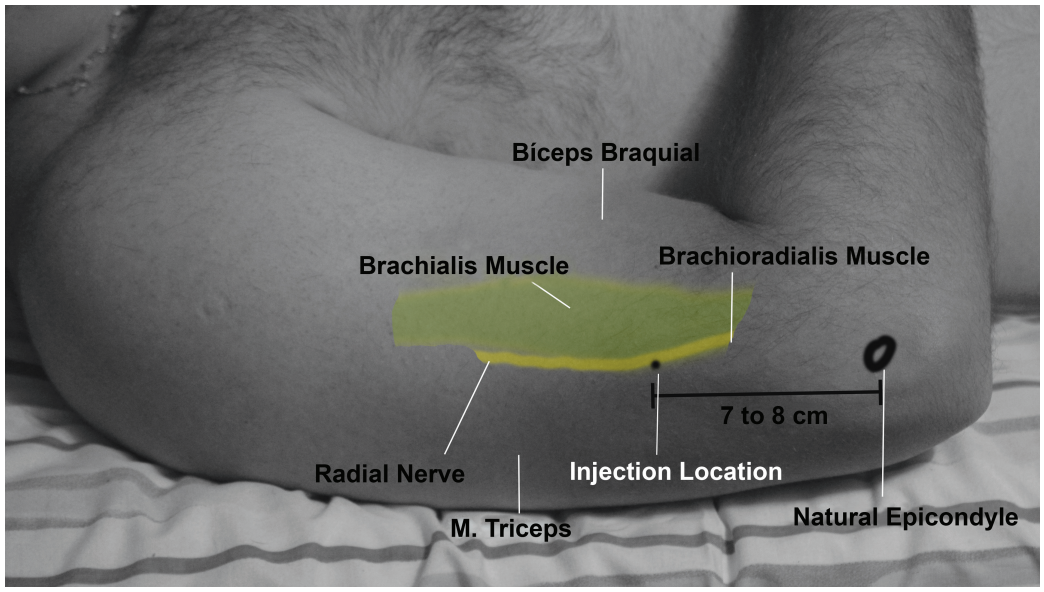


Fig. 1 Radial nerve block technique.

indication of non-surgical reduction, agreement in the participation by part of the patient or guardian, patient with cognitive capacity that would allow the procedure and answering the questionnaire. The exclusion criteria of the study involved patients with previous neurological injury or due to current trauma; as well as those who had some contraindication to perform the procedure in the emergency room, or contraindication to the use of lidocaine.

Forty patients were involved in the study with the diagnosis of fracture of the distal third of the radius, which were divided into 2 groups, 20 patients allocated in the radial nerve SCB group, and 20 patients allocated in the fracture focus infiltration (FFI) group. The randomization of the patients was performed on a first-come, first-served basis, and the data collected were: age, gender, joint involvement, presence or not of comminution and associated ulna fracture.

Anesthetic block was performed with a sterile syringe kit and sterile needle, and lidocaine 2% (Xylestesin 2% without vasoconstrictor, Cristália, SP, Brazil) was injected[12,13] in both groups. No auxiliary imaging methods were used in either group. All procedures were performed by two of the study researchers and, for radial nerve block, training was used before the beginning of the study, using anatomical models and ultrasound, with the objective of better localization, based on anatomical points.

To perform radial nerve SCB, we used the lateral epicondyle as an anatomical parameter, inserting the needle into the lateral face of the arm at a point approximately 7 to 8 cm proximal to it, near the distal limit of the radial sulcus of the humerus and the origin of the brachioradial muscle. The correct location was confirmed by paresthesia along the nerve path (►**Fig. 1**).

Palpation of the anatomical defect resulting from the fracture and the insertion of the needle at this point was used for the FFI. The location was confirmed by aspiration of the hematoma from the fracture focus.

To quantify and classify pain, we used the numerical pain rate scale (NPRS), which is a variant of the visual analog scale (VAS),[14] measured in four moments: before blockade, after block, during reduction, and after reduction. To calculate the analgesic effect of the techniques, we used the differences between the NPRS values obtained at each moment: we called NPRS1 the difference between the values obtained before and after the blockade, NPRS2 the difference between the values obtained during the reduction and after the blockade, and NPRS3 the difference between the values obtained before the blockade and after the reduction.

Statistical Analysis

All data were analyzed using the statistical analysis software Jamovi 2.2.2 (Library R 4.0.2). The hypothesis of nullity of absence of difference was rejected if the p-value was < 0.05. To evaluate the SCB and FFI's groups homogeneity, we used the Chi-squared and Fisher tests for the nominal variables.

The normal distribution of parametric variable data was evaluated using the Shapiro-Wilk test, histograms, and mean and median comparisons. Thus, the results of the means that presented normal distribution were evaluated using the Student t test. On the other hand, the results considered as nonparametric were evaluated with the Mann-Whitney test.

Results

The study included 40 patients with the diagnosis of fracture of the distal third of the radius, who were divided into 2 groups, 20 patients allocated in the FFI group, and 20 patients allocated in the radial nerve SCB group.

The age of the patients ranged from 8 to 87 years, with an average of 50 years in the FFI group; and it ranged from 9 to 90 years, with an average of 41 years in the SCB group (►**Fig. 2**). The distribution between genders showed a higher female prevalence in both groups, being 15 (75%) patients in the FFI group and 11 (55%) patients in the SCB group (►**Fig. 3**).

Associated ulna fracture was present in 7 (35%) patients in the FFI group, and in 5 (25%) patients in the SCB group (►**Fig. 4**); joint involvement occurred in 6 (30%) patients in the FFI group and 7 (35%) in the SCB group (►**Fig. 5**); and in both groups we found 6 patients with fracture comminution (►**Fig. 6**). The characteristics of the fracture in relation to the presence of ulna involvement, comminution and joint involvement were homogeneous in the two groups studied, when evaluated with the Chi-squared and Fisher tests.

There were no complications during the execution of both anesthetic block techniques, neither in the FFI nor in the SCB group.

The NPRS values found before blockade ranged from 2 to 10 in the FFI group, with an average of 6.9; and from 0 to 10 in the SCB group, with an average of 6.1. There was no statistical difference between means of NPRS values before the block. Numerical pain rate scale values after block ranged from 0 to 8 in the FFI group, with an average of 3.0; and from 0 to 8 in the SCB group, with an average of 2.6 (►**Table 1**). There was no statistical difference between means of NPRS values after the block (Table 2).

The NPRS values found during reduction ranged from 2 to 10 in the FFI group, with an average of 7.35; and from 0 to 10 in the SCB group, with an average of 7.6. There was no statistical difference between means of NPRS values during block The NPRS values after reduction ranged from 0 to 6 in the FFI group, with an average of 2.25; and from 0 to 10 in the SCB group, with an average of 2.3. There was no statistical difference between means of NPRS values after block (►**Table 2**)

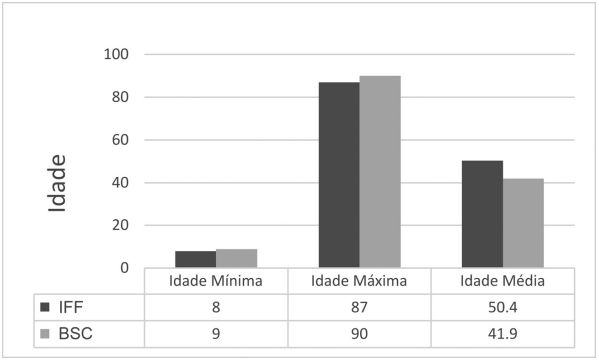


Fig. 2 Distribution by age group.

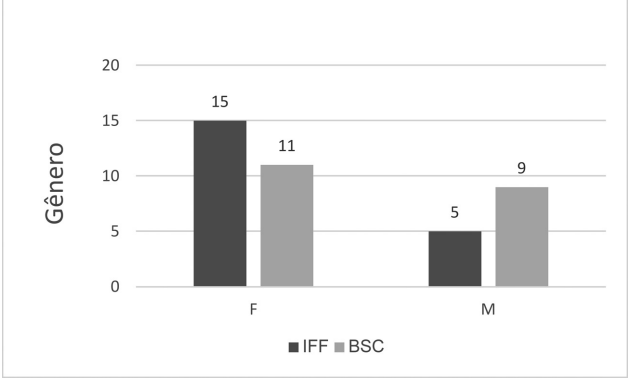


Fig. 3 Distribution by gender.

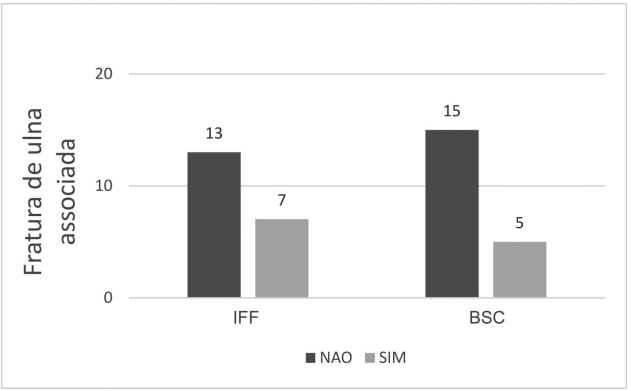


Fig. 4 Association with ulna fracture.

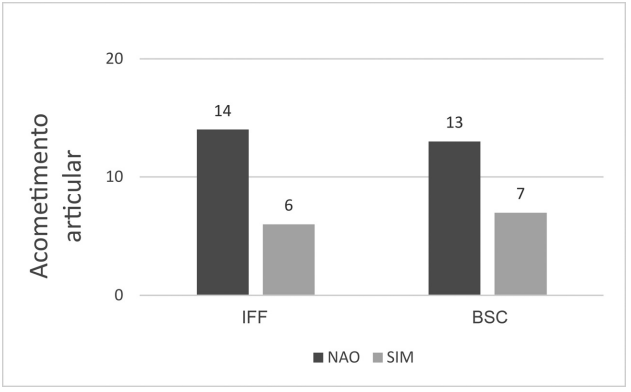


Fig. 5 Joint involvement.

The results obtained from NPRS1 (difference between the values obtained before and after blockade) ranged from 1 to 10 in the FFI group, with an average of 3.9; and from -6 to 10 in the SCB group, with an average of 3.5. There was no statistical difference between the means of NPRS1 values (►**Tables 3** and **4**). The values found in NPRS2 (difference between the values obtained during reduction and after blockade) ranged from -5 to 10 in the FFI group, with an average of 4.35; and from -3 to 10 in the SCB group, with an average of 5.0. There was no statistical difference between the means of NPRS2 values (►**Tables 3** and **4**). Finally, NPRS3 (difference between the values obtained before block and

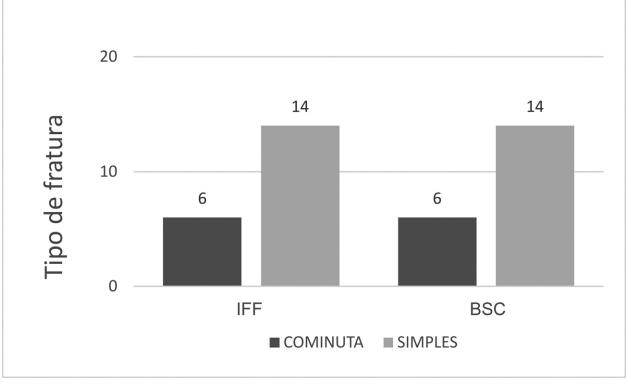


Fig. 6 Comminution of the radius fracture.

Table 1 Numerical pain rate scale measured values

	Technique	Preblock	Postblock	Reduction	Postreduction
Average	FFI	6.90	3.00	7.35	2.25
	SCB	6.10	2.60	7.60	2.30
Standard deviation	FFI	2.59	2.66	2.46	2.17
	SCB	3.31	2.39	3.10	2.90
Minimum	FFI	2	0	2	0
	SCB	0	0	0	0
Maximum	FFI	10	8	10	6
	SCB	10	8	10	10

Abbreviations: SCB, supracondylar block; FFI, fracture focus infiltration.

Table 2 Numerical pain rate scale comparison between the two analgesia techniques

	Preblock	Postblock	Reduction	Postreduction
Shapiro-Wilk	0.022	0.007	< 0.001	< 0.001
Mann-Whitney U	0.494	0.710	0.453	0.776

after reduction) results ranged from 1 to 10 in the FFI group, with an average of 4.65; and from -3 to 10 in the SCB group, with an average of 3.8. There was no statistical difference between the means of NPRS3 values (►**Tables 3** and **4**).

Discussion

Fractures of the distal third of the radius are extremely common in emergency orthopedic care and affect patients of all ages.[1,2] Reducing and immobilizing in the emergency room can reduce costs, wait time, and length of hospital stay.[15,16]

For the study, two analgesia methods used in non-surgical treatment of fractures of the distal third of the radius were chosen, which could be reproduced without major difficulties, without the use of special equipment or requiring monitoring during the procedure. Thus, they are applicable in the reality of most emergency care units. In addition, to quantify pain, we used the NPRS, which is a variant of the VAS, because it is simple to understand and easy to reproduce.[14]

In the institution where the study was conducted, the analgesia pattern used is the FFI, with good acceptance and effective analgesia.[6,17] Radial nerve block was chosen for the possibility of performing the procedure without creating communication between the fracture and the external environment, and because it theoretically facilitates local manipulation, not expanding the volume of the manipulation site.[18]

During the anesthetic procedure, a greater ease was observed in the execution of hematoma block, requiring less time to perform the procedure due to the fracture deformity being palpable and the presence of blood on aspiration confirming the correct location. However, we did not use any evaluation measure for this variable. In radial nerve block, more specific training was required before the beginning of the study, using anatomical models and

Table 3 Values obtained from NPRS1, NPRS2, and NPRS3 in analgesia techniques

	Block	NPRS2	NPRS2	NPRS3
Average	FFI	3.90	4.35	4.65
	SCB	3.50	5.00	3.80
Minimum	FFI	1	-5	1
	SCB	-6	-3	-3
Maximum	FFI	10	10	10
	SCB	10	10	10

Abbreviations: SCB, supracondylar block; NPRS1, difference between values obtained before and after block; NPRS2, difference between values obtained during reduction and after block; NPRS3, difference between values obtained before block and after reduction; FFI, fracture focus infiltration.

Table 4 Comparison of NPRS1, NPRS2 and NPRS3 values between analgesia techniques

			95% confidence interval	
		p	Inferior	Superior
NPRS2	Shapiro-Wilk	0.026		
	Mann-Whitney	0.880	-1.00	2.00
NPRS2	Shapiro-Wilk	0.269		
	Student T	0.583	-3.02	1.72
NPRS3	Shapiro-Wilke	0.267		
	Student T	0.407	-1.20	2.90

Abbreviations: NPRS1, difference between values obtained before and after block; NPRS2, difference between values obtained during reduction and after block; NPRS3, difference between values obtained before block and after reduction.

ultrasonography, with the aim of better localization, based on anatomical points. In addition, we believe that greater collaboration of the patient is necessary, informing the sensation of paresthesia in the nerve path.

The anesthetic chosen was lidocaine at 2% without vasoconstrictor, because it is easily accessible, it has low price, low latency, and it provides sufficient effect time to perform the entire procedure.[19] The volume of anesthetic in the SCB group was higher (on average, used 3 to 4mL more), with consequent higher latency for this purpose, since patients needed a few minutes to report improvement of pain, while in the FFI group, improvement was almost immediate.

The study was carried out without major complications, and patients had no complications or sequelae due to the application of anesthetic methods. The main possible complications were infection at the infiltration site, administration of anesthetic in the vascular structure, or nerve injury by intraneural application.[20] Although possible, they are rare events when following the hygiene and safety protocols,[17] and we did not identify the occurrence in any patient involved in our study.

The results obtained in this study were compatible with those previously published in the literature, both in terms of analgesic effectiveness of the method and in the rate of complications.[6,7] Nevertheless, even with the aid of ultrasound, Frenkel et al.[5] did not obtain complete anesthesia, and Bear et al.[21] had 2 cases (7.69%) of paresthesia. These data are reinforced by the methodology used in this study, in which no complications were reported with the two analgesia techniques employed.

Three comparisons were made, and hematoma block was better in all, but statistical analysis was not significant. Although we obtained effective analgesia, radial nerve block did not produce complete anesthesia for the procedure, and this can be explained by the fact the radio region is not completely innervated by the radial nerve.[21]

Thus, although both methods were effective in reducing patients' pain before reduction, as evidenced by the statistical evaluation of means of NPRS measured before and after the block, none promoted complete anesthesia. Thus, the choice of the technique to be used should be up to the executing professional, always respecting the autonomy of the patient, opening the possibility of reduction under sedation in the operating room, if they so wish, after explaining the risks and benefits.

Conclusion

The study showed that both methods have similar analgesic efficacy, with both showing improvement. Despite a slight superiority of the hematoma fracture block in the comparisons, no statistical significance was observed in any of them.

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Conflict of Interest
The authors declare that there is no conflict of interest.

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Epidemiological Analysis of 245 Patients with Athletic Pubalgia*

Análise epidemiológica de 245 pacientes com pubalgia atlética

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Abstract

Objective To analyze the clinicoepidemiological characteristics of pubalgia in athletes and to define the epidemiological profile of patients complaining of lower abdomen and groin pain at a specialized center.

Methodology We conducted a retrospective study based on a case series to evaluate the epidemiological profile of 245 athletes with pubalgia reported in their medical records from October 2015 to February 2018. The selected sample underwent a clinical evaluation, and the results were recorded through the application of a questionnaire.

Results The sample consisted of 245 patients aged between 14 and 75 years. Soccer and running were the most prevalent sports. Most subjects (58%) trained or played sports 3 or more days a week. After evaluating specific sports movements, symptoms worsened in 24% of the patients when changing direction; in 23%, when kicking; in 22%, during sprints and speed training; in 17%, during long runs; and in 14%, when jumping. Pain during intercourse was reported by 13% of the patients. For most subjects (80%), the inguinal region, the adductor muscles, and the pubis (midline) were the main pain sites. The tests involving adductor contraction against resistance with an extended knee was positive in 77.6% of the patients, and the one involving simultaneous hip and abdomen flexion against resistance was positive in 76.7% of the sample.

Keywords
- sports
- epidemiology
- inguinal
- hernia
- pubalgia
- athletic injuries

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Conclusion The present study has demonstrated the predominance of pubalgia in male patients who play soccer and practice running. In most cases (80%), pain occurred in the inguinal region, the adductor muscles, and the pubis. Confirmation of the clinical diagnosis took more than six months for most patients.

Resumo

Objetivo Analisar as características clínico-epidemiológicas da pubalgia do atleta, e definir o perfil epidemiológico dos pacientes com queixa de dor na região baixa do abdômen e virilha avaliados em um centro especializado.

Metodologia Realizou-se um estudo retrospectivo de uma série de casos, no qual se avaliou o perfil epidemiológico de 245 pacientes esportistas com pubalgia, registrados em prontuário, entre outubro de 2015 e fevereiro de 2018. A amostra selecionada foi submetida a uma avaliação clínica, e os resultados foram documentados a partir da aplicação de um questionário.

Resultados A amostra estudada foi de 245 pacientes com idades que variavam entre 14 e 75 anos. O futebol e a corrida foram os esportes mais prevalentes, e 58% treinavam ou praticavam esporte 3 ou mais dias por semana. Após a avaliação dos movimentos esportivos específicos, foi observada piora dos sintomas em 24% com a troca de direção; em 23%, nos chutes; em 22%, nos *sprints* e treinos de velocidade; em 17%, nas corridas longas; e em 14%, nos saltos. Dor durante o ato sexual foi relatado em 13% dos pacientes. A maior parte dos pacientes (80%) relatou que a região inguinal, os adutores e o púbis (linha média) eram os principais sítios da dor. O teste de contração dos adutores contra resistência com joelho em extensão foi positivo em 77,6% dos pacientes avaliados, e o teste de Flexão simultânea do Quadril + Abdômen contra resistência foi positivo em 76.7% dos pacientes.

Conclusão O presente estudo demonstrou o predomínio dessa lesão nos pacientes do sexo masculino praticantes de futebol e de corrida. A dor, na maioria dos casos (80%), estava presente na região inguinal, nos adutores e no púbis. A maioria dos pacientes demorou mais de seis meses para ter o diagnóstico clínico confirmado.

Palavras-chave
- esportes
- epidemiologia
- hérnia
- inguinal
- pubalgia
- lesões em atletas

Introduction

Pubalgia refers to lower abdominal and inguinal pain involving the pubic bones, the pubic symphysis, and adjacent structures. The condition may be associated with systemic inflammatory diseases or genital and urinary infections.[1]

This type of pain is frequent in athletes, especially those of sports that demand intense and multidirectional muscle contractions.[2] Pubalgia is reported in approximately 6% of all chronic injuries related to sports.[3,4] According to Brunt and Barile[5] (2013), its diagnosis and management are always challenging, as symptoms are insidious and diffuse in a complex anatomical region, and multiple causes can coexist.

The pubis functions as a fulcrum for several movements, and adjacent muscles provide dynamic stability. Falvey et al.[6] (2009) have described the groin triangle in layers, from the superficial to the deepest, and the structures that can cause pain in the region. Regarding anatomical aspects, Meyers et al.[7] (2005) have described the concept of macro-joints (lumbosacral, sacrococcygeal, sacroiliac, and pubic symphysis) and micro-joints (muscle attachments, including the psoas and adductor muscles).

There are four main groups of causes of chronic groin and pubic pain: pubalgia, adductor muscle dysfunction, hip joint conditions, and osteitis pubis. In athletes, pubalgia is the weakening of the posterior wall of the inguinal canal with dilation of the transverse fascia and widening of the inguinal triangle.[8]

The main mechanism of injury is trunk hyperextension, thigh hyperabduction, and an imbalance between the strong thigh adductors and weak lower abdominal muscles. This creates a shear force in the pubic symphysis. The incidence of pubalgia is higher among football, rugby, and hockey players.[8]

Today, three major theories describe the pathophysiological aspects of athletic pubalgia. The first theory suggests that the main cause of the condition is ilioinguinal or iliohypogastric nerve entrapment by the external oblique muscle, causing a slightly more proximal pain.[9,10] The second theory states that pubalgia is due to a weakness in the posterior abdominal wall, with compression of the genitofemoral nerve by the pseudoherniated bulb.[8] Finally, the third theory suggests a muscle imbalance due to a precursor lesion in the adductor musculature increasing the pressure in the adductor compartment. This results in macro or microscopic lesions in the pubic attachments close to the pubic cartilage plate.[11]

Athletic pubalgia is diagnosed based on the clinical complaint, physical examination findings, and imaging tests,

such as radiography, magnetic resonance imaging, and ultrasound.[12,13]

The initial treatment is conservative, with rest, analgesic and anti-inflammatory drugs, and physical therapy. Surgical treatment is indicated for refractory cases.[8]

The present paper describes the epidemiological profile of athletic pubalgia at a reference center for the care and treatment of athletes. In addition, it aims to establish links with age group, gender, the type and level of sport, training frequency, characteristics, time until diagnosis, location of symptoms, and the semiological tests and maneuvers more frequently used.

Materials and methods

The present is a retrospective study based on case series that was conducted after obtaining approval from the institutional Research Ethics Committee (under opinion number 2.925.919). We reviewed medical records of patients with lower abdominal and inguinal pain regardless of gender, age, the type of sport, the frequency of the training, the time elapsed since the onset of symptoms, and previous follow-ups with a specialist from October 2015 to February 2018.

Patients diagnosed with prostatitis, urinary tract infection, varicocele, ovarian cyst, endometriosis, appendicitis, diverticulitis, adhesions, overactive bladder syndrome, and those surgically treated for athletic pubalgia were excluded from the study.

All 245 participants underwent a clinical evaluation with the application of a direct, specific questionnaire (►**Fig. 1**), as well as a physical evaluation (►**Fig. 2A-J**).

The routine physical examination consisted of the provocative tests shown in ►**Fig. 2**. We categorized age into groups and expressed the characteristics as frequencies and proportions (%). Data comparison used the Fisher exact test. The statistical analysis was performed using the R (R Foundation for Statistical Computing, Vienna, Austria) software, version 3.6.1. Values of $p < 0.05$ were considered statistically significant.

Results

Epidemiological profile of the patient with athletic pubalgia

This case series comprised 245 participants, 29 women and 216 men, with ages between 14 and 75 years. Most of the participating athletes were Brazilian citizens from 21 different states (Acre, Amazonas, Bahia, Ceará, Distrito Federal, Espírito Santo, Goiás, Maranhão, Minas Gerais, Mato Grosso, Pará, Pernambuco, Paraná, Rio de Janeiro, Rio Grande do Norte, Rondônia, Roraima, Rio Grande do Sul, Santa Catarina, Sergipe, and São Paulo). And four athletes were foreigners (from Angola, Guinea, France, and Portugal).

A total of 44 participants were professional athletes, 19 practiced sports at the university/school level, and 182 played recreationally. Acute pain was reported by 36 participants. After the medical evaluations, 23 participants had indications for surgical procedures to mitigate their symptoms.

Distribution of sports practiced by athletes with pubalgia

The participants practiced 25 different types of sports (►**Fig. 3**), and 3 stood out as the most common among participants, either as the main or as secondary activities. The most prevalent primary sport was soccer (N = 148), followed by running (N = 81) and gym workout (N = 70).

Soccer was the main sport for 129 participants, followed by running and gym workout, with 43 and 16 subjects respectively. Altogether, these 3 sports accounted for 76.7% of the sample (188 of 245). The 3 modalities most selected as secondary or auxiliary sports were gym workout (N = 54), running (N = 38), and soccer (N = 19), regardless of the primary modality. Most (66.1%; 111 out of 168) athletes with pubalgia selected these 3 modalities as secondary sports.

Most participants who primarily played soccer also practiced gym workouts (N = 32) and running (N = 22) as secondary modalities (►**Fig. 4A**). Gym workout and running were the secondary sports for 66.7% of the participants (54 out of 81). Among the participants who primarily practiced running, the two sports most practiced as an auxiliary activity were gym workout (N = 9) and soccer (N = 8) (►**Fig. 4B**), accounting for up to 58.6% of secondary sports (17 out of 29). Among those who primarily practiced gym workouts, running (N = 5) and soccer (N = 3) were the secondary activities, representing 57.1% of the secondary sports practiced by these athletes (8 out of 14).

Evaluation of physical examinations

►**Table 1** shows the results of the physical examination and provocative tests. The test of adductor contraction against resistance with an extended knee (EF4) was positive in 77.6% of the evaluated patients, followed by the test of simultaneous hip and abdominal flexion against resistance (EF2), which was positive in 76.7% of the patients. The hamstring flexibility test (EF9) showed the lowest sensitivity, since it was only positive in 29% of the patients.

Association with sport level, age, and time until diagnosis

Regarding the time elapsed until the diagnosis of pubalgia, 118 patients had their diagnoses established in less than 90 days since the onset of pain, including 20 professional athletes, 88 recreational athletes, and 10 university athletes (►**Table 2**). Diagnostic confirmation occurred after 90 days for 127 patients (24 professional, 94 recreational, and 9 university athletes). The age range between 25 and 40 years predominated in both groups.

Considering the 3 main sports (soccer, running, and gym workout) alone, the most affected age group was that between 25 and 40 years, corresponding to 57% of the total number of athletes evaluated. Regarding gender, there was a male predominance, representing 89% of the sample. As for physical conditioning, 75% of the subjects diagnosed with pubalgia practiced sports at a recreational level, while 18%

Pubalgia

Name: _____ Age: _____ Gender: _____

Contact (Email or cell phone): _____

Main sport you practice: _____ Other sports: _____

Other sports: _____ Location (Gym/Team) _____

Level: Professional ( ) - University/School ( ) - Recreational ( )

Pain characteristics and history: _____

_____

Time since the start of the symptom: _____ Acute start or progressive worsening: _____

Time taken until diagnosis: _____

Number of physicians sought before arriving at the Specialist: _____

Does it interfere with your sports performance? Yes ( ) ; No ( )

Do you feel pain: Cough ( ) ; Sneeze ( ) ; Sexual Relationship ( ) ; Sports ( ) ; Races ( ) ; Walks ( )

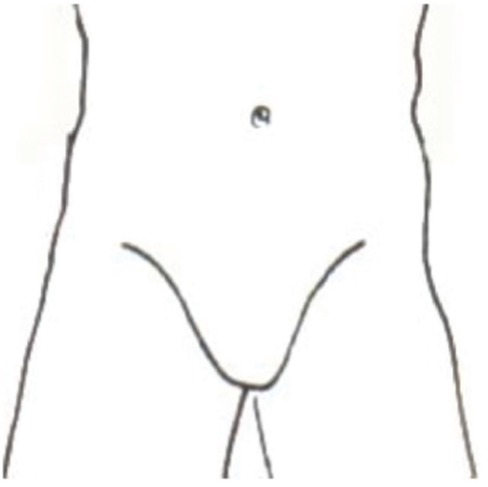
At rest: The pain improves ( ) ; The pain persists ( ); The pain gets worse ( )

In which sports movements do you notice it gets worse: Change of direction ( ) ; Long runs ( )

"Shooting" and speed training ( ) ; Jumps ( ) ; Kicks ( )

Main sites of pain (mark in the figure):

(a) Pubis - midline;
(b) Periumbilical - superior;
(c) Inguinal region;
(d) Adductor region;
(e) Scrotum;
(f) Lumbar spine - posterior



( ) I authorize the use of the above data in the research "Epidemiological Analysis of patients with Pubalgia in Brazil"

Sign: _____

Fig. 1 Model of the evaluation form/directed questionnaire.



Fig. 2 Routine physical examination and provocative tests. (**A**) Orthostatic compression of the anterior compartment (EF1); (**B**) simultaneous hip and abdomen flexion against resistance (EF2); (**C**) adductor contraction against resistance with a flexed knee (EF3); (**D**) adductor contraction against resistance with an extended knee (EF4); (**E**) palpation of the inguinal ring (EF5); (**F**) palpation of the adductor attachment in the pubis (EF6); (**G**) palpation of the pubic body (EF7); (**H**) oblique muscle test against resistance (Grava maneuver) (EF8); (**I**) flexibility tests, especially for the hamstrings (EF9); (**J**) hip range of motion (EF10).

were professional athletes, and 7.4% were university athletes. ►**Table 3** shows these data.

Discussion

The present case series evaluated athletes with pubalgia who practiced 25 different sports, both as main or secondary activities. It is not surprising that soccer is the sport most played by patients treated for pubalgia globally. In the present study, however, the athletes who preferred soccer were not only more predominant, but also those who practiced other activities more often. The discrepancy in the choice of secondary activities is remarkable: 81 soccer players reported practicing secondary activities, while these numbers among athletes who practice running and gym workouts were considerably smaller (29 and 14, respectively).

Most of our patients (88.1%) were male, which is consistent with other studies.[14] It is believed that the gynecoid pelvis protects against lesions, probably because it provides a greater attachment area for the abdominal musculature, increasing the surface for force distribution.

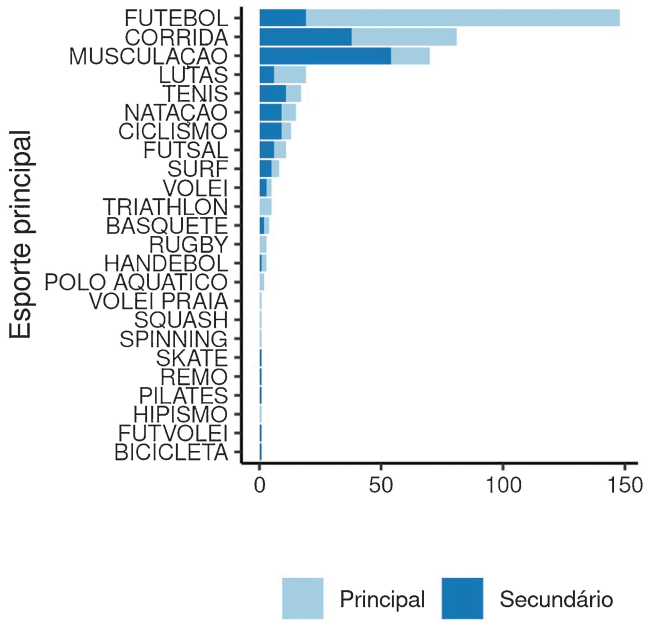


Fig. 3 Prevalence of sports among athletes with pubalgia.

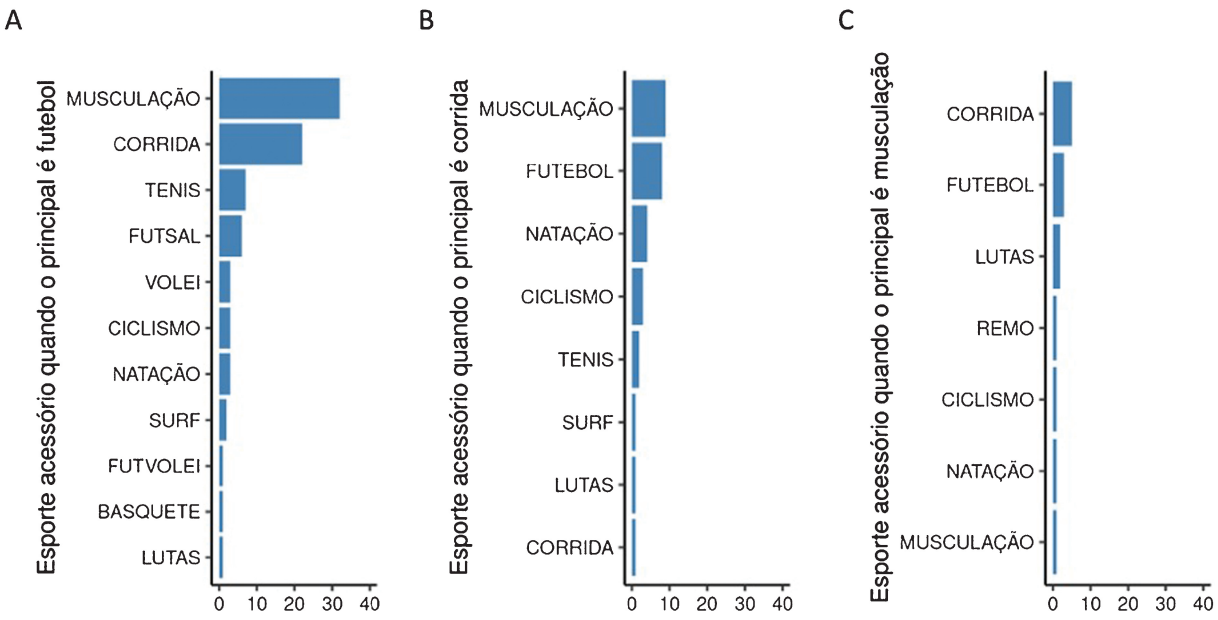


Fig. 4 Secondary sports practiced by the evaluated patients. (**A**) When the main sport evaluated is soccer; (**B**) When the main sport evaluated is running; (**C**) When the main sport evaluated is gym workouts.

In the first studies about pubalgia, virtually all patients were professional athletes. But this has gradually changed over the years, and now a significant number of recreational athletes comprise similar case series.[14] In the present study, 58% of the patients played sports 3 or more times a week.

According to Brunt and Barile[5] (2013), among professional athletes, football, soccer, and hockey account for more than 70% of the cases of pubalgia. In the present study, soccer (60%) and running (15%) were the most prevalent sports.

Soccer is usually the sport with the highest incidence of pubalgia, followed by rugby,[8] football, and ice hockey.[12,13] Regarding track and field, running is a sport with a low incidence of pubalgia if we compare data from Brazilian studies with that if other series; in the present study, its prevalence was of 15%.

Regarding the time since symptom onset until diagnosis, 55% of the subjects reported it was longer than 6 months, and 15%, longer than 12 months. The literature[3] reports that the mean time between symptom onset and the definitive

Table 1 Evaluation of the frequency of response in the physical examinations (N = 245)

Physical examination	n (%)
EF1	77 (31.4)
EF2	188 (76.7)
EF3	166 (67.8)
EF4	190 (77.6)
EF5	153 (62.4)
EF6	102 (41.6)
EF7	168 (68.6)
EF8	71 (29.0)
EF9	37 (15.1)
EF10	120 (49.0)

Abbreviations: EF1, orthostatic compression of the anterior compartment; EF2, simultaneous hip and abdomen flexion against resistance; EF3, adductor contraction against resistance with a flexed knee; EF4, adductor contraction against resistance with an extended knee; EF5, palpation of the inguinal ring; EF6, palpation of the adductor attachment in the pubis; EF7, palpation of the pubic body; EF8, oblique muscle test against resistance (Grava maneuver); EF9, flexibility tests, especially for the hamstrings; EF10, hip range of motion.

diagnosis ranges from 1 to 53 months, with a median time of 6 months.

Regarding the characteristics of the pain, most patients reported symptom improvement at rest and worsening during the practice of sports, running, and walking. Another 13% had pain during sexual intercourse, 11%, when sneezing, and 8%, when coughing. As for specific sports movements, symptoms worsened when changing direction, during long runs, sprints and speed training, jumps, and kicks. Most patients referred pain in the inguinal region, adductor muscles, and pubis. Other affected sites were the lumbar spine, the proximal thigh, the

Table 2 Association of the physical examinations, sport level, and age, with the time until diagnosis

Physical examination	≤ 90 days; N = 118–n (%)	> 90 days; N = 127–n (%)	*p*-value[b]
EF1	33 (28%)	44 (35%)	0.27
EF2	94 (80%)	94 (74%)	0.36
EF3	83 (70%)	83 (65%)	0.42
EF4	93 (79%)	97 (76%)	0.76
EF5	72 (61%)	81 (64%)	0.69
EF6	44 (37%)	58 (46%)	0.20
EF7	76 (64%)	92 (72%)	0.22
EF8	36 (31%)	35 (28%)	0.67
EF9	13 (11%)	24 (19%)	0.11
EF10	59 (50%)	61 (48%)	0.80
Age			0.88
< 25 years old	20 (17%)	25 (20%)	
25-40 years old	70 (59%)	72 (57%)	
> 40 years old	28 (24%)	30 (24%)	
Sport level			0.88
Professional	20 (17%)	24 (19%)	
Recreational	88 (75%)	94 (74%)	
University/ School	10 (8.5%)	9 (7.1%)	

Abbreviations: EF1, orthostatic compression of the anterior compartment; EF2, simultaneous hip and abdomen flexion against resistance; EF3, adductor contraction against resistance with a flexed knee; EF4, adductor contraction against resistance with an extended knee; EF5, palpation of the inguinal ring; EF6, palpation of the adductor attachment in the pubis; EF7, palpation of the pubic body; EF8, oblique muscle test against resistance (Grava maneuver); EF9, flexibility tests, especially for the hamstrings; EF10, hip range of motion.
Note: [b]Fisher exact test.

Table 3 Association of the most prevalent sports with age group, gender, and sport level

Characteristics	Total; N = 188–n (%)	Soccer; N = 129–n (%)	Running; N = 43–n (%)	Gym workout; N = 16–n (%)	*p*-value[b]
Age					< 0.001
< 25 years old	38 (20%)	35 (27%)	2 (4.7%)	1 (6.2%)	
25-40 years old	108 (57%)	72 (56%)	24 (56%)	12 (75%)	
> 40 years old	42 (22%)	22 (17%)	17 (40%)	3 (19%)	
Gender					< 0.001
Female	21 (11%)	0 (0%)	15 (35%)	6 (38%)	
Male	167 (89%)	129 (100%)	28 (65%)	10 (62%)	
Sport level					0.034
Professional	33 (18%)	29 (22%)	2 (4.7%)	2 (12%)	
Recreational	141 (75%)	90 (70%)	39 (91%)	12 (75%)	
University/ School	14 (7.4%)	10 (7.8%)	2 (4.7%)	2 (12%)	

Note: [b]Fisher exact test.

perineum, and the testes.[15] Patients from other countries also reported inguinal, adductor, and pubic pain.[14,16]

In the present study, the most prevalent positive clinical test was the adductor contraction against resistance with an extended knee, in 190 patients, followed by simultaneous unilateral hip and abdomen flexion against resistance, in 188 patients. This finding is consistent with those of the literature,[15] as muscle contraction in adduction against resistance, trunk flexion, and inguinal palpation were the most sensitive tests for the diagnosis of pubalgia. Although valuable for patient assessment, inguinal palpation relies on the experience of the examiner, especially their ability to differentiate pubalgia from inguinal and femoral hernias. Other findings described include tenderness in the conjoint tendon, pubic tubercle, and medial inguinal region.[12]

Conclusion

Most patients with suspected pubalgia are male young adults between the ages of 26 and 45 years, who practice soccer or running at a recreational level. They present symptoms that interfere with sports performance. Their pain improves with rest and worsens with exercises, sexual intercourse, sneezing, coughing, and specific sports movements, such as changing direction, sprints and speed training, jumping, and kicking. The pain was most prevalent in the inguinal region and the pubis. The most commonly positive pain-related clinical tests were adductor contraction against resistance with an extended knee and simultaneous unilateral hip and abdomen flexion against resistance. For some patients, the time from symptom onset until final diagnosis took more than 12 months.

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

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Treatment of Infected Pseudarthrosis of the Tibia Using the Ilizarov Method and the Orr Dressing

Tratamento das pseudoartroses infectadas da tíbia pelo método de Ilizarov associado ao curativo de Orr

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Abstract

Objective This study aims to analyze outcomes and clinical and epidemiological data of infected tibial pseudarthrosis using the Ilizarov method and the Orr dressing.

Methods Data from n = 43 patients diagnosed with infected tibial pseudarthrosis were analyzed by descriptive and inferential statistical methods. In addition, Paley's assessment criteria evaluated bone and functional outcomes. Qualitative variables were presented as the distribution of absolute and relative frequencies. The presentation of quantitative variables followed the D'Agostino-Pearson test.

Results Thirty-seven (86.04%) subjects were males, and six (13.95%) were females. The most frequent age group among patients was 50 to 59 years old (25.6%), with a p-value = 0.8610. The treatment time was longer for the trifocal treatment (23.8 months) when compared to the bifocal treatment (15.6 months), with a p-value = 0.0010* (highly significant). Excellent bone outcomes represented 72.09% of the sample; 23.25% of outcomes were good. Functional outcomes were excellent in 55.81%, good in 6.97%, and regular in 27.90% of subjects. The Orr dressing (using Vaseline gauze) proved effective, achieving wound healing with soft tissue coverage in all patients evaluated.

Conclusions The Ilizarov method resulted in a substantial change in the treatment of bone infections, especially infected pseudarthrosis. The versatility of this method has turned it into an effective tool, allowing the healing of the infectious process and the correction of potential deformities and shortening.

Keywords
- Ilizarov Technique
- pseudoarthrosis
- tibia
- treatment outcome

Study developed at Hospital Regional de Sobradinho, Brasília, Distrito Federal, Brazil.

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Resumo

Objetivo Analisar os resultados e os dados clínicos e epidemiológicos do tratamento das pseudoartroses infectadas da tíbia pelo método de Ilizarov associado ao curativo de Orr.

Métodos Para analisar os dados de n = 43 pacientes com diagnóstico de pseudoartrose infectada da tíbia foram aplicados métodos estatísticos descritivos e inferenciais e os resultados ósseos e funcionais foram avaliados de acordo com os critérios de avaliação de Paley. As variáveis qualitativas foram apresentadas por distribuição de frequências absolutas e relativas. As variáveis quantitativas foram apresentadas pelo teste de DAgostino-Pearson.

Resultados Foi encontrado que 37 (86,04%) eram do sexo masculino, 6 (13,95%) femininos. A faixa etária mais frequente entre os pacientes foi de 50 a 59 anos (25.6%), p-valor = 0.8610. O tempo de tratamento é maior no tratamento trifocal (23.8 meses) quando comparado com o Bifocal (15.6 meses), p-valor =0.0010* (altamente significante). Os resultados ósseos excelentes representaram 72,09%, 23,25% foram de resultados considerados bons. Os resultados funcionais considerados excelentes foram 55,81%, os resultados bons foram 6,97%, resultados regulares foram 27,90. O curativo com gaze vaselinada (curativo de Orr) mostrou-se eficaz, alcançando assim a cicatrização das feridas com cobertura de partes moles em todos os pacientes avaliados.

Conclusões O método de Ilizarov proporcionou uma mudança substancial no tratamentos das infecções ósseas, especialmente das pseudoartroses infectadas. A versatilidade deste método se transformou em uma ferramenta eficaz, permitindo a cura do processo infeccioso, bem como correção das possíveis deformidades e do encurtamento.

Palavras-chave

- pseudoartrose
- tíbia
- resultado do tratamento
- Técnica de Ilizarov

Introduction

Pseudarthrosis is one of the most significant issues faced by orthopedic surgeons globally when treating long tubular bone fractures. In addition to consolidation issues, severe problems such as deformity, infection, and limb length discrepancy accompany the clinical picture.[1]

Fractures may evolve with delayed consolidation or nonunion. Pseudarthrosis is the lack of fracture healing with clinical, radiological, or both evidence that the fracture healing process has ended and that its progression will be highly unlikely.[2]

Pseudoarthrosis requires a treatment that stimulates bone healing, treats the infection, and solves the issues of length discrepancy and angular deformities.[3] In 1951, in Kurgan, Russia, Gavriil Abramovich Ilizarov introduced an external fixation device and successfully developed his method to treat several orthopedic and trauma injuries.[4]

The possibility of bone lengthening safely and predictably by gradual traction, following the principle proposed by Ilizarov, allowed this lengthening under a new biological perspective and the development of a new technique called compression-removal osteosynthesis.[5]

Therefore, this study seeks to analyze the outcomes and clinical and epidemiological data from infected tibial pseudarthrosis treated by the Ilizarov method and the Orr dressing.

Methods

The Research Ethics Committee approved this study under number 53773621.3.0000.5553.

We retrospectively evaluated 43 medical records of patients diagnosed with infected tibial pseudarthrosis at the Hospital Regional de Sobradinho, Distrito Federal, Brazil, from July 2012 to December 2019. Inclusion criteria were infected tibial pseudarthrosis treated with the Ilizarov method for at least six months after fixation removal in patients over 18 years old, from both genders, who had all the data available in their medical records. Exclusion criteria were uninfected pseudarthrosis, tibial pseudarthrosis treated with other methods, congenital tibial pseudarthrosis, patients younger than 18 years old, and subjects with insufficient data in their medical records.

Data collection from electronic medical records used spreadsheets developed by the authors. Evaluation of bone and functional outcomes results followed the criteria reported by Paley et al.[6] (►**Tables 1** and **2**).

Descriptive and inferential statistical methods analyzed data from n = 43 patients diagnosed with infected tibial pseudarthrosis. Qualitative variables were presented as the distribution of absolute and relative frequencies. Quantitative variables were shown as measures of central tendency and variation. The D'Agostino-Pearson test $D^* = \frac{D - \mathrm{E}\{D\}}{s(D)}$ assessed

Table 1 Criteria for bone outcomes assessment according to Paley et al.

Bone outcomes	Bone consolidation	Lack of infection	Angular deformity lower than 7°	Tibial length discrepancy lower than 2.5 cm
Excellent	All above criteria			
Good	Bone consolidation plus two other criteria			
Regular	Bone consolidation plus one other criterion			
Poor	No bone consolidation, refracture, or lack of any other criterion			

Table 2 Criteria for functional outcomes assessment according to Paley et al.

Functional outcomes	Significant claudication	Equinus deformity	Soft tissue dystrophia	Pain and inactivity
Excellent	Active subject with none of the four criteria			
Good	Active subject with one or two criteria			
Regular	Active subject with three or four criteria			
Poor	Inactive subject regardless of other criteria			

normality. Analysis also employed adhesion chi-square tests, $x^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$, Student's *t*-test $t = \frac{Z}{\sqrt{V/\nu}}$, and Pearson's linear correlation $t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$.[7] An alpha error of 5% was previously set for rejecting the null hypothesis. Statistical processing used the BioEstat version 5.3 and the STATA release 17 software.[8]

Surgical technique and outpatient treatment

Each patient underwent a clinical and radiological evaluation before surgery. Assembly of the Ilizarov apparatus occurred during the perioperative period according to the size of the segment and the verification of the required length and width. Incisions usually followed the topographies of previous surgical scars.

Any implanted material, when present, was removed. An anterior or anteromedial incision allowed the resection of non-viable bone tissue. Necrotic tissue or a bone edge smaller than 2/3 of the regular diameter was deemed non-viable. Resected samples were sent for histopathological study.

Ilizarov external fixators assembly followed the pattern from the Italian school,[5] using 1.8-mm Kirschner wires and 6-mm tapered Schanz pins. The fasteners were extended to the foot to minimize equinus deformity in bone elongations greater than 4 cm or if there was a distal metaphyseal bone failure. Corticotomies employed a Gigli saw (American technique).

The type of bone reconstruction depends on the size of the bone defect. Treatment of bone defects smaller than 4 cm used bifocal bone transport, while those greater than 4 cm underwent trifocal bone transport. Treatment of bone defects larger than 10 cm employed tetrafocal bone transport or reconstruction with a fibula; one patient underwent a tibialization of the fibula.

The surgical wound at the resection site of non-viable bone tissue remained open. Wound size varied according to the dimensions of the bone resection; it could be smaller than 4 cm in bifocal transports, larger than 4 cm in trifocal transports, and even greater than 10 cm in major resections. Dressings consisted of gauze moistened with sunflower oil. These deep dressings were changed weekly at the orthopedics outpatient facility per the Orr technique.[9] No additional procedures were performed, such as plastic surgery.

Table 3 Characterization of n = 43 subjects diagnosed with infected tibial pseudoarthrosis

General features		Frequency	χ^2
Categories	n = 43	%	p-value
Age range			**0.8610**
20 to 29 years	7	16.3	
30 to 39 years	9	20.9	
40 to 49 years	7	16.3	
50 to 59 years	11	25.6	
60 years or older	9	20.9	
Gender			**<0.0001***
Female	6	14.0	
Male	37	86.0	
Reason for trauma			**<0.0001***
Firearm	2	4.7	
Hit and run	3	7.0	
Motorcycle accident	16	37.2	
Fall from own height	1	2.3	
Not specified	21	48.8	
Laterality			**0.7604**
Right	20	46.5	
Left	23	53.5	

*Chi-square test for adherence to equal expected proportions.

Table 4 Treatment details and complications in n = 43 subjects diagnosed with infected tibial pseudoarthrosis

Treatment and complications		Frequency	χ^2
Feature	**n = 43**	**%**	**p-value**
Treatment time (months)			**0.0063***
11 months or less	9	20.9	
12 to 23 months	19	44.2	
24 to 35 months	12	27.9	
36 months or more	3	7.0	
Type of treatment			**<0.0001***
Bifocal	20	46.5	
Trifocal	20	46.5	
Tetrafocal	2	4.7	
Tibialization of the fibula	1	2.3	
Complication			**<0.0001***
Regenerating tissue fracture	2	4.7	
Osteolysis/pin loosening	1	2.3	
Pin path infection	38	88.3	
Refracture	2	4.7	

*Chi-square test for adherence to equal expected proportions.

Patients were usually discharged from the hospital within the first 48 hours after surgery. Subjects received prescriptions for oral antimicrobial and analgesic agents to take during the first week per the pre-established hospital protocol. After surgical resection, antibiotics were discontinued or even not used at all; antibiotic therapy was reserved only for cases of infection in the pins and wires path.

We asked the patients to keep the limb elevated and use an elastic orthosis for passive ankle dorsiflexion. Weight-bearing was encouraged from the third week after surgery. In addition, physical therapy was widely recommended but often impaired or neglected due to socioeconomic factors.

Bone transport started in the second or third week after surgery. The speed for each regenerating tissue construction was 0.5 mm per day, divided into two daily manipulation steps.

After wound closure by second intention healing and bone transport completion, the patient underwent a new surgical procedure for grafting autologous spongy bone from the iliac crest in the pseudarthrosis foci.

Following grafting, the patient underwent a monthly radiological evaluation to verify pseudarthrosis union, regenerating tissue consolidation, and potential complications. Fixator removal occurred after complete device dynamization, pseudarthrosis consolidation, regenerating tissue corticalization on at least three of the four sides, lack of pain on bone palpation, and when the patients supported a total load on the affected limb. After removing the device, subjects used protective orthoses such as boots for at least one month to avoid refractures.

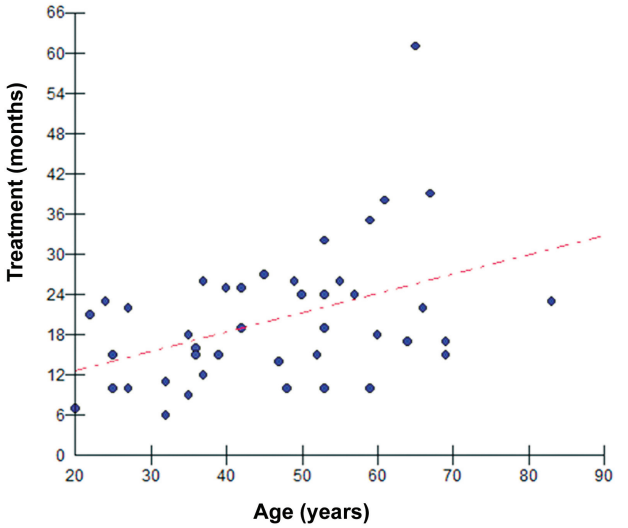


Fig. 1 Correlation between the subjects' age (years) and treatment time (months) of n = 43 patients diagnosed with infected tibial pseudarthrosis.

Results

This study analyzed data from n = 43 patients diagnosed with infected tibial pseudarthrosis. ►**Table 3** characterizes

Table 5 Post-treatment functional outcomes in n = 43 subjects diagnosed with infected tibial pseudoarthrosis

Functional outcomes assessment		Frequency	χ^2
Features	**n = 43**	**%**	**p-value**
Claudication			**0.3602**
Yes	18	41.9	
No	25	58.1	
Equinus deformity			**<0.0001***
Yes	5	11.6	
No	38	88.4	
Dystrophia			**<0.0001***
Yes	2	4.7	
No	41	95.3	
Pain/inactivity			**<0.0001***
Yes	4	9.3	
No	39	90.7	
Discrepancy lower than 1.5 cm			**0.0008***
Yes	33	76.7	
No	10	23.3	

*Chi-square test for adherence to equal expected proportions.

Table 6 Treatment time per functional outcomes assessment in n = 43 subjects diagnosed with infected tibial pseudoarthrosis

		Treatment time (months)		
	n	Average	Standard deviation	p-value
Reason for trauma				**0.2876**
Firearm	2	16.0	14.1	
Hit and run	3	23.7	4.0	
Fall from motorcycle	16	19.3	12.8	
Fall from own height	1	25.0	—	
Not specified	21	20.9	8.9	
Type of treatment				**0.0100***
Bifocal	20	15.6	6.4	
Trifocal	20	23.8	11.6	
Tetrafocal	2	33.5	2.1	
Tibialization of the fibula	1	21.0	—	
Claudication				**0.0469****
Yes	18	24.2	12.1	
No	25	17.6	7.6	
Equinus deformity				**0.4272**
Yes	5	23.8	10.7	
No	38	19.9	10.2	
Dystrophia				**n/a**
Yes	2	37.0	2.8	
No	42	19.5	9.7	
Pain/inactivity				**0.1509**
Yes	4	37.3	19.3	
No	39	18.6	7.2	

*Student's t-test (Bifocal x Trifocal)
**Student's t-test (Claudication x No claudication)

the treated patients. The age group between 50-59 years was the most frequent, accounting for 25.6% of subjects. Males were 86% of the sample, and the left tibia was the most affected bone (53.5%). The most frequent trauma reason was motorcycle accidents (37.2%).

As shown in ►**Table 4**, it is possible to estimate the treatment time per the following equation: **Treatment time = 6.7 + Age * 0.2895**, indicating that the correspondence is directly proportional (►**Fig. 1**). Treatment lasted 12 to 23 months in 44.2% of patients. Treatment consisted of bifocal and trifocal bone transport in 46.5% and 46.5%, respectively, of subjects. Infection at the pin path occurred in 88.3% of patients.

►**Table 5** describes the post-treatment functional outcomes assessment. Please note that 58.1% of the patients had no claudication, and 95.3% did not present dystrophy. ►**Table 6** characterizes the treatment time, which is longer in patients with claudication (24.2 months) compared to patients with no claudication (17.6 months), with a p-value = 0.0469* (statistically significant) (►**Fig. 2**).

Pathological anatomy findings were available for only eight of the 43 patients evaluated, and these eight samples were positive for osteomyelitis. Cultures were not usually requested as we decided not to use antibiotics after bone resection and reconstruction.

Bone and functional outcomes were retrospectively evaluated based on the information from the medical records of all patients after the end of treatment using the criteria reported by Paley et al.[6] (►**Table 1**).

Most (72.09%) patients had excellent bone outcomes (►**Fig. 3**) and 23.25% presented good outcomes. No patient had regular bone outcomes, and 4.65% had poor bone outcomes. All patients presented bone infection resolution and pseudarthrosis union. Regular and poor outcomes resulted from deformities, residual discrepancies, or refractures.

Functional outcomes (►**Table 2**) were excellent in 55.81% of patients (►**Fig. 4**); in addition, functional outcomes were good in 6.97%, regular in 27.90%, and poor in 9.30% of subjects.

Regarding complications during treatment, we observed that, at some point, all patients had infections related to the Schanz pins and Kirschner wires. In one subject, the pin came loose, requiring an additional procedure for surgical

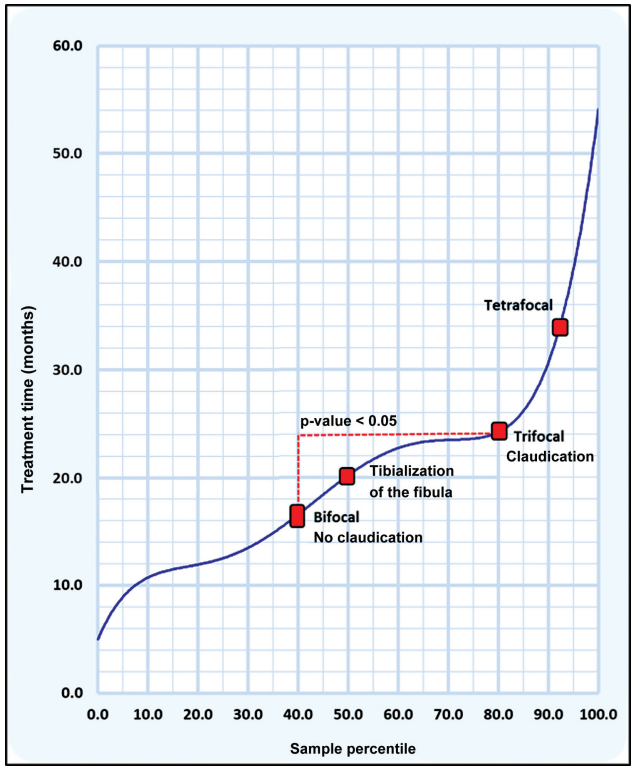


Fig. 2 Treatment time according to the type of treatment and claudication in n = 43 patients diagnosed with infected tibial pseudarthrosis.

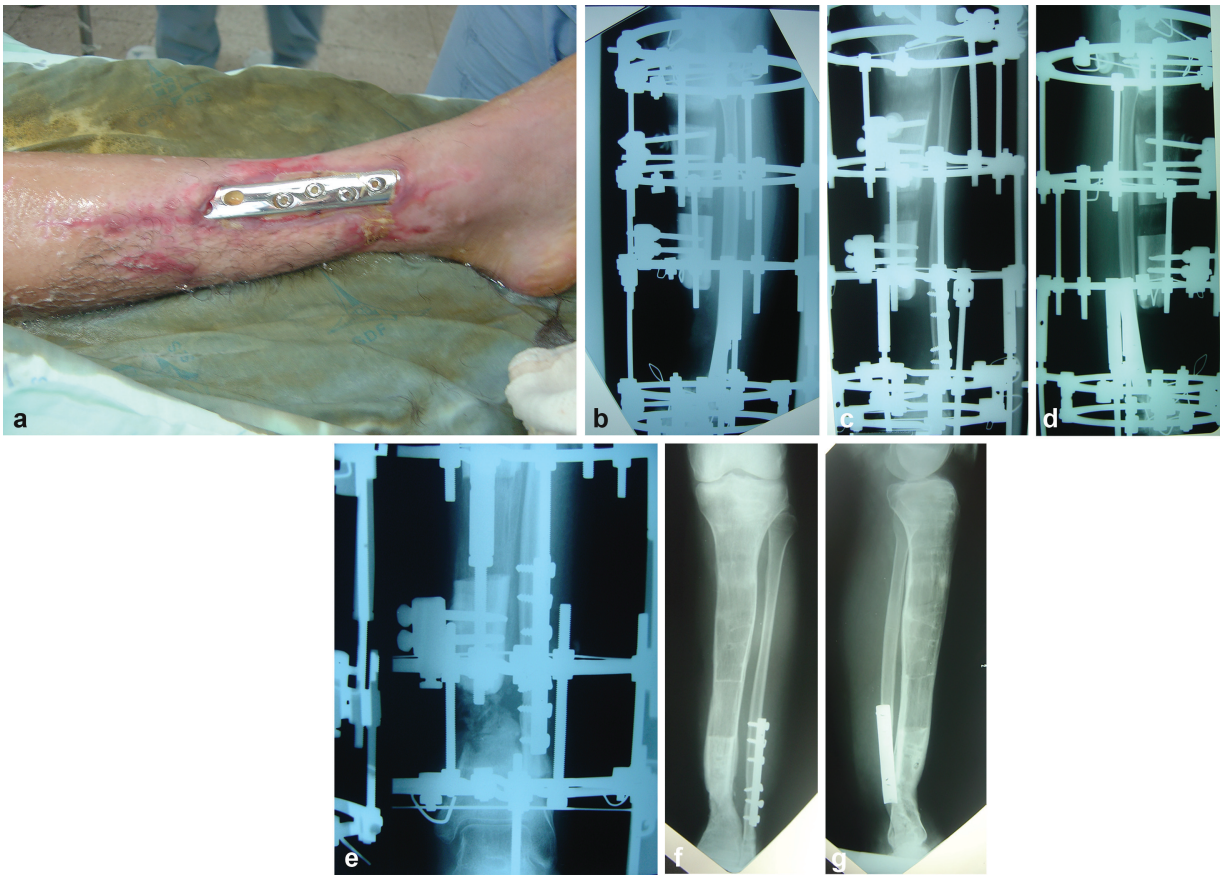


Fig. 3 **(a)** Male subject with pseudarthrosis of the right and left tibia and synthesis material exposure; **(b)** Radiograph after material removal, bone resection, and assembly of the Ilizarov fixator aiming at trifocal bone transport; **(c, d)** Radiograph showing bone transport; **(e)** Radiograph showing the status near transport completion; **(f, g)** Consolidated fracture.

debridement of the path and fixation of a new pin. In another patient, this infectious process led to instability of the distal fixator block, successfully treated with a new device revision procedure.

Two patients had refracture after fixator removal and were treated conservatively with plaster casts and boot-type orthoses. One patient presented a fracture of the regenerating bone and underwent treatment with a boot-type immobilizing orthosis, which resulted in bone healing without deformities.

Regarding soft tissue outcomes, no patient required additional procedures such as skin flaps or grafts. The dressing consisted of gauze moistened with liquid Vaseline or sunflower oil (Orr technique),[9] achieving wound healing by secondary intention in all evaluated subjects.

Discussion

Ilizarov postulated new biological concepts and techniques for an external fixation system that revolutionized the treatment of pseudarthrosis. With minimal osteosynthesis, this system allows deformity correction, infection eradication, limb equalization, and bone defect elimination while maintaining joint function and permitting early bodyweight loading.[6]

Epidemiological (age, gender, and laterality) data were consistent with another study[3] including 20 patients with infected unilateral tibial pseudarthrosis treated using the Ilizarov method. This study consisted of 16 male and four female patients with a mean age of 32 years (range, 17-74). As for the affected side, nine (45%) injuries were on the right side, and 11 (55%) were on the left side.

Regarding treatment options and time, in the present study, bifocal and trifocal bone transports were the most used techniques, and the mean treatment time was 20.34 months. An Indian study[9] employed bifocal transport in 85% of patients. In contrast, an American study[5] had 10 patients undergoing monofocal compression-distraction treatment, seven patients receiving bifocal treatment, and three subjects undergoing a bifocal treatment combined with infected bone resection.

These data differ from other studies[6,10] since one found a mean consolidation time of 12.57 months, and the other had a mean follow-up time of 40.8 months. Other authors,[11] however, observed that 85% of patients underwent a bifocal transport.

Our bone outcomes were consistent with those reported by Maini et al.,[12] who observed 70% of excellent outcomes, 10% of good outcomes, no regular outcomes, and 20% of poor outcomes. These findings are similar to those reported by



Fig. 4 **(a)** Male subject during the immediate postoperative period of Ilizarov fixator placement to treat an infected pseudarthrosis; **(b, c)** Patient during treatment; **(d, e, f, g)** Functional outcome after Ilizarov fixator removal.

McNally et al.,[11] who had 60% of excellent outcomes, 15% of good outcomes, 25% of regular outcomes, and no poor outcomes. However, they do not agree with another study[13] reporting 22% of excellent outcomes, 36.34% of good outcomes, 22% of regular outcomes, and 18.18% of poor outcomes.

Two other studies presented comparable findings.[6,14] The first reported the following bone outcomes: 60.87% excellent, 26.09% good, 8.7% regular, and 4.35% poor. The second obtained 50% excellent, 29% good, 3.6% regular, and 17.4% poor outcomes.

Functional outcomes were excellent in 55.81%, good in 6.97%, regular in 27.90%, and poor in 9.30% of our patients. This scenario is similar to another study,[14] reporting excellent, good, regular, and poor outcomes in, respectively, 55%, 30%, 5%, and 10% of the sample.

These data differ from four other studies[6,13,15,16] presenting the following conclusions: the first had 26.7% excellent, 40% good, 10% regular, and 28.3% poor functional outcomes; the second reported 5.56% excellent, 22.22% good, 33.33% regular, and 38.89% poor functional outcomes; the third showed 25% excellent, 39.2% good, 14.3% regular, and 2.15% poor functional outcomes; at last, the fourth study presented 64% excellent, 28% good, 4% regular, and 4% poor functional outcomes.

Certain complications and intercurrences are frequent and inherent to external fixators, including infection in pin and wire paths, joint contractures, vascular and nervous injuries, and loss of device stability. However, certain complications are specific to bone transport in pseudarthrosis.[17]

Premature consolidation and delayed ossification of the regenerating tissue are complications arising from the lack of rhythm balance and stretching periodicity. Other complications include regenerating tissue angular deformity and fracture, often resulting from early device removal or the patient falling during or after treatment.[18]



Fig. 5 **(a)** Example of Orr vaseline gauze dressing; **(b)** Male subject; intraoperative image of the Ilizarov fixator for tetrafocal tandem bone transport; **(c)** Immediate postoperative radiograph of the Ilizarov fixator for tetrafocal transport; **(d)** A few weeks after initiation of bone transport and Orr dressing changes; **(e)** Patient after transport completion, removal of Ilizarov fixator, and Orr dressing changes; **(f)** Radiograph after Ilizarov fixator removal and tetrafocal transport.

As for complications during treatment, all patients had infections related to Schanz pins and Kirschner wires at some point. Another study supported this observation,[18] concluding that superficial infection in pins and/or wires path can occur in up to 100% of cases and is always present at some stage of treatment.

Regarding soft tissue outcomes, no patient required additional procedures such as skin flaps or grafts. The use of Vaseline gauze dressings (Orr dressing) resulted in wound healing with soft tissue coverage in all patients evaluated.

War surgeon H. Winnett Orr[9] introduced the treatment of acute osteomyelitis through drainage and placement of an aseptic dressing inside and around the wound, not removing or changing it for several weeks. Two or four dressings are often enough to ensure healing; meanwhile, the limb is immobilized with a cast, and dressings replacement occurs through a window in the cast.

This Vaseline gauze tampon dressing has been used since World War I (►**Fig. 5**). Solid Vaseline impregnates the gauze and does not allow the penetration of vascular neoformation buds in its margins. At the same time, however, it allows the flow of secretions. Tissue growth gradually pushes the tampon out and, when reaching the skin, the epithelium from the wound edges covers the defect.[19]

Conclusion

The Ilizarov method led to a substantial change in the treatment of bone infections, especially infected pseudarthrosis. The versatility of this method made it an effective tool since it allows the healing of the infectious process and the correction of potential deformities and limb shortening.

Most of the literature corroborates epidemiological data and bone and functional outcomes of this study. As such, we demonstrated the method's effectiveness, which resulted in infectious process resolution, bone consolidation, and reasonable functional recovery for the evaluated subjects.

Complications are inherent to the treatment due to the usual prolonged period until healing. They must be understood and properly managed by the attending physician and the patient to minimize these complications as much as possible.

Soft tissue management is also a significant factor to consider. Vaseline gauze dressing proved to be an effective and inexpensive option for treating soft tissues, as it eliminates the need for additional surgical procedures, saving resources and resulting in less physical and emotional distress for patients.

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Conflict of Interests

The authors declare no conflict of interests.

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Telemedicine Effectiveness in the First Elective Orthopedic Care Compared to a Standard Face-to-face Visit

Efetividade da teleconsulta no primeiro atendimento ortopédico eletivo comparada ao padrão presencial

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Abstract

Objective The study aimed to compare whether the diagnoses of orthopedic diseases at telemedicine (TM) consultations are the same as those established at face-to-face visits.

Method Primary, observational, prospective, analytical study, with subjects from the local municipal network who were referred to the orthopedics outpatient clinic from May to June 2021. Subjects underwent two assessments: a telemedicine (TM) consultation and a face-to-face (FF) visit. Two different physicians attended to the patients and established a diagnosis. The physician performing the FF visit was not aware of the previous diagnoses. We compared the diagnoses obtained at both modalities to assess the degree of similarity. In addition, we determined the time required for consultations and the degree of satisfaction of the physicians.

Results We evaluated 43 patients and seven physicians, totaling 44 TM and 43 FF visits. The diagnostic similarity index was 81.4%. TM consultations were shorter (mean time, 4.8 minutes) than FF visits. Physicians were less satisfied with TM in the four criteria evaluated (respective scores of 79.1, 23.3, 46.6, and 37.2).

Conclusion TM consultations have a diagnoses agreement higher than 80% compared with FF visits. On the other hand, TM consultations were faster, and physicians were less satisfied with them in comparison with FF visits.

Keywords
- treatment adherence and compliance
- diagnosis
- orthopedics
- teleconsultation

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Resumo

Objetivo O objetivo do estudo foi comparar se os diagnósticos das doenças ortopédicas realizados por teleconsulta (TC) são os mesmos dos atendimentos presenciais.

Método Estudo primário, observacional, prospectivo, analítico, com dados colhidos de maio a junho de 2021, com participantes provenientes da rede municipal local que foram encaminhados ao ambulatório de ortopedia de referência e oferecida participação no estudo com duas avaliações: a primeira por teleatendimento e a segunda de forma presencial. Cada participante foi atendido por dois diferentes profissionais, e cada um emitiu um diagnóstico. Os profissionais do atendimento presencial não conheciam os diagnósticos prévios. Os diagnósticos emitidos foram comparados para avaliar o grau de semelhança. Ainda, foi aferido o tempo para realização dos atendimentos e o grau de satisfação do profissional participante.

Resultados Foram avaliados 43 pacientes e 07 profissionais participaram, totalizando 44 TC e 43 atendimentos presenciais. O índice de semelhança do diagnóstico foi de 81,4%. A TC teve um tempo menor para realização (média de 4,8 minutos), que o presencial. A satisfação dos profissionais foi menor na TC nos quatro critérios avaliados, sendo, respectivamente, 79,1, 23,3, 46,6 e 37,2.

Conclusão A TC tem concordância no diagnóstico superior a 80% em comparação ao atendimento presencial. Já a realização do teleatendimento teve menor tempo de duração e os profissionais se consideraram menos satisfeitos em relação ao atendimento presencial.

Palavras-chave

- cooperação e adesão ao tratamento
- diagnóstico
- ortopedia
- teleconsultas

Introduction

The improvement in audiovisual communication within the last 20 years, especially with the widespread use of smartphones and greater access to high-speed internet,[1] allowed the expansion of telemedicine.[2,3] In 2020, the COVID-19 pandemic made social distancing a requirement and boosted health systems to implement remote care. The enactment of the Brazilian federal law number 13989 from April 15, 2020, about telemedicine (TM) during the COVID-19 crisis recognizes the importance of telehealth as an instrument for citizen protection.[4]

Studies showed that TM satisfaction rates are comparable with face-to-face (FF) visits, and patients who underwent virtual consultations are more likely to seek them again.[5] Buvik et al.[6] analyzed orthopedic patients undergoing TM and FF visits and revealed that 99% of them classified TM as very satisfactory or satisfactory. In addition, 86% of the subjects would prefer TM in the future. There is also an economic impact resulting from cost reduction.[7]

Remote assistance by digital means (telehealth) is growing because it is safe, efficient, and cheaper.[7] However, health professionals and patients who are not used to this technology report limitations. These limitations include the inability to perform semiology, the lack of established commercial rules, insecurity with the accelerated implementation, and discomfort with this tool.[8]

This study aimed to evaluate the agreement in diagnoses of a first elective orthopedic consultation performed by TM compared with an FF visit. We hypothesize that the diagnostic agreement between these modalities of care is high.

Material and Methods

Primary, observational, prospective, analytical study. The research ethics committee approved this protocol.

Eligible participants were adults up to 75 years old who sought elective orthopedic care for the first visit to our institution after a referral from the municipal network. We did not include emergency, urgency, or fracture follow-up visits. After scheduling at the appointment center, the hospital's administrative team invited the subjects to the study; in case of compliance, we asked patients to fill in an informed consent form (ICF) and a demographic data form (►**Annex 1**, supplementary material). In addition, we checked the equipment available for remote access and the patient's familiarity with digital tools for video calls. Patients had to have a cell phone capable of video calls using the Microsoft Teams application (Redmond, Washington, USA).

Each patient underwent visits in both modalities: first, a TM consultation and, at another time, an FF visit. Different orthopedists were responsible for each patient's consultations, so the second physician would not be aware of the first diagnosis. TM occurred at a conventional outpatient care room with a high-speed internet access desktop, a camera (Ecam X, HK REXSO COM TECH), a microphone, and speakers (flat3w RMS, Multilaser) for video calls using the Microsoft Teams platform (Redmond, Washington, USA). For convenience, a secretary from our institution distributed TM and FF visits to prevent the same orthopedist from seeing the same patient using both modalities.

Outcomes and data standardization

The primary outcome was the agreement between the diagnosis established at TM and FF (considered the gold standard), either in its descriptive form or as code from the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10). Secondary outcomes included consultation time and the physician's satisfaction with the modality. The principal investigator analyzed the descriptive diagnoses for relative and not absolute similarity; for instance, we considered knee pain and gonalgia, or low back pain and intervertebral disc disorder, the same diagnosis. In cases of divergence, two other researchers would evaluate the diagnosis and define this agreement.

Telemedicine

TM was not standardized. Each orthopedist performed it according to their knowledge and experience; moreover, the physician was free to request maneuvers from the patient. TM started with a link to a Microsoft Teams (Redmond, Washington, USA) video call. The lead author created this link and shared it with the patients. TM started with video recording (a platform resource allowed by the subject). During TM, the physician used a specific form (►**Annex 2**, supplementary material), including clinical history, physical examination, special tests, complementary exams (if available), descriptive diagnosis with its ICD-10 code, prescribed treatment, and visit time, that is, the recording time. Treatments would not occur at this moment, only registered. In the end, the physician completed a satisfaction questionnaire adapted from Buvik et al.[5] This questionnaire evaluated the following four criteria: patient cooperation for information collection, examination/assessment, ease in providing information to the patient, and treatment. Each criterion was classified per a Likert scale with five rating levels (very good, good, neither good nor bad, bad, and very bad) (►**Annex 3**, supplementary material). The questions about evaluation and treatment included an additional criterion, "not applicable," as an option selected by a physician unable to perform them. Scores ranged from 1 to 5. After TM, the subject was referred to an FF visit with a different orthopedist unaware of any previous findings.

Face-to-face Visit

The FF visit followed the same steps as TM, filling in forms (►**Annexes 2** and **3**, supplementary material). This visit was conventional, with a referral for treatment, which did not affect our study.

Data protection and anonymity

We assured participants of privacy regarding their information and recordings. We did not identify them personally during data analysis using a Microsoft Excel 2013 spreadsheet.

Sample size calculation

We calculated the sample size using the G*Power 3.1 software to test the correlation between the medical diagnosis at TM and FF. Literature data provided the effectiveness of TM as a diagnostic tool based on a study published by Buvik in 2016, in addition to the research feasibility, which allowed the evaluation of the effect size as high ($w = 0.50$). We estimated the need for 44 participants considering a two-tailed test, 95% confidence, and 80% power.

Statistical Analysis

The descriptive analysis consisted of absolute (n) and relative (%) frequencies of qualitative variables and mean ± standard deviation values of quantitative variables. Paired Student's t-test detected differences in visit time, and the Wilcoxon test revealed differences in physicians' perceptions about FF and TM. Cohen's d calculated the effect size. The chi-square adherence test assessed the percentage of absolute diagnosis agreement between TM and FF visits. The Spearman correlation test determined the relationship between variables. The analyzes were performed with IBM SPSS statistical software version 20.0 (IBM Corp., Armonk, NY, USA), adopting $p < 0.05$ as statistical significance.

Results

The initial study sample consisted of 44 participants, including 27 women. The subjects were 18 to 73 years old, with an average age of 48. Thirty-four patients studied up to high school, and 16 had active jobs. One subject was excluded from the analysis as she did not undergo an FF visit due to hospitalization for COVID-19. In total, there were 43 subjects for statistical analysis (►**Table 1**).

The most frequent diagnoses were knee pain and low back pain both at TM and FF visits (►**Figs. 1** and **2**, respectively). The diagnostic agreement was 81.4% (35 of 43 diagnoses) according to the similarity in diagnosis description, ICD-10 code, or both ($X^2 = 16.953$; $p < 0.001$) (►**Fig. 3**).

Table 1 Demographics of the sample (n = 43)

Variable	Mean ± Standard deviation n (%)
Gender	
Female	27 (62.8%)
Male	16 (37.2%)
Age (years)	48.1 ± 13.3
Functional status	
Retired	10 (23.4%)
Actively working	16 (37.3%)
Unemployed	6 (14.0%)
On disability	6 (14.0%)
Other	5 (11.6%)
Reason for referral	
Referral from primary care	33 (76.7%)
Maintenance/Follow-up at the University Hospital	7 (16.3%)
Other	3 (7.0%)

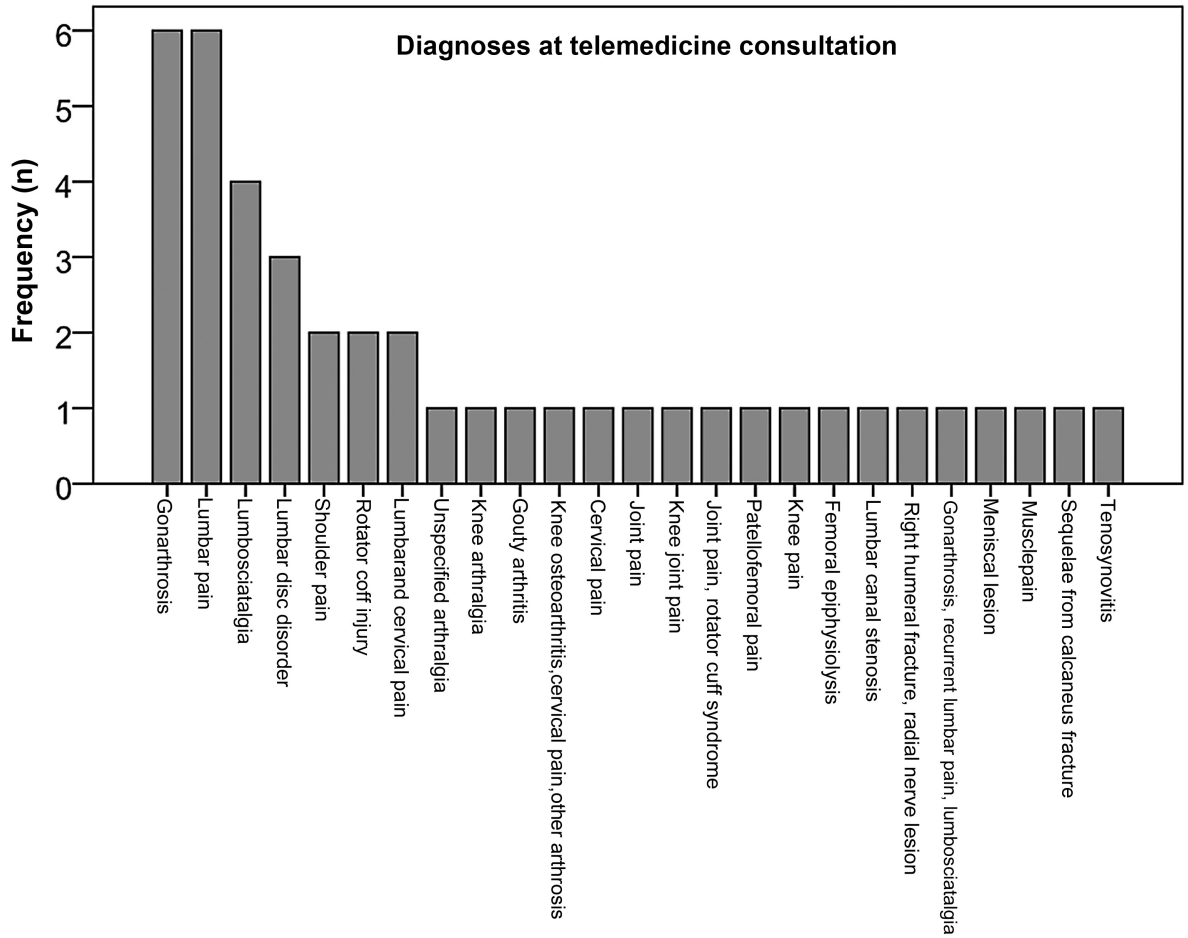


Fig. 1 Frequency of diagnoses established at telemedicine consultations (n = 43).

There was a statistically significant difference in visit time, which was shorter for TM compared with FF (14.0 ± 5.7 vs. 18.8 ± 7.1 minutes, respectively; $p < 0.001$; $d = 0.75$). The observed size effect suggests that the average difference of 4.8 minutes in visit time is relevant from a practical point of view (►**Fig. 4**).

Physicians' satisfaction with TM was lower in the four criteria evaluated. The first criterion, regarding patients' cooperation, scored 79.1 points out of 100 ($Z = -2.282$; $p = 0.004$). The second criterion, about the ability to assess/examine the patient, scored 23.3 ($Z = -5.442$; $p < 0.001$). The third criterion measured the ability to provide information to the patient and scored 46.6 ($Z = -4.915$; $p < 0.001$). Lastly, the fourth criterion evaluated the ability to treat patients and scored 37.2 ($Z = -5.334$; $p < 0.001$). It is noteworthy that these scores were the sum of "good" and "very good" and present statistical significance (►**Figs. 3–6**).

Discussion

The evaluation of the diagnosis of orthopedic disease by TM showed an 81.4% agreement rate compared with FF visits in our series. This finding is consistent with a study from Cotrel et al.[9] These authors observed an 83% agreement rate in the physical therapy diagnosis comparing TM and FF. Moreover, our findings suggest the effectiveness of TM compared with FF, supporting its use for patients with geographical barriers and mobility issues requiring specialized care.[9]

TM consultations were faster than FF visits in our series, differing from the literature, in which TM had a longer[10] or at least similar duration.[5] This data can assist further studies about TM implementation in reference centers for musculoskeletal conditions.

This study identified a lower degree of physicians' satisfaction with TM compared with FF visits in the four criteria evaluated. According to the Likert scale, the lowest satisfaction rates referred to patient assessment/physical examination (23.3 points) and treatment prescription (37.2 points). It is worth mentioning that physicians must feel comfortable and satisfied with any work method before its implementation.

This dissatisfaction was even lower than previously expected. The unfeasibility of a physical examination by direct contact limits remote orthopedic care. The place chosen by the patient and the free handling of the sound and video equipment (i.e., smartphones) with no fixed, stable points or a standard distance also hinder assessment. All these factors can influence the results.

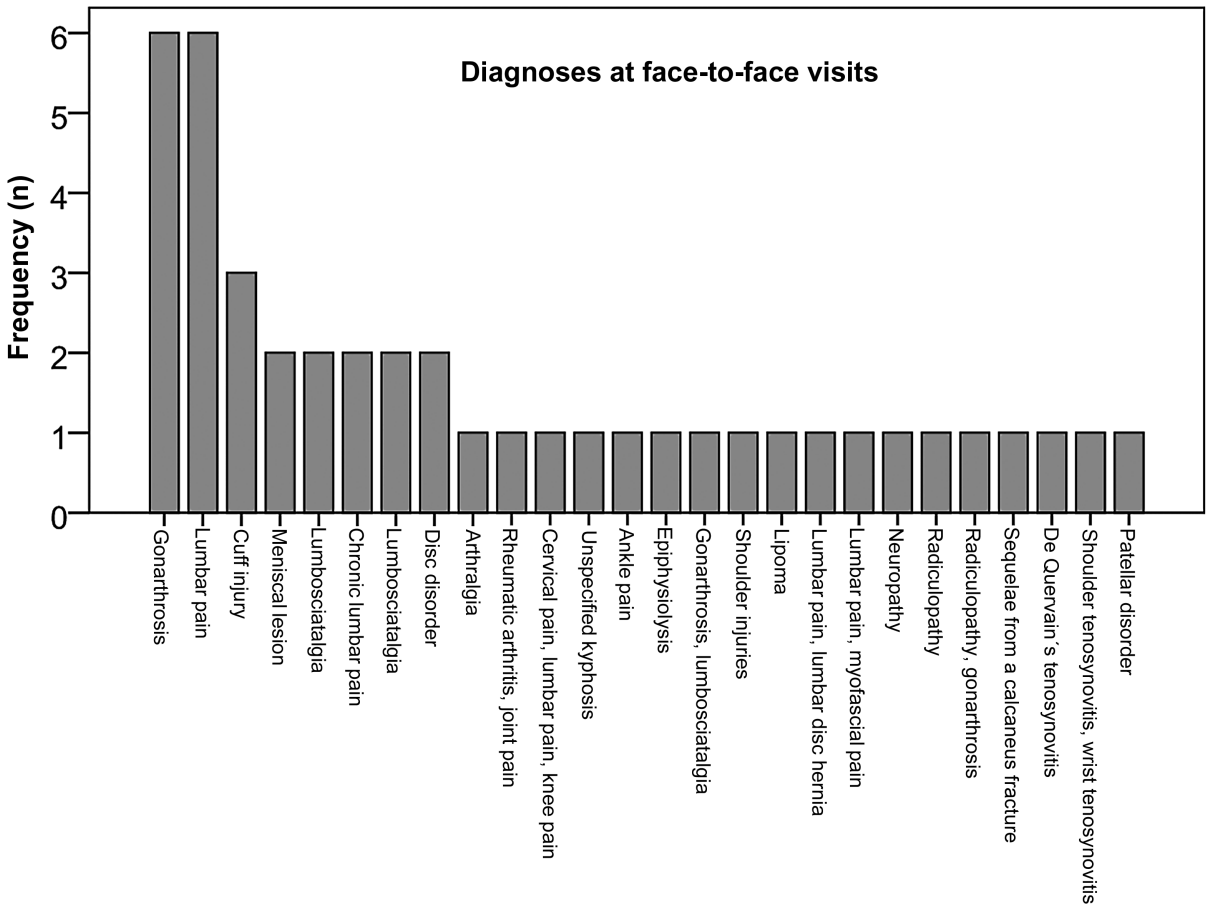


Fig. 2 Frequency of diagnoses established at face-to-face visits (n = 43).

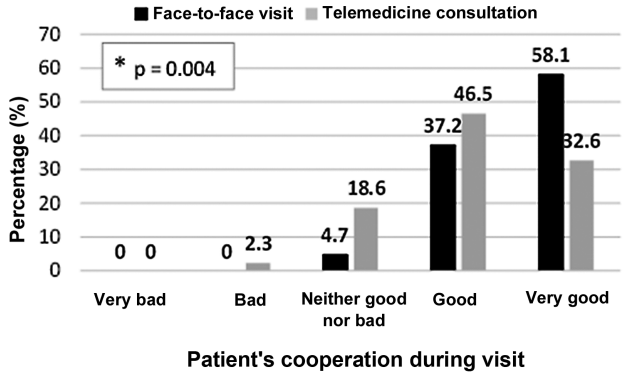


Fig. 3 Physicians' perception on patients' cooperation during a face-to-face visit and a telemedicine consultation. *Statistically significant difference, $p < 0.05$.

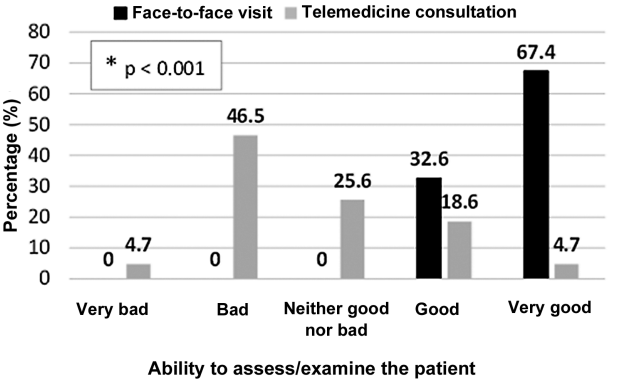


Fig. 4 Physicians' perception on the ability to assess/examine the patient during a face-to-face visit and a telemedicine consultation. *Statistically significant difference, $p < 0.05$.

This level of professional dissatisfaction is inconsistent with the literature, which demonstrated a high degree of satisfaction with TM by orthopedists and patients, with 98% of remote consultations rated as "good" or "very good."[5]. Brennan et al.[11] evaluated TM for patients' assessment and treatment in an emergency department. They reported that, on average, physicians' satisfaction rate was 3.8 (ranging from 1, not very satisfied, to 5, very satisfied) regarding diagnoses and treatment in this population. The authors conclude that TM is a good technique based on patients' and physicians' assessments.

TM is potentially beneficial to patients because it eliminates geographical barriers, expanding access to healthcare. However, its adoption has been limited by issues with logistics, technology platforms, healthcare providers, physicians, and patients.[7] The pandemic

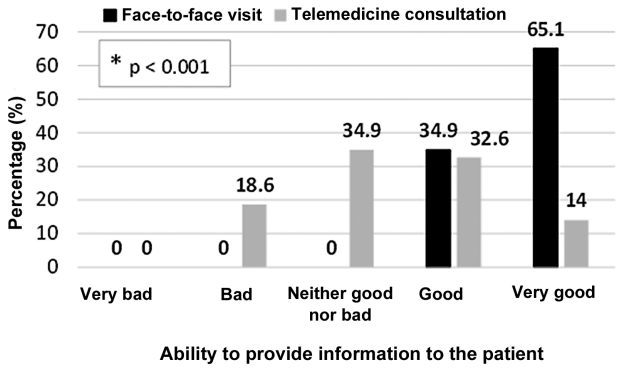


Fig. 5 Physicians' perception on the ability to provide information to the patient during a face-to-face visit and a telemedicine consultation. *Statistically significant difference, $p < 0.05$.

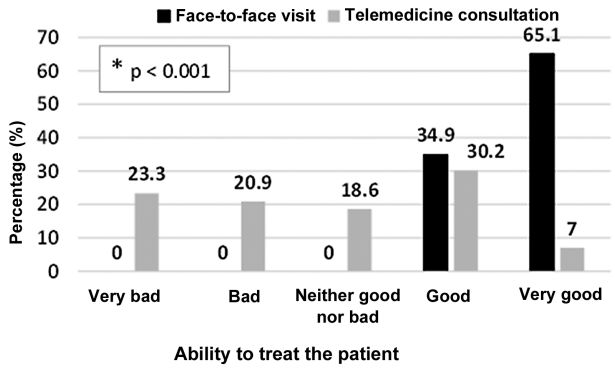


Fig. 6 Physicians' perception on the ability to treat the patient during a face-to-face visit and a telemedicine consultation. *Statistically significant difference, $p < 0.05$.

accelerated TM adoption,[3] and this unscheduled speed could explain the dissatisfaction observed in our study.

Our study is a pioneer in the Portuguese language regarding TM evaluation in orthopedics. It demonstrated that its implementation is feasible. The understanding of the diagnostic agreement difference between TM and FF visits may improve by increasing evaluators' training and using an appropriate environment and fixed, well-positioned audio and video equipment. In addition, an increased familiarity with the platform can improve TM performance and satisfaction rates. A sample standardization with a similar syndromic diagnosis may increase concordance.

The limitation of this study was the lack of assessment of the degree of patient satisfaction. This evaluation could have contributed to the results. The lack of experience of the physicians was also an issue, and it must be addressed by further studies.

Conclusion

TM consultation has 81.4% diagnostic agreement and a shorter duration compared with FF visits. However, physicians reported being less satisfied with it.

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Conflict of Interests

The authors declare no potential conflict of interests regarding this research, paper authorship, or publication.

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Timing of Surgery and Pre-operative Physiological Parameters as Clinical Predictors of Surgical Outcomes in Traumatic Subaxial Cervical Spine Fractures and Dislocations

Momento da cirurgia e parâmetros fisiológicos pré-operatórios como fatores preditivos clínicos de desfechos cirúrgicos em fraturas e luxações traumáticas subaxiais da coluna cervical

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Abstract

Objective To evaluate the risk factors and outcomes in patients surgically treated for subaxial cervical spine injuries with respect of the timing of surgery and preoperative physiological parameters of the patient.

Methods 26 patients with sub-axial cervical spine fractures and dislocations were enrolled. Demographic data of patients, appropriate radiological investigation, and physiological parameters like respiratory rate, blood pressure, heart rate, PaO2 and ASIA impairment scale were documented. They were divided pre-operatively into 2 groups. Group U with patients having abnormal physiological parameters and Group S including patients having physiological parameters within normal range. They were further sub-divided into early and late groups according to the timing of surgery as U_{early}, U_{late}, S_{early} and S_{late}. All the patients were called for follow-up at 1, 6 and 12 months.

Results 56 percent of patients in Group S had neurological improvement by one ASIA grade and a good outcome irrespective of the timing of surgery. Patients in Group U having unstable physiological parameters and undergoing early surgical intervention had poor outcomes.

Conclusion This study concludes that early surgical intervention in physiologically unstable patients had a strong association as a risk factor in the final outcome of the patients in terms of mortality and morbidity. Also, no positive association of improvement in physiologically stable patients with respect to the timing of surgery could be established.

Keywords
- cervical vertebrae
- operative time
- risk factors
- prospective studies

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Resumo

Objetivo Avaliar os fatores de risco e os desfechos em indivíduos submetidos ao tratamento cirúrgico de lesões subaxiais da coluna cervical em relação ao momento da cirurgia e aos parâmetros fisiológicos pré-operatórios dos pacientes.

Métodos O estudo incluiu 26 pacientes com fraturas e luxações subaxiais da coluna cervical. Dados demográficos, investigação radiológica apropriada e parâmetros fisiológicos, como frequência respiratória, pressão arterial, frequência cardíaca, pressão parcial de oxigênio (PaO_2) e escalas de disfunção da *American Spine Injury Association* (ASIA), foram documentados. No período pré-operatório, os pacientes foram divididos em dois grupos. O grupo instável (I) continha pacientes com parâmetros fisiológicos anormais e o grupo estável (E) era composto por pacientes com parâmetros fisiológicos dentro da faixa de normalidade. Os pacientes foram ainda subdivididos em grupos de tratamento precoce e tardio de acordo com o momento da cirurgia como $I_{precoce}$, I_{tardio}, $E_{precoce}$ e E_{tardio}. Todos os pacientes foram chamados para consultas de acompanhamento em 1, 6 e 12 meses.

Resultados Cinquenta e seis por cento dos pacientes do grupo E apresentaram melhora neurológica em um grau ASIA e desfecho bom independentemente do momento da cirurgia. Os desfechos em pacientes do grupo I com parâmetros fisiológicos instáveis e submetidos à intervenção cirúrgica precoce foram maus.

Conclusão Este estudo conclui que a intervenção cirúrgica precoce em pacientes com instabilidade fisiológica teve forte associação como fator de risco no desfecho final em termos de mortalidade e morbidade. Além disso, não foi possível estabelecer nenhuma associação positiva de melhora em pacientes com estabilidade fisiológica em relação ao momento da cirurgia.

Palavras-chave

- vértebras cervicais
- duração da cirurgia
- fatores de risco
- estudos prospectivos

Introduction

The burden of disability and rehabilitation with Spinal Cord Injury is immense and increasing with the advent and easier availability of high-speed vehicles in developing countries.[1,2] But the role and timing of surgical intervention with severe injuries still remains disputed.[3–9]

Primary insult to spinal cord caused by compression due to dislocation or burst is irreversible. This injury further leads to progressive and continuous compression leading to hypoperfusion of the injured segment increasing the oedema and cord contusion. Pre-clinical studies have suggested direct correlation between the period of compression of the cord and the extent of the structural irreversible damage to the cord.[10] This finding has led spine surgeons to offer early surgical intervention to mitigate the damage and promote neurological recovery in such patients.[3,11] An early surgical decompression targets to attenuate a secondary hit mechanism cascade including ischemia which ultimately leads to permanent loss of function for spinal cord.[4,12] Despite the worldwide use of early decompression in patients with sub axial cervical fracture dislocation as a standard, it's role in improving neurology and decreasing mortality/morbidity remains controversial.[3,4,7,11,13,14] Also there has been recent effort to establish the significance of the extent of spinal cord decompression in neurological outcomes which have suggested bias in studies suggesting superiority of early intervention in such patients.[6,15]

Multiple factors have been noted to influence the outcome such as injury segment, cause of the injury, length of the cord oedema segment, pre-operative physiological parameters, requirement of inotropes, SLIC score and ASIA score.[4,6,11,14–18] There is a lacunae in the data of the surgical and functional outcomes of sub axial cervical spine fractures and dislocations in terms of patient's pre-operative physiological profile and surgical timing. Also there has been a considerable difference in the studies performed in the developing world and the developed world with respect to the surgical and functional outcomes, disability and mortality.[7,8,19,20] This may be due to constraints of resources, sporadic health infrastructure, disregard for aggressive rehabilitation of the patients with permanent disabilities, lack of research funding and prioritization of other communicable and curable diseases with respect to the spinal cord injuries in developing countries.[7,8,21] In this study, we have aimed to evaluate the risk factors associated with sub axial cervical spine fractures and dislocations in terms of patient's pre-operative physiological parameters and surgical timings.

Materials and Methods

A prospective observational study of 26 patients with subaxial cervical spine fractures and dislocations who underwent surgery at a tertiary health setup from May 2017 to May 2019 was conducted. After institutional ethical clearances, informed consents were obtained from all the

participating patients and then they were enrolled for the study (Protocol No.184/18).

The inclusion criteria were 1) Age of the patient more than eighteen. 2) Patient must have been admitted within 7 days of injury. 3) Patients with sub axial cervical spine fracture dislocation who underwent surgery. The exclusion criteria were 1) Patients with head injuries Glasgow Coma Scale of less than 8/15. 2) Sub axial Cervical Injury Classification score of less than Four. 3) Pathological fractures and patients with uncertain follow up. Twenty-six (26) patients fulfilling this criterion were included consisting of 24 males and 2 females. All patients were evaluated thoroughly, and their detailed history, demography and clinical radiological data were obtained. Four physiological parameters respiratory rate, heart rate, blood pressure, PaO2 were documented pre-operatively. A pre-operative respiratory rate greater than 24, heart rate less than 60, blood pressure less than 90 systolic or 60 diastolic mm of hg, PaO2 value in last 24 hours < 94 were given a score of 2 each arbitrarily and patients with score of more than 4 were assigned to Group U. Patients with score less than or equal to 4 were assigned to Group S. Further, these groups were sub-divided into early (U_{Early}, S_{Early}) and late (U_{Late}, S_{Late}) groups with respect to the timing of surgery. Patients taken to surgery within 72 hours were assigned as early and the rest were assigned as late.[19,20,22]

The mean age of the patients was 42 years, 18-year-old being the youngest and 68-year-old being the oldest. High velocity motor vehicular accidents were the most common cause of injuries followed by fall from height (►**Table 1**). Most of the patients were presented to the hospital within 72 hours of injury.

Physiological parameters were noted at the time of presentation, pre-operative and post-operative daily during hospital stay. Neurological assessment was done using American Spinal Cord Injury Association impairment scale pre-operatively, post-operatively and during follow up. All patients underwent radiological evaluation including X-Ray and magnetic resonance imaging (MRI) of cervical spine to determine the level of spinal injury, spinal cord compression, associated cord oedema and contusions and status of inter vertebral discs. The C5-C6 level ($n = 10$, 38.4%) was most injured in this series with 10 of the patients having injury at C5-C6 level (►**Table 1**); followed by C4-C5 which was the second most commonly injured segment ($n = 7$, 27.0%); followed by C6-C7 segment ($n = 5$, 19.2%); and C3-C4 segment ($n = 4$, 15.4%). The pre-operative neurological status was noted and graded based on America Spine Injury Association grading(ASIA; ASIA-A, 16 cases; ASIA-B, three cases; ASIA-C, four cases; ASIA-D, three cases) and SLIC (SLIC score four, one case; SLIC score five, seven cases; SLIC score six, nine cases; SLIC score seven, three cases; SLIC score eight, two cases; SLIC score nine, two cases).

Associated injuries with sub axial cervical spine injuries were also documented and relevant radiological examination were done. One patient had bilateral calcaneus fracture and two had associated long bone fractures. Patients presenting within eight hours of injury were administered methylprednisolone.

Table 1 Preoperative patient findings

Characteristics	Number (Percentage)
Number of Patients	26
Gender:	
Male	24
Female	2
Mode of Injury:	
1. High Velocity Motor Vehicular accident	11
2. Fall from height	9
3. Others	6
Level of Injury:	
1. C3-C4	10(38.4%)
2. C4-C5	7(27%)
3. C5-C6	5(19.2%)
4. C6-C7	4(15.4%)
Physiological Parameters:	
1. Unstable group	17(65.38%)
2. Stable group	9(34.62%)

All the patients were taken for surgery as soon as possible and the patients underwent reduction under general anaesthesia followed by surgery by anterior approach if reduced. The patients underwent an Anterior-Posterior-Anterior approach for reduction and fixation of injury segments for irreducible fractures and dislocations. A standard Smith-Robinson approach was used for anterior discectomy/corpectomy and fusion. For posterior approach, standard midline approach was taken.

Patients' recovery was monitored in Intensive Care Unit (ICU). Patients were put on collar for the next 3 months. All patients underwent aggressive physical rehabilitation post-operative. Patients were called for follow up at 1, 3, 6 and 12 months and neurological recovery graded by ASIA grade and by X-Ray obtained to assess fusion and position of implants. The statistical association was calculated by using binary logistic regression with 95% confidence interval. Mortality was taken as a dependent variable and the timing of surgery and physiological parameters were taken as independent variables.

Results

All patients were taken for surgery at the earliest after required radiological and routine investigations. Out of the 26 patients, the fracture-dislocations of 24 patients could be reduced under general anesthesia in the operation theatre followed by anterior Discectomy/corpectomy and fusion. In two cases, Anterior-Posterior-Anterior approach had to be taken for irreducible fractures and dislocations. Mean operating time was 1.5 hours (90 min) for anterior surgery and three hours for Anterior-Posterior-Anterior approach. Mean blood loss was 150 ml during surgery.

Table 2 ASIA impairment scale pre-operatively and at 12 months follow up. (n = 26)

	Follow up ASIA Scale after 12 months						
ASIA Impairment Scale Pre-operatively	ASIA A	ASIA B	ASIA C	ASIA D	ASIA E	Death	Total
ASIA A	0	2	0	0	0	14	16
ASIA B	0	2	0	0	0	1	3
ASIA C	0	0	1	2	0	1	4
ASIA D	0	0	0	1	2	0	3
ASIA E	0	0	0	0	0	0	0
Total	0	4	1	3	2	16	26

ASIA, American Spine Injury Association

All patients were monitored in ICU and were put on cervical braces for six weeks. All patients were administered deep vein thrombosis prophylaxis. Aggressive physiotherapy was done post-operatively and the relatives were taught to care for the paraplegic. Aggressive rehabilitation was initially aimed at helping patients and relatives understand the need for weight-shifting maneuvers to prevent pressure sores. Also, patients were taught to self-catheterize for bladder care. During follow ups, social and vocational integration of the patient was attempted.

Patients were grouped according to the timing of surgery and pre-operative physiological parameters of the patients; 15 patients were grouped in U_{early}, 2 in U_{late}, 5 in S_{early} and 4 in S_{late}. Two patients with ASIA grade A improved by one grade at one year follow up. 14 patients with ASIA grade A succumbed at one year follow up of which 13 belonged to group U. Two patients each with ASIA Score C and D also showed improvement of one grade each at one year follow up (►**Table 2**).

Patients with unstable physiological parameters who were operated within 72 hours had outcomes even under intensive hospital care and at one year follow up(p-value = 0.016). 15 patients grouped in U_{Early} group underwent decompression and fixation within 72 hours of admission and were having unstable physiological parameters of which 14 patients expired (►**Table 3**). In contrast, patients who were physiologically stable and did not require pre-operative mechanical and ventilator support fared better irrespective of whether the surgery was performed within 72 hours or later. We could not find a positive association with early or late surgery groups where they had stable physiological parameters pre-operatively. Also, while statistically analyzing various clinical predictors by binary logistic regression method, timing of surgery was found to be not significant in predicting the outcome(p-value = 0.067). Out of the 26 patients, 14 patients required post-operative mechanical ventilation support. 11 patients could not make it eventually and expired because of respiratory arrest or of ventilator acquired pneumonia. One patient developed deep bed sores and later had systemic infections and succumbed to the same. 12 patients died during hospital care and four patients died during the follow up period of one year.

Discussion

Spinal Cord injury due to sub axial cervical fracture dislocation, either complete or incomplete is an overwhelming injury for the patient, for the family, and also for the country because of the permanent disability associated with it even with recent advances in operative techniques and instrumentations and aggressive rehabilitation protocols.[1,2,7]

Despite awareness among the public about primary care, many patients were transported to the emergency room without neck immobilizer. This is suggested by the high number of complete injury patients in this study compared to studies done elsewhere in the world. Thus, there is a scope for awareness of the importance of extrication of the patient from the site of injury and proper immobilization during transport.[7,8,12,23]

The role of timing of surgery in sub axial cervical spine fracture dislocation has always been controversial, with studies supporting both early and late timing of surgery present in literature, but very few are prospective and randomized.[4–6,11,14,21,24,25] In this study, good outcome was reported with incomplete spinal cord injuries while patients with complete cervical injuries had high mortality rate and morbidity, indicating that an aggressive approach while selecting patients with complete injury and patients

Table 3 Outcomes in terms of mortality in four groups U_{early}, U_{late}, S_{early}, S_{late}

	U_{early}	U_{late}	S_{early}	S_{late}	*Total*
Total (percentage)	15(57.69%)	2(7.69%)	5(19.23%)	4(15.38%)	26(100%)
Mortality	14(53.84%)	1(3.84%)	1(3.84%)	0	16(61.53%)
Alive	1(3.84%)	1(3.84%)	4(15.38%)	4(15.38%)	10(38.46%)

with physiological unstable parameters for early surgical procedures may not be warranted.[7–9,11] Various risk factors have been evaluated with respect to spinal cord injuries like duration of injury, incomplete surgical decompression, length of oedema segment in MRI, injury segment and age.[3,15,17,18,23,24] But very few studies have corelated the pre-operative physiological parameters, need for inotropes and mechanical support to the timing of surgery and the eventual outcomes in sub axial cervical spine fracture dislocations. Various studies for evaluating the timing of decompression have been undertaken but due to various bias caused by differences in methodology, tools for assessment, number of patients enrolled and long periods of follow up, the effectiveness of such studies is disputed. The role of the timing of surgery in treatment of acute spinal cord injuries has been controversial as no proper randomized study regarding the same is available due to the ethical concerns of randomizing such patients and denying them early surgery. Aarabi et al.[11] in 2019 concluded in their study that timing of decompression did not influence neurological improvement but identified length of intramedullary lesion as a main clinical predictor for the surgical outcome. Seventy percent of patients were operated after a week in the study conducted by Dhakal et al.[8] but almost half of the patients had neurological improvement despite the delay in the surgery indicating importance of factors other than the timing of surgery. Study conducted by Gupta et al.[3] in level 1 trauma center favors early decompression but also had greater mortality rate in motor complete injury patients and the study had shorter mean follow up of less than one year. Another study by Admasu et al.[7] set in resource limited set-up concluded that there was no significant advantage of aggressive early treatment and treaded on fine line advocating proper patient selection while dealing with complete cervical injuries, but this study had limitations of being retrospective. We have in this prospective observational study analyzed those patients with unstable physiological parameters pre-operatively who underwent early surgery had poor outcomes and high mortality ratio. Patients having stable physiological parameters had better outcomes and survivability. This suggested that an early surgery in an already compromised and physiologically unstable patient may lead to a secondary hit which may become irreversible leading to patient mortality. So, a careful selection of the patient should be made for early decompression and fixation especially in a resource limited set-up like India where post-operative ICU beds and intensivists for management of such patients are scarce.

The goals for sub axial cervical spine fracture dislocation are stabilization of cervical spine to allow for early mobilization and rehabilitation and also to do an early decompression of the cord to give the patient every chance of neurological recovery as well as an attempt to attenuate secondary hit to the spinal cord. These goals should be carefully weighed against the patient's physiological profile to reduce complications and mortality. The lack of randomization of this study as well as the small number of study participants in quadriplegic and paraplegic patients posed a few limitations to the study.

Conclusions

This study concludes that early major surgical procedures in physiological unstable patients having traumatic sub axial cervical spine fracture dislocation had significant association as a risk factor in the final outcome of the patients in terms of mortality and morbidity. Also, patients with incomplete injury and stable physiological parameters, irrespective of the timing of surgery, had good outcomes in terms of neurological recovery and mortality. The goals of sub-axial cervical spine surgery should be weighed against the patient's physiological profile before recommending an early surgery in all patients as this may offer no benefit to him; instead, this may be associated with increased mortality and complication rates.

Authors' Contributions

Each author contributed individually and significantly to the development of this article: AK - Principal investigator of the study and author. HM - Operating surgeon and co-author. VC - Care of the patients included in the study and editing of manuscript. PS, KP and CN – Care of the Patient.

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Conflict of Interest

No potential conflict of interest related to this article.

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Low Back Pain in Medical Students and Professors During the Pandemic: Retrospective Cohort Study*

Lombalgia em estudantes e professores de medicina durante a pandemia: Estudo de coorte retrospectivo

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Abstract

Objective This study aimed to determine the prevalence of low back pain before and during the pandemic, comparing both periods.

Methods A questionnaire was administered, containing questions about the presence of low back pain, sociodemographic characteristics and environmental factors that could be related to such pain.

Results Among the 978 responses obtained, the prevalence of low back pain during the pandemic was 69.94%, which represented a significant increase over values from the pre-pandemic period (57.37%). A high prevalence of low back pain was found between all groups, especially among women. Some factors were associated with the incidence of low back pain, such as having previously diagnosed spinal problems and sedentary lifestyle.

Conclusions The prevalence of low back pain increased significantly during the pandemic in the studied groups.

Keywords
- low back pain
- students
- pandemics
- prevalence
- risk factors

Resumo

Objetivo Este estudo teve como objetivo determinar a prevalência de lombalgia antes e durante a pandemia, comparando os dois períodos.

Métodos Foi aplicado um questionário contendo questões sobre a presença de lombalgia, características sociodemográficas e hábitos que poderiam estar relacionados à essa dor.

Resultados Entre as 978 respostas obtidas, a prevalência de lombalgia durante a pandemia foi de 69,94%, o que representou um aumento significativo em relação aos valores do período pré-pandêmico (57,37%). Foi encontrada alta prevalência de lombalgia entre todos os grupos, principalmente entre as mulheres. Alguns fatores foram associados à incidência de lombalgia, como ter problemas de coluna previamente diagnosticados e sedentarismo.

Conclusões A prevalência de lombalgia aumentou significativamente durante a pandemia nos grupos estudados.

Palavras-chave
- dor lombar
- estudantes
- pandemias
- prevalência
- fatores de riscos

* *Work developed in the Universidade Anhembi Morumbi, Sao Paulo, Brazil.*

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Introduction

Approximately 80% of the population, at some point in their lives, will suffer a brief and acute episode of low back pain.[1,2] Generally, low back pain is divided into two types: specific and nonspecific, where the nonspecific has no apparent cause and accounts for up to 90% of the cases.[3] Low back pain, in addition to limiting various daily activities and impairing quality of life, is also one of the main factors responsible for absenteeism from work and decreased productivity in the workplace.[4]

A number of risk factors are described in the literature that can play a crucial role in the etiology of low back pain, such as being female, overweight, previous history of spinal problems, family history of spinal problems, prolonged sitting time and sedentary lifestyle,[5–8] or even psychological factors, such as anxiety and stress.[8,9] Due to the highly demanding schedule of medical courses, students and professors are often exposed to several of these risk factors, such as stress and sedentary lifestyle, long hours in hospitals and clinics, which can contribute to a higher prevalence of low back pain when compared to the general population.[10] Furthermore, the presence of low back pain can affect the productivity and participation of students during classes, which could influence their future medical career.[10]

A study carried out in Brazil with 629 medical students revealed that recurrent low back pain was present in 81% of them.[11] Another study, carried out with 1,243 medical students from a French college, reported a prevalence of low back pain of 72.1%.[12] Despite the limitation that musculoskeletal pain represents for adolescents and young adults, there is a lack of data regarding low back pain in medical students.[13]

Similarly, few studies have investigated the presence of low back pain in professors,[14] and this dearth is even greater when it comes to medical school professors, who are also exposed to several risk factors for the presence of low back pain, such as repetitive movements when writing, standing for long periods of time and daily use of the computer.[15] In a study carried out with teachers at a primary school in Ethiopia, a prevalence of low back pain of 74.8% was found, which was related to some risk factors, such as standing for a long period of time, lack of sleep and sedentary lifestyle.[16]

During the COVID-19 pandemic, face-to-face classes were canceled, forcing universities to adopt a remote learning model. However, this change favored some aspects related to the prevalence of low back pain, such as sitting for a long period of time, physical inactivity and greater psychological stress, which could increase the prevalence of low back pain in students and professors during this atypical period. The aim of this study was to determine the prevalence of low back pain in medical students and professors at three Brazilian universities during the pandemic and compare this to the pre-pandemic period, in addition to identifying associated risk factors to develop such pain.

Materials and Methods

Ethics Approval

The protocol was approved by the institutioǹs research ethics committee, in October 4, 2020 (CAAE No. 38595320.9.0000.5492).

Questionnaire and Participants

This research has been approved by the IRB (Institutional Review Board) of the authors' affiliated institutions, and consent was obtained from all participants. A retrospective cohort study was carried out through the administration of a questionnaire to medical students and professors from three Brazilian medical schools located in different states of the country. The inclusion criteria were that participants had to be medical students or professors from the three participating universities. Participants were excluded from the study if they disagreed in signing consent form, those who were not medical students or professors from the participating universities, and women in gestational period. The questionnaire was distributed between December 2020 and March 2021 and covered questions about sociodemographic characteristics (such as gender, age and ethnicity), presence of low back pain before and during the pandemic, quantification of the intensity of this low back pain, family history of diseases and spinal surgeries and several behavioral factors that could be associated with the prevalence of low back pain in this population, in addition to the impact on their daily activities and on their emotional state.

Statistical Analysis

In view of the approximate total of 3,000 medical students and 200 professors in these three universities, we adopted a confidence level of 95% and a margin of error of 5%, calculating a sample of 341 students and 132 professors. And since the three universities are located in different states and may present regional discrepancies, with the purpose of analyzing subgroups by educational institution, while maintaining a 95% confidence level and 5% margin of error, the sample by institution had to be at least 278 students and 60 professors.

Descriptive analysis of the results was performed to characterize the research participants. To describe the results, the absolute frequency and percentage for categorical variables were used. In order to compare the proportion of low back pain before and during the pandemic within the different groups, the McNemar test was used. To investigate possible factors associated with low back pain during the pandemic, univariate logistic regression was used, estimating odds ratios (OR) as a measure of effect, with a 95% confidence interval (CI). Subsequently, the variables that showed at least moderate association ($P < 0.25$) with the variable of interest were selected using the chi-square test. These variables were included in the multivariate model, estimating the adjusted odds ratio, considering possible interactions between them. The quality of the multivariate model was assessed using the Hosmer and Lemeshow test. For all analyses, only $P < 0.05$ was considered statistically significant.

Table 1 Number of participants from each university, per group

	University 1 n(%)	University 2 n(%)	University 3 n(%)	Total(n%)
Students from 1st to 4th year	295 (35.49%)	250 (30.08%)	286 (34.43%)	831(100%)
Students from 5th and 6th year	19 (31.66%)	35 (58.33%)	6 (10.01%)	60 (100%)
Professors	70 (80.45%)	10 (11.49%)	7 (8.06%)	87 (100%)

Results

In total, 978 individuals answered the questionnaire. Among them, 831 were students from the 1st to the 4th year, 60 students from the 5th and 6th year (medical internship) and 87 professors (►**Table 1**).

Prevalence of Low Back Pain

When asked about the presence of low back pain before and during the pandemic, the percentages of affirmative answers increased among professors and students from 1st to 4th year, and decreased among students from 5th to 6th year. Among professors, 28.74% who did not have low back pain started to experience it during the pandemic ($P < 0.001$). Similarly, 20.10% of 1st to 4th year students who did not have low back pain before the pandemic began to complain of low back pain ($P < 0.001$). During the pandemic, only for the group of 5th and 6th year students there was no increase in the prevalence of low back pain ($P = 1.000$).

For 1st to 4th year students, the prevalence of low back pain increased from 54.75% before the pandemic to 71.48% during the pandemic ($P < 0.001$). Among 5th and 6th year students, the prevalence did not change significantly, registering 66.67% before and 65% during the pandemic ($P = 1,000$). Finally, among professors, the prevalence increased from 31.03% before to 58.62% during the pandemic ($P < 0.001$) (►**Table 2**).

Associated Risk Factors

Students from 1st to 4th year were significantly more likely to have low back pain when compared to professors (OR: 1.77, 95% CI: 1.12-2.77; $P = 0.013$). Among survey participants who do not have back pain, 60.2% are female, while among those who do, this percentage rises to 79.97%, with men having significantly lower chances of having low back pain when compared to women (OR: 0.38, 95% CI: 0.28-0.51; $P < 0.001$). It was also noted that those previously diagnosed with any spinal problems had significantly higher chances of low back pain when compared to those who did not (OR: 3.56, 95% CI: 2.4-5.43; $P < 0.001$). In addition, individuals with a family history of spinal problems were also significantly more likely to experience low back pain (OR: 1.78, 95% CI: 1.35-2.36; $P < 0.001$). Respondents from university 2 were less likely to have low back pain when compared to the other institutions (OR: 0.56, 95% CI: 0.4-0.77; $P < 0.001$).

Regarding posture when sitting, those who always sit correctly, those who sit correctly most of the time, and even those who sit correctly less often, had significantly lower chances of having low back pain when compared to those who never sit correctly (ORs of 0.11; 0.32 and 0.65 and $P < 0.001$; $P < 0.001$ and $P = 0.012$, respectively). Considering the consumption of tobacco, coffee and alcoholic beverages, none of them was statistically significant for the prevalence of low back pain among any of the groups ($P = 0.915$; $P = 0.274$ and $P = 0.255$, respectively).

Sleeping hours also significantly affected the chances of experiencing low back pain. Those who slept 6 to 9 hours a day before the pandemic had a lower chance of low back pain when compared to those who slept less than that (OR: 0.61, 95% CI: 0.45-0.83; $P = 0.002$). Similarly, individuals who sleep 6 to 9 hours a day during the pandemic also had a lower chance of low back pain (OR: 0.41, 95% CI: 0.26-0.63; $P < 0.001$). Moreover, individuals who sleep more than 9 hours a day during the pandemic also had lower chances of experiencing low back pain (OR: 0.54, 95% CI: 0.3-0.96; $P = 0.038$). Also, those who exercise during the pandemic had

Table 2 Frequency of low back pain in each group, comparing before and during the pandemic

	Professors n(%)	Students from 1st to 4th year n(%)	Students from 5th and 6th year n(%)	General n(%)
Low back pain before the pandemic				
No	60 (68.97%)	376 (45.25%)	20 (33.33%)	456 (46.63%)
Yes	27 (31.03%)	455 (54.75%)	40 (66.67%)	522 (53.37%)
Low back pain during the pandemic				
No	36 (41.38%)	237 (28.52%)	21 (35.00%)	294 (30.06%)
Yes	51 (58.62%)	594 (71.48%)	39 (65.00%)	684 (69.94%)

significantly lower odds of having low back pain when compared to those who do not (OR: 0.57, 95% CI: 0.42-0.76; P < 0.001). For all the other variables, there is insufficient evidence that the odds of individuals with such characteristics were significantly different compared to the characteristics set as a baseline at 5% significance.

In the multiple logistic model, only being male (adjusted OR: 0.47, 95% CI: 0.33-0.66; P < 0.001), always sitting correctly (adjusted OR: 0.11, 95% CI: 0.04-0.3; P < 0.001), sitting correctly most of the time (adjusted OR: 0.31, 95% CI: 0.19-0.49; P < 0.001), sitting correctly less often (adjusted OR: 0.59, 95% CI: 0.4-0.86; P = 0.006), being from the university 2 (adjusted OR: 0.54, 95% CI: 0.35-0.83; P = 0.005), studying/working between 1 to 4 hours per day during the pandemic (adjusted OR: 0.49, 95% CI: 0.24-0.97; P = 0.046) and sleeping 6 to 9 hours per day during the pandemic (adjusted OR: 0.4, 95% CI: 0.23-0.66; P < 0.001) stood out as protective factors for low back pain. On the other hand, still in the multiple logistic model, only having previously diagnosed spinal problems (adjusted OR: 3.79, 95% CI: 2.42-6.14; P < 0.001) and a positive family history of spinal problems (adjusted OR: 1.82, 95% CI: 1.32-2.52; P < 0.001) stood out as risk factors. ►**Table 3** summarizes important factors and their association with low back pain.

Moreover, 41.2% of the participants who had low back pain reported that their pain affects their performance in

Table 3 Factors associated with low back pain

Variable	Low back pain				OR	CI (95%)	*p* Value
	No n (%)		Yes n (%)				
Group							
Professors	36	12,24%	51	7,46%	1	–	–
Students (1st to 4th year)	237	80,61%	594	86,84%	1,77	1,12-2,77	0,013*
Students (5th to 6th year)	21	7,14%	39	5,70%	1,31	0,67-2,61	0,436
Gender							
Female	177	60,20%	547	79,97%	1	–	–
Male	117	39,80%	137	20,03%	0,38	0,28-0,51	<0,001*
Institution							
1	100	34,01%	284	41,52%	1	–	–
2	114	38,78%	181	26,46%	0,56	0,4-0,77	<0,001*
3	80	27,21%	219	32,02%	0,96	0,68-1,36	0,834
Previous spinal problem							
No	263	89,46%	482	70,47%	1	–	–
Yes	31	10,54%	202	29,53%	3,56	2,4-5,43	<0,001*
Family history of spinal problems							
No	177	60,20%	314	45,91%	1	–	–
Yes	117	39,80%	370	54,09%	1,78	1,35-2,36	<0,001*
Sits correctly							
No	66	22,45%	255	37,28%	1	–	–
Almost never	129	43,88%	323	47,22%	0,65	0,46-0,91	0,012*
Almost always	80	27,21%	98	14,33%	0,32	0,21-0,47	<0,001*
Yes	19	6,46%	8	1,17%	0,11	0,04-0,25	<0,001*
Daily sleeping before the pandemic							
Less than 6 hours	74	25,17%	242	35,38%	1	–	–
6-9 hours	216	73,47%	434	63,45%	0,61	0,45-0,83	0,002*
More than 9 hours	4	1,36%	8	1,17%	0,61	0,19-2,34	0,433
Daily sleeping during the pandemic							
Less than 6 hours	26	8,84%	127	18,57%	1	–	–
6-9 hours	233	79,25%	464	67,84%	0,41	0,26-0,63	<0,001*
More than 9 hours	35	11,90%	93	13,60%	0,54	0,3-0,96	0,038*

(*Continued*)

Table 3 (*Continued*)

Variable	Low back pain				OR	CI (95%)	*p* Value
	No n (%)		Yes n (%)				
Alcohol consumption							
No	104	35,37%	270	39,47%	1	–	–
Yes	190	64,63%	414	60,53%	0,84	0,63-1,11	0,227
Coffe consumption							
No	76	25,85%	202	29,53%	1	–	–
Yes	218	74,15%	482	70,47%	0,83	0,61-1,13	0,242
Tabbaco cosumption							
No	283	96,26%	661	96,64%	1	–	–
Yes	11	3,74%	23	3,36%	0,9	0,44-1,93	0,767
Physical exercise before the pandemic							
No	88	29,93%	213	31,14%	1	–	–
Yes	206	70,07%	471	68,86%	0,94	0,7-1,27	0,707
Physical exercise during the pandemic							
No	84	28,57%	282	41,23%	1	–	–
Yes	210	71,43%	402	58,77%	0,57	0,42-0,76	<0,001*

Abbreviations: CI, confidence interval; OR, odds ratio.
* = statistically significant.

college related activities. Besides that, 52.3% of the participants who reported having low back pain indicated that it impairs their concentration. Also, 59.6% of them reported that the pain altered their humor significantly, causing anxiety, sadness or anger. Other than that, 37.9% of those who reported low back pain also reported that the pain makes it difficult to remain sited for more than 30 minutes. Thus, it is evident that low back pain in these individuals is certainly able to impair their academic and daily life.

When asked about the intensity of their pain in a scale of 1-10, before the pandemic, the most common reported pain intensities were between 4 and 5. During the pandemic, however, the most common reported pain intensities were between 6 and 7. Although there was only a slight increase in pain intensity, due to a higher exposure to risk factors, the pandemic could have had worsen these individuals low back intensity.

Discussion

The aim of this study was to investigate the presence of low back pain in medical students and professors in three universities located in different regions of Brazil.

There was a significant increase in the prevalence of low back pain in all studied groups, except in 5th and 6th year students. This probably occurred because these students continued their normal schedule, even with the pandemic, because at this stage of the medical course, they basically only go to hospitals. The overall prevalence of low back pain, considering all participants, increased from 53.37% before the pandemic to 69.94% during the pandemic. Considering only 1st to 4th year students, the prevalence of low back pain was 54.75% before and 71.48% during the pandemic. It is evident that, during the pandemic, the academic routine of 5th and 6th year students was altered as much when compared to the routine of 1st to 4th year students and professors, which may explain the unaltered prevalence of low back pain in this group, as there was no increased exposure to risk factors related to low back pain.

Also, the prevalence of low back pain is higher among women than among men, corroborating findings by other authors.[17–19] Furthermore, in our study, the existence of a family history of spinal problems was related to the prevalence of low back pain. The same result was obtained by Alshagga et al.[20] and Ilic et al.,[21] who found a positive relationship between family history of musculoskeletal disorders and the prevalence of low back pain.

Regarding tobacco use, several studies indicate that smoking could be a risk factor for low back pain.[22–24] However, in our study, it was not possible to determine this association, as in another study carried out in Brazil with 629 students of medicine during a non-pandemic period.[11] Furthermore, engagement in physical exercise proved to be protective against the onset of low back pain, corroborating the study by Sihawong et al.[25]

Having good quality sleep, in our study, was also a protective factor against the onset of low back pain, in line with another study that found a trend of worse low back pain in individuals with poor quality sleep.[26] On the other hand, although sitting correctly was found to be a protective factor

against low back pain, De Carvalho et al.,[27] in their meta-analysis, did not find a significant relationship between sitting positions and the presence of low back pain compared to standing positions, concluding that more studies are needed to better elucidate this issue. It is worth mentioning that sitting correctly was evaluated according to the perception of each respondent and needs to be viewed with caution.

Respondents from institution number 2 were less likely to have low back pain when compared to the other institutions. Comparing the exposure to risk factors among individuals from the three participating universities, individuals from institution number 2 reported greater engagement in exercise during the pandemic (77.96% reported practicing, compared to 65.88% and 48.17% in the other two institutions) and better sleep quality (92.54% reported sleeping more than 6 hours per night, compared to 75.5% in institution number 1, for example). This may reflect lower exposure to risk factors related to low back pain.

Considering the high rate of individuals who reported impairment in their college activities due to the presence of low back pain (28.83%), it is evident that this condition could impact the academic performance of these professors and students.

The main limitations of this study are inherent to the retrospective cohort model. In addition, data related to professors should be analyzed with caution, as the number of participants in this group was below the expected number, except for professors from university 1. However, there is a very high prevalence of low back pain in medical students and professors, indicating the need to implement preventive strategies to minimize the problem.

Conclusion

The prevalence of low back pain is high among medical students and professors, further increasing during the pandemic period, except among 5th and 6th year students. Family and personal history of spinal problems, female gender and poor posture when sitting were found to be risk factors, while physical exercise and good quality sleep were protective factors against the onset of low back pain. Furthermore, considering the paucity of data on the real impacts of this high prevalence of low back pain in these groups, more specific studies on the subject are still needed.

Authors' Contributions

Each author contributed individually and significantly to the development of this article**.** AFM (0000-0002-9419-7777)*: data curation (equal), investigation (equal), methodology (equal), writing-original draft (equal) and writing-review and editing (equal); NFL (0000-0002-3874-4588)*: data curation (equal), investigation (equal), methodology (equal), writing-original draft (equal) and writing-review and editing (equal); MW (0000-0003-1961-6537)*: conceptualization (equal), methodology (equal), project administration (equal), supervision (equal), writing-original draft (equal) and writing-review and editing (equal); and DEM (0000-0001-5510-3507)*: conceptualization (lead), data curation (equal). Investigation (equal), methodology (equal), project administration (equal), supervision (equal), writing-original draft (equal) and writing-review and editing (equal). *ORCID (Open Researcher and Contributor ID).

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Conflicts of Interests

The authors declare that they have no conflict of interest.

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Intravenous Use of Tranexamic Acid in Total Knee Arthroplasty with no Tourniquet*

O uso endovenoso de ácido tranexâmico na artroplastia total de joelho sem uso de torniquete

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Abstract

Objective: To identify blood transfusion requirements and postoperative complications in patients undergoing total knee arthroplasty (TKA) with no tourniquet and intraoperative intravenous administration of tranexamic acid.

Methods: This retrospective observational study analyzed 49 preopeative and postoperative medical records of patients undergoing TKA. A paired t-test compared changes in hemoglobin (HB) and packed cell volume (PCV), and an independent t-test with Welch correction compared HB and PCV changes between genders. A Spearman correlation test determined associations between age and days of postoperative hospitalization with HB and PCV changes. The significance level adopted was $p < 0.05$.

Results: The patients' mean age was 71.9 ± 6.7 years; most subjects were women (73.5%). The right side (59.2%) was the most affected. Only one participant required a blood transfusion, while three subjects had complications during the postoperative follow-up. No patient had a thromboembolic event. The median length of postoperative hospital stay was 2 days (interquartile range [IQR] = 1.0). There were reductions in HB and PCV levels between the pre-operative and postoperative period, and female patients had a higher HB reduction.

Conclusion: TKA with tranexamic acid and no tourniquet did not cause significant postoperative complications or require blood transfusions.

Keywords
- tranexamic acid
- arthroplasty, replacement, knee
- tourniquet

* *Work developed at the Department of Orthopedics and Traumatology, Hospital Policlínica Pato Branco, Pato Branco, Paraná, Brazil.*

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Resumo

Objetivo: Identificar a necessidade de transfusão sanguínea e intercorrências inerentes ao pós-operatório de pacientes submetidos à artroplastia total de joelho (ATJ), a partir de manejos realizados sem o uso de torniquete e com administração de ácido tranexâmico endovenoso intra-operatório.

Métodos: Trata-se de um estudo observacional retrospectivo, a partir da observação de 49 prontuários médicos de pacientes submetidos à ATJ em pré e pós-operatório. Foi utilizado o teste t pareado para fazer comparações das modificações de hemoglobina (HB) e hematócrito (HT) e o teste t independente com correção de Welch para comparar as modificações de HB e HT entre os sexos. As associações de idade e dias de internação no pós-operatório com as modificações de HB e HT foram testadas pela correlação de Spearman. O nível de significância adotado foi $p < 0,05$.

Resultados: Os pacientes apresentaram idade média de $71,9 \pm 6,7$ anos. A maioria da amostra foi composta por mulheres (73,5%) e o lado direito (59,2%) foi o mais acometido. Apenas um participante necessitou de transfusão de sangue e três participantes apresentaram intercorrências durante o seguimento pós-operatório. Nenhum paciente apresentou evento tromboembólico. A mediana da duração da internação no pós-operatório foi de dois dias (IIQ= 1,0). Verificaram-se reduções nas dosagens de HB e HT entre o pré e pós-operatório, e pacientes do sexo feminino apresentaram maior redução de HB.

Conclusão: ATJ com uso de ácido tranexâmico e sem uso de torniquete não acarretou complicações pós-operatórias ou necessidade de transfusão sanguínea significativas.

Palavras-chave

- ácido tranexâmico
- artroplastia do joelho
- torniquete

Introduction

Population aging and the growing demand for quality of life have increased the indication for total knee arthroplasty (TKA). Approximately 4% of the conditions in the Brazilian population are related to osteoarthritis; the knee is the second most affected joint, accounting for 37% of cases.[1,2] It is one of the most successful procedures in orthopedics, with more than 95% implant survival after 15 years. In addition, it significantly improves the patient's quality of life.[3,4]

TKA (►**Fig. 1**) is a surgical procedure often used to treat knee osteoarthritis. It causes considerable blood loss during surgery (on average, 1,000 milliliters [mL]), which relatively increases the need for blood transfusion. As such, TKA is usually performed with a high-pressure tourniquet around the leg during all or part of the procedure, creating a cleaner surgical field and restricting blood flow. It is worth noting that tourniquet is routinely used for TKA by more than 90% of surgeons in the United Kingdom, the United States, and Europe, being an uncontested practice for decades.[5,6]

At the same time, a study from Ahmed et al.[7] emphasizes that using a tourniquet during TKA is a practice focused only on benefits, with little consideration for potential harm. In addition, it presents substantial evidence-based



Fig. 1 Total knee replacement.

risks since the tourniquet increases the risk of postoperative venous thromboembolism and contributes to higher pain levels. Therefore, it does not have a relevant advantage for the patients, making its use questionable in this context.

We emphasize the investigation of outcomes using tranexamic acid (TXA) as a strategy to reduce bleeding in major surgeries, such as TKA, due to the higher risk of blood transfusion-related infections and immune reactions. Guerreiro et al.[8] revealed that TXA at a dose of 1.0 g (at a 50 mg/mL concentration) decreased bleeding, minimized pain, and improved functional and flexion gain recovery, greatly contributing to postoperative recovery.

Therefore, the present study aims to identify the need for post-surgical blood transfusion in patients undergoing TKA with no tourniquet and intraoperative administration of intravenous TXA.

Methods

This is an observational, retrospective study based on pre-operative and postoperative blood red cell indices from patients undergoing TKA. The study occurred in a reference hospital in Orthopedics and Traumatology.

The research sample consists of all TKA procedures performed by the same knee orthopedic surgeon from Orthopedics and Traumatology service clinical staff from this hospital between January/2020 and July/2021, totaling 49 patients. It is a study with a convenience sample, in which the researcher selects the elements with available access. This fact justifies the concentration of the sample group in the same place, making this study feasible in logistical and financial terms.

The inclusion criteria for this study were patients of both genders with knee osteoarthritis who underwent TKA with no pre-operative changes in HB and PCV or blood dyscrasia. Exclusion criteria were the following: evidence of joint infection, congenital or acquired coagulopathies, active intravascular coagulation, acute occlusive vasculopathy, hypersensitivity to Transamin® components, history of severe or moderate allergy to plasma transfusion, and large bone defects requiring bone grafting.

The surgical procedure used spinal anesthesia (15 mg of heavy bupivacaine and 60 to 80 mcg of morphine) and intravenous application of 1 g of TXA (four vials with 5 mL each at a 50 mg/mL concentration) diluted in 250 mL of 0.9% saline solution. The approach was medial parapatellar, followed by eversion and lateral dislocation of the patella, resection of the menisci and anterior cruciate ligament (ACL), a femoral and tibial section with specific guides, placement of prosthetic components, and testing their functionality. After surgery, the patients remained hospitalized in the ward for postoperative clinical and laboratory follow-up.

The criterion to determine the postoperative need for blood transfusion was Hb lower than 7mg/dL, PCV lower than 21%, or both. However, please note that adequate clinical judgment is essential to assess the need for transfusion regardless of laboratory values.

The collection of blood samples from all patients occurred in the intraoperative period before the incision and was repeated 24 hours after the surgical procedure. Outpatient follow-up took place with the first visit 15 days after hospital discharge and then every 30 days for 6 months to perform a routine orthopedic evaluation and observe potential intercurrences (for instance, persistent pain, excessive bleeding in the surgical wound, presence of thromboembolic events, etc.).

Data normality assessment used the Shapiro-Wilk test and visual analysis of the histogram, which indicated a parametric data distribution (except for hospitalization days in the postoperative period). Sample description used central tendency and dispersion measures (mean and standard deviation for variables with a normal distribution and median and interquartile range for variables with no normal distribution) and relative and absolute frequency (for categorical variables).

Comparisons between pre-operative and postoperative HB and PCV values employed the paired t-test. Changes in HB and PCV between the pre-operative and postoperative period were calculated as follows: postoperative values – pre-operative values. Comparisons of HB and PCV changes in HB and HT between genders used the independent t-test with Welch correction for heterogeneity of variances. The Spearman correlation determined the association of age and days of postoperative hospitalization with changes in HB and PCV. All analyses were performed at the statistical software STATA MP 14.1 (StataCorp, College Station, TX, USA), with a significance level set at $p < 0.05$.

The Research Ethics Committee (REC) approved this study with a waiver of the informed consent term (ICF).

Results

This study obtained data from 49 patients who underwent total knee arthroplasty. Their mean age was 71.9 ± 6.7 years. Most patients were women (73.5%), and the right side (59.2%) was the most affected (►**Table 1**). Only one (2.0%) participant required a blood transfusion, while three (6.1%) subjects had complications during the postoperative follow-up (two presented persistent pain at the surgical site and one had excessive bleeding in the surgical wound until hospital discharge). No patient had a thromboembolic event. The median duration of postoperative hospital stay was 2 days (interquartile range [IQR] = 1.0).

►**Table 2** compares HB and PCV levels between the pre-operative and postoperative periods. HB ($t_{(48)} = 20.6$; $p < 0.01$; mean difference = -2.8 mg/dL) and PCV levels ($t_{(48)} = 18.7$; $p < 0.01$; mean difference = -7.8 mg/dL) decreased between the two time points.

►**Fig. 2** compares HB and PCV changes between the pre-operative and postoperative periods between genders. Women showed a higher HB reduction ($t_{(Welch)}$ (18.8) = -2.6; $p = 0.01$; mean difference = -0.8 mg/dL) and PCV ($t_{(Welch)}$ (19.7) = -2.8; $p = 0.01$; mean difference = -2.6 mg/dL) compared to men.

Table 1 Sample characteristics

Age (M ± SD)	**71.9 ± 6.7**
Gender (n [%])	
Female	36 (73.5%)
Male	13 (26.5%)
Side (n [%])	
Left	20 (40.8%)
Right	29 (59.2%)
Transfusion (n [%])	
No	48 (98.0%)
Yes	1 (2.0%)
Intercurrences (n [%])	
No	46 (93.9%)
Yes	3 (6.1%)
Postoperative hospitalization days (median [IQR])	2.0 (1.0)

Abbreviations: IQR, interquartile range; M, mean; n, number of participants; SD, standard deviation.

►**Table 3** correlates the age and number of postoperative hospitalization days with HB and PCV changes. There were no significant associations.

Discussion

The literature regarding blood loss in total knee arthroplasty presents different results. Barros et al.[9] showed that TKA with no tourniquet led to HB and PVC changes of 2.04 and 6.82, respectively. In addition, 33.33% of patients required a blood transfusion. In contrast to our study, these authors did not use TXA. Tan et al.[10] stated that TXA is an essential ally in reducing bleeding. Indeed, in our study, the procedure with no tourniquet associated with intravenous TXA administration led to a single patient (2.04%) requiring a blood transfusion.

Monteiro et al.[11] corroborated these outcomes when comparing TKA procedures, revealing that patients who received intravenous TXA had a statistically significantly lower mean volume of blood drained than the other groups (with topical TXA or no TXA). These authors also observed no adverse effects or thromboembolic events in TXA-treated groups.

Almeida et al.[12] presented similar results in a sample of 101 patients undergoing TKA (51 TXA and 50 placebo). These authors found statistically significant reductions ($p < 0.05$) in the following parameters: HB, PCV, estimated blood loss, and drain output. All values were lower in the TXA group, and only patients from the placebo group required blood transfusions.

Regarding tourniquet use, we found that the surgical procedure without it did not present significant postoperative complications (6.12%). In a systematic review of the literature on TKA using a tourniquet or not, Ahmed et al.[7] observed that tourniquets were associated with a higher rate of serious adverse events, longer hospital stay, and higher mean pain score on the first postoperative day. As such, these authors concluded that the routine use of a tourniquet in TKA is not justified.

Like any study using data from medical records, one of the limitations of our research is the information collected, which is subject to the accuracy of those filling out and even not inserting it in the files.

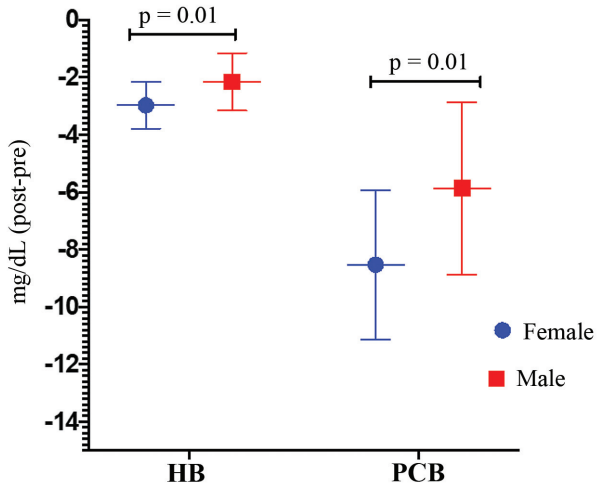


Fig. 2 Comparison of hemoglobin (HB) and packed cell volume (PCV) between genders (n = 49).

Table 3 Correlation between age and postoperative hospitalization days and hemoglobin (HB) and packed cell volume (PCV) levels alterations

	HB alterations	PCV alterations
	Rho (p)	Rho (p)
Age (years)	0.01 (1.00)	0.02 (0.95)
Postoperative hospitalization period (days)	-0.12 (0.95)	-0.11 (0.98)

Abbreviation: Rho, Spearman correlation.

Table 2 Comparison between pre- and postoperative hemoglobin (HB) and packed cell volume (PCV) levels

	Pre-operative		Postoperative				
	M	SD	M	SD	Δ	t*	p*
HB (mg/dL)	13.8	1.0	11.0	1.3	-2.8	20.6	<0.01
PCV (mg/dL)	40.9	3.4	33.1	4.1	-7.8	18.7	<0.01

Abbreviations: M, mean; SD, standard deviation; Δ, mean difference (postoperative – pre-operative levels). *: Paired t test.

Conclusion

As expected, HB and PCV values diminished from the preoperative to the postoperative period. However, these reductions did not cause significant postoperative complications or require blood transfusions.

It is worth noting that the results of this study should not be analyzed in a generalized way, as they are limited to the sample and the study model adopted. However, they present hypotheses for testing in future research.

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Conflict of Interests
The authors declare no conflict of interests.

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Analysis of the Mechanical Behavior of Porcine Graft Fixation in a Polyurethane Block Using a 3D-printed PLA Interference Screw*

Análise do comportamento mecânico da fixação do enxerto suíno em um bloco de poliuretano usando um parafuso de interferência PLA impresso em 3D

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Abstract

Objective The interest in using 3D printing in the healthcare field has grown over the years, given its advantages and potential in the rapid manufacturing of personalized devices and implants with complex geometries. Thus, the aim of the present study was to compare the mechanical fixation behavior of a 3D-printed interference screw, produced by fused deposition modeling of polylactic acid (PLA) filament, with that of a titanium interference screw.

Methods Eight deep flexor porcine tendons, approximately 8 mm wide and 9 cm long, were used as graft and fixed to a 40 pounds-per-cubic-foot (PCF) polyurethane block at each of its extremities. One group was fixed only with titanium interference screws (group 1) and the other only with 3D-printed PLA screws (BR 20 2021 018283-6 U2) (group 2). The tests were conducted using an EMIC DL 10000 electromechanical universal testing machine in axial traction mode.

Results Group 1 (titanium) obtained peak force of 200 ± 7 N, with mean graft deformation of 8 ± 2 mm, and group 2 (PLA) obtained peak force of 300 ± 30 N, and

Keywords
- bone screws
- lactic acid
- printing, three-dimensional

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mean graft deformation of 7 ± 3 mm. Both the titanium and PLA screws provided good graft fixation in the polyurethane block, with no slippage or apparent deformation. In all the samples, the test culminated in graft rupture, with around 20 mm of deformation in relation to the initial length.
Conclusion The 3D-printed PLA screw provided good fixation, similar to that of its titanium counterpart, producing satisfactory and promising results.

Resumo

Objetivo O interesse em utilizar a impressão 3D na área da saúde tem crescido ao longo dos anos, dadas as suas vantagens e o seu potencial na rápida fabricação de dispositivos e implantes personalizados com geometrias complexas. Assim, o objetivo do presente estudo foi comparar o comportamento de fixação mecânica de um parafuso de interferência impresso em 3D, produzido pela modelagem fundida de deposição do filamento de ácido polilático (PLA), com o de um parafuso de interferência de titânio.
Métodos Oito tendões suínos flexores profundos, de aproximadamente 8 mm de largura e 9 cm de comprimento, foram utilizados como enxerto e fixados em um bloco de poliuretano de 40 PCF em cada uma de suas extremidades. Um grupo foi fixado apenas com parafusos de interferência de titânio (grupo 1) e o outro apenas com parafusos PLA impressos em 3D (BR 20 2021 018283-6 U2) (grupo 2). Os testes foram realizados utilizando uma máquina de teste universal eletromecânica EMIC DL 10.000 no modo de tração axial.
Resultados O grupo 1 (titânio) obteve força máxima de 200 ± 7 N com deformação média do enxerto de 8 ± 2 mm, e a força máxima do grupo 2 (PLA) foi de 300 ± 30 N e deformação média do enxerto de 7 ± 3 mm. Ambos os parafusos de titânio e PLA forneceram boa fixação de enxerto no bloco de poliuretano, sem deslizamento ou deformação aparente. Em todas as amostras o teste culminou na ruptura do enxerto, com cerca de 20 mm de deformação em relação ao comprimento inicial.
Conclusão O parafuso PLA impresso em 3D proporcionou boa fixação, semelhante à de sua contraparte de titânio, produzindo resultados satisfatórios e promissores.

Palavras-chave
- parafusos ósseos
- ácido láctico
- impressão tridimensional

Introduction

Knee ligament reconstruction, especially of the anterior cruciate ligament (ACL), is among the most commonly performed orthopedic surgeries. Typically, these ligaments are not eligible for primary suture, requiring replacement of the injured ligament with a graft. As such, the type of graft and fixation methods have been extensively studied.[1]

There is a wide range of materials available to fix these grafts, with a significant difference in techniques and surgery costs. In surgery, interference screws are a widely used and accepted option,[2–4] but their cost remains a considerable obstacle. When public health policies are proposed, particularly in countries with few health resources, the cost of surgical materials is still a decisive factor in their selection.[5]

Rapid prototyping or 3D printing involves a set of technologies aimed at constructing physical prototypes from their virtual analogs. Interest in using 3D printing in the healthcare field has increased over the years, given its advantages and potential in the rapid production of personalized devices and implants with complex geometries. With an increase in 3D printing, operating costs decline, making this technology and its products more accessible.[6]

Polylactic acid (PLA) exhibits attractive properties for biomedical use due to its biocompatibility. It is biodegradable, since it can be disintegrated by biological agents, and bioabsorbable, because the product of its degradation participates in the metabolic process of the human body. Among the manufacturing techniques used for PLA parts aimed at biomedical applications, 3D printing is one of the most promising, primarily because of the possibility of producing personalized and individualized parts, in addition to detailed prototyping and lower costs, which would make them more accessible, such as 3D-printed PLA interference screws.[6,7]

Thus, the aim of the present study was to compare the mechanical fixation behavior of a 3D-printed interference screw, produced by fused deposition modeling of PLA filament, with that of a titanium interference screw.

Material and Methods

Manufacture of 3d-Printed Interference Screws

An interference screw was created, similar to a trapezoidal-threaded power screw, with an internal conical hexagonal cavity. After 3D modeling (.stl / Autodesk Fusion 360), a virtual 3D model was created, using the Ultimaker Cura software, responsible for printer slicer settings and parameter analysis, in which it is possible to obtain, beforehand, a sample of the printed part and map its entire development process.

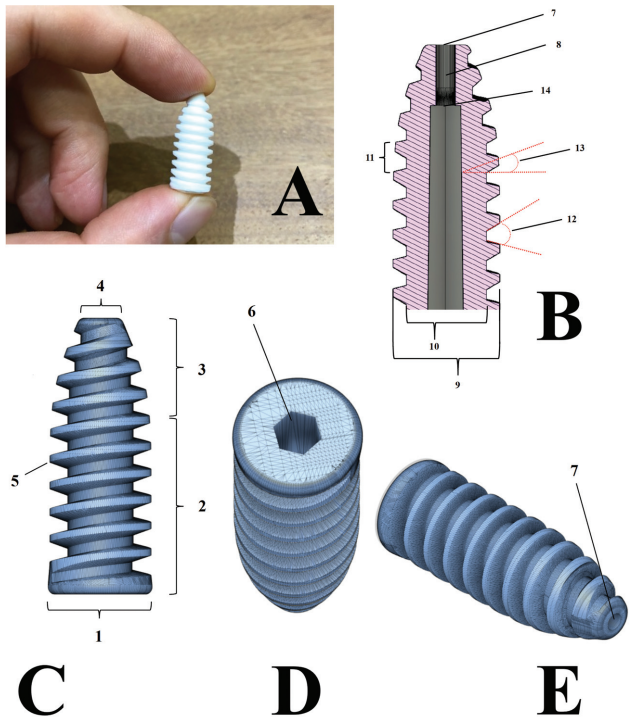


Fig. 1 A 3D-printed PLA interference screw, produced according to the BR 20 2021 018283-6 U2 utility model. **B** Section in the coronal plane with respect to the major axis of the interference screw in a profile view. **C** Profile view of the interference screw. **D** Oblique inferior view of interference screw. **E** Oblique superior view of interference screw. 1. Circular screw base; 2. Parallel zone, of the same diameter, corresponding to the proximal 2/3 of the screw length; 3. Conical zone, corresponding to the distal 1/3 of the screw length; 4. Screw apex; 5. Tangent, left-hand, trapezoidal-shaped external thread, similar to a power screw; 6. Hexagonal conical internal cavity, centered on the long axis, with a length corresponding to the proximal 80% of the total length of the screw, for fitting the wrench; 7. 1.5 mm diameter cylindrical internal cavity; 8. Cylindrical internal cavity, with a length corresponding to the distal 20% of the total length of the screw, centered on the long axis, which communicates with the hexagonal conical internal cavity (6), allowing the passage of a guide wire through the entire internal length of the screw; 9. Larger diameter of the screw thread, corresponds to the width of the screw in its proximal 2/3; 10. Minor thread diameter (10) is equivalent to 2/3 of the major thread diameter of screw (9); 11. Thread pitch, corresponding to 1/3 of the smaller diameter of the screw thread (10); 12. 30° thread angle; 13. 6.5° thread feed angle; 14. Most distal region of the hexagonal conical internal cavity.

The screw was 3D-printed (3DMax A1v2) using the fusion deposition method (FDM) of the PLA filament, a natural biodegradable thermoplastic polymer from renewable sources. The present solution complies with biomaterial guidelines, such as ABNT NBR 15998 and 15743-7. The printed screw (►**Fig. 1**), the object of study, was produced according to the BR 20 2021 018283-6 U2 utility model, measuring 30 mm long, 9 mm wide, with a thread pitch of 2 mm. The following parameters were used in printing:

- Table temperature: 60 °C.
- Nozzle temperature: 200 °C.
- Printing speed: 50 mm/s.
- Layer height: 0.16 mm.
- Infill: 100%.
- Fiber arrangement: Concentric.
- The PLA filament was used with the following characteristics: white, average diameter of 1.75 mm and 3.03 gram/meter.

Polyurethane Block

In order to prepare the test samples, a simulated surgery was carried out, in which a hole was opened in the polyurethane block, representing the "bone tunnel", allowing graft insertion, fixing with the interference screw, as would occur in practice.

According to the ABNT NBR 15678:2020, which regulates the standard material for the mechanical testing of implants and orthopedic instruments, rigid unicellular polyurethane foam with the following characteristics was applied:

- Dimensions: 100 mm x 100 mm x 30 mm.
- Color: brown.
- Density: 40 PCF – 0.96 g/cm3.
- Hole / tunnel: 9 mm in diameter on the central axis of the 100 mm x 100 mm surface, over the entire height of the block (30 mm).

Graft

Similar to that described in the biomechanical study of Moré et al.,[8] we used recently frozen Landrace pig legs in the experiments. The tendons were harvested in a slaughterhouse. Eight legs were stored at –20 °C and thawed 12 hours before the test. Each tibia was dissected, and the deep flexor tendon, approximately 8 mm wide and 9 cm long, was extracted for use as graft.

Sample Preparation

The samples were divided into two groups (►**Fig. 2**):

- (Group 1) control group: the graft was fixed at the extremities of the polyurethane blocks with 30 mm-long and 9 mm-wide metallic interference screws, made of ASTM F136 titanium alloy (Traumédica Ltda., Campinas, SP, Brazil).
- (Group 2) PLA group: the graft was fixed at the extremities of the polyurethane blocks with 30 mm-long and 9 mm-wide 3D-printed screws.

The average graft length was 9 cm, 3 cm inside each block and 3 cm "free" between the blocks. The fixation procedures were carried out by a trained orthopedic surgeon. All the polyurethane blocks contained a 9 mm-long tunnel, made by the surgeon into which an 8 mm graft was inserted. This procedure created a 1 mm space between the graft and the tunnel wall. The screw was implanted with the aid of a Kirschner wire to avoid divergence and false trajectory. At the end, the test specimens displayed the following configuration: screw – block – graft – block – screw (►**Fig. 3**).

Conducting the Tests

The tests were carried out on an EMIC DL 10000 electromechanical universal testing machine, using its axial traction in order to determine the efficiency of graft fixation with

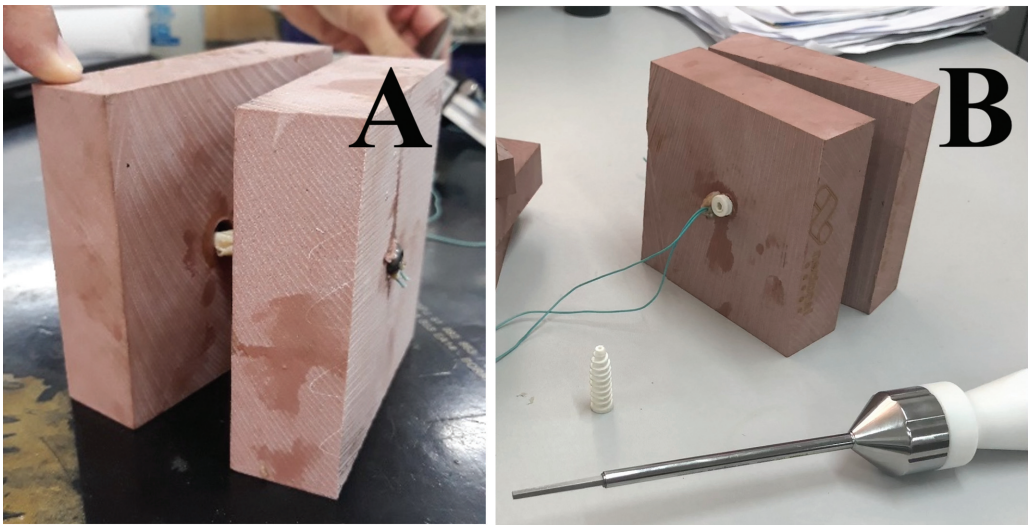


Fig. 2 The samples. A - (Group 1) control group: the graft was fixed at the extremities of the polyurethane blocks with 30 mm-long and 9 mm-wide metallic interference screws, made of ASTM F136 titanium alloy (Traumédica); B - (Group 2) PLA group: the graft was fixed at the extremities of the polyurethane blocks with 30 mm-long and 9 mm-wide 3D-printed screws.

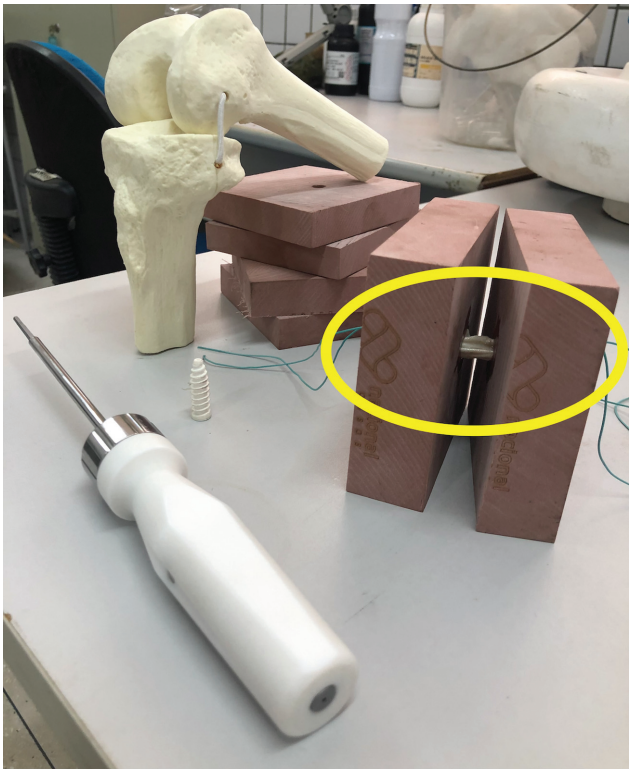


Fig. 3 Test specimens displayed the following configuration (yellow circle): screw – block – graft – block – screw.



Fig. 4 The sample (screw – block – graft – block – screw) on the testing machine (EMIC DL 10000 electromechanical universal testing machine).

interference screws, and a computer to register the data obtained.

In the tests, the experimental length of the sample was correlated by deformation (mm) in relation to time (seconds), stipulated as 10 mm^{-2}/s, with traction applied until graft rupture or slippage of the screw/graft assembly. The apparatus assembled in the testing machine is shown in ►**Fig. 4**.

Methodology and Data Analysis

The categorical and numerical variables were tabulated and analyzed using the R software Rr Mac OS X GUI 1.73 (7892 Catalina build). Analyses with a 95% confidence interval and p-value < 0.05 were considered statistically significant.

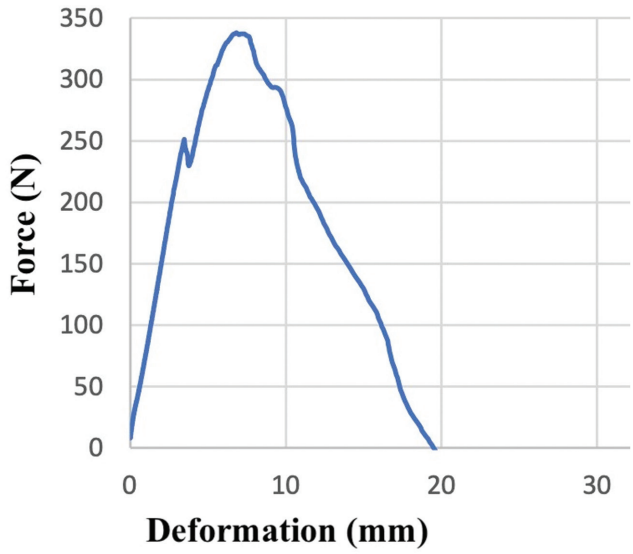


Fig. 5 Graph of the Force (N)/deformation (mm) ratio suffered by the sample number 1 fixed with the PLA screw.

Results

The data obtained from the tests were the time, deformation (mm), and force (N) to which the sample was submitted. With these data, graphs were made of the force (N)/deformation (mm) ratio suffered by the sample fixed with the titanium screw and with the PLA screw (►**Fig. 5**).

The samples in which the graft was fixed at their extremities with titanium interference screws obtained peak force of 200 ± 7 N, with average graft deformation of 8 ± 2 mm. With an increase in deformation, force declined until the graft ruptured, with around 20 ± 1 mm of deformation in relation to initial length. The titanium screw provided good graft fixation in the polyurethane block, with no slippage or apparent deformation. In all the samples, the test culminated in graft rupture.

The samples in which the graft was fixed at their extremities with PLA interference screws obtained peak force of 300 ± 30 N, in average deformation of 7 ± 3 mm. An increase in deformation caused a decline in force until the graft ruptured, with around 19 ± 2mm of deformation in relation to initial length. The PLA screw also exhibited good fixation in the polyurethane block, with no slippage or apparent deformation. In all the samples, the test culminated in graft rupture.

Discussion

The main finding of the present study was to demonstrate that the PLA screw fixation is similar to that of titanium, with similar maximum peak force and graft deformation, thereby exceeding graft strength.

During the tests, both control and PLA screws showed good block graft fixation, with no sign of slippage until the end of the tests, with graft strength being responsible for terminating the tests. However, the results obtained are not sufficient to recommend the use of the present PLA prototype for human ligament reconstruction.

Maximum tensile force of the native ACL is approximately $1{,}725 \pm 270$ N, lower than the peak that occurs during vigorous athletic activities.[9] Ideally, a graft used for ACL reconstruction surgery should, as much as possible, recreate the anatomical and biomechanical properties of the native ligament, which guarantees secure fixation and rapid biological integration, shortening recovery time and reducing donor site morbidity.[10] Several grafts are available for ACL reconstruction, including autografts (bone patellar tendon bone [BPTB], hamstring [HS] etc.), allografts, and synthetic grafts.[11] The HS graft shows failure with an average load of 2,422 N when compared to 1,785 N for the BPTB graft.[12] In other words, in the present study, we did not exceed the load needed for failure of a human graft.

Moré et al.[8] conducted a biomechanical study with a porcine model, using a deep Landrace pig flexor tendon model as graft. These grafts were then fixed to the tibia by 10 bioabsorbable interference screws (9×20 mm PLLA 70/30, Linvatec), and 10 metallic interference screws (9×20 mm Hexagon). The single-cycle load-to-failure test showed that the rupture load was not significantly different between the 2 types of screws (607.11 ± 97.49 N and 628.41 ± 234.93 N for bioabsorbable and metallic screws, respectively).[8]

Weiler et al.[13] compared flexor tendons as grafts and observed different behavior between metallic and bioabsorbable screws, with load to failure of 507 N for the bioabsorbable screw and 419 N for its metallic counterpart. The values reported by Weiler et al.[13] were closer to those of the present study.

Using 3D printing, Liu et al.[7] produced a well-defined, orthogonal porous PLA screw, subsequently coated with hydroxyapatite (HA) to improve its osteoconductivity, and, loaded with mesenchymal stem cells (MSCs). This screw was assessed by in vitro and in vivo tests, in rabbit ACL models. This model exhibited significant bone growth and bone-graft interface formation inside the bone tunnel, demonstrating that the manufacture of 3D-printed surgical implants may be feasible, effective, and economic.

After immersing a PLA component in a phosphate-buffered saline solution, Medeiros[14] assessed the changes in its mechanical properties, fatigue life and chemical alterations for biomedical applications produced by 3D printing. Medeiros[14] concluded that the printed PLA displayed relevant hydrolytic degradation properties as a biomaterial, exhibiting a decline in fatigue life and granular erosion due to degradation. This enables its application to release drugs and implants such as conductive cell membranes in tissue engineering, but further studies on enzymatic degradation and cell tests are needed for total confirmation regarding the efficacy of this biomaterial.

Feltz et al.[15] studied the mechanical properties of orthopedic 3D-printed, one third tubular plates, and cortical screws, concluding that 3D printers can print biocompatible materials to replicate low-cost surgical implant designs. However, current materials and structures do not resemble the properties of stainless-steel implants.

Carvalho et al.[16] studied the biocompatibility and biodegradation of PLA, implanting the material in the subcutaneous cell tissue on the lateral surface of horses necks, and concluded that PLA is biocompatible and biodegradable, with potential use in equine medicine.

Kamiya et al.[17] measured the financial-environmental performance of PLA parts using fusion deposition modeling. These authors concluded that 3D-printed PLA parts have a low environmental impact and good economic performance, demonstrating the biomedical and commercial usability of 3D-printed PLA parts.

Goes Filho[18] produced and biomechanically assessed orthopedic implants for fracture fixation in PLA (plates and screws), using 3D-printed fused polymer layer deposition for subsequent experimental application in rabbit femur. In a 4-point bending test, the 6-hole plate obtained values of 748 ± 62 N, while the 4-hole locking plate obtained 374 ± 29 N. The screw was submitted to the pullout capacity test in a polyurethane foam that simulates cortical bone, obtaining an average value of 33 ± 6 N. The anatomically optimized plate obtained 662 ± 220 N in the bend test and 193 ± 20 N after irradiated with 40 KGy. From the standpoint of mechanical resistance to the bend test, Goes Filho[18] showed the feasibility of producing orthopedic implants for fractures that received little mechanical load, although further in vivo studies are needed to confirm the efficacy of the production technique and the material used. These findings were similar to those reported by Lough et al.,[19] Tappa et al.,[20] and MacLeod et al.[21]

The expected dependence of graft fixation biomechanics on thread design generally differs between polymer and metallic screws. These differences typically involve distinct fixation performance, which was not observed in the tests. Thus, many other mechanical and tribological aspects clearly play important roles in the interfaces, ruling out simple explanations for different fixation behavior.

However, the main limitation of the present study was the graft selected for the tests. We used animal tissue as graft due to its easy acquisition, but a porcine graft is not as strong as its young human counterpart. As such, we could not test the strength of the screw-polyurethane-graft complex. Nevertheless, the methodology used is a useful model for future research. Despite these limitations, our results corroborate those reported by similar studies. In general, the findings obtained indicate that both types of interference screws exhibit similar biomechanical performance at low loads. However, more research is needed to determine the clinical relevance of these findings.

Conclusion

The 3D-printed PLA screw provided good fixation, similar to that of its titanium counterpart, producing satisfactory and promising results.

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

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Trigger Finger or De Quervain Tenosynovitis after Surgical Treatment for Carpal Tunnel Syndrome*

Dedo em gatilho ou tenossinovite de De Quervain após tratamento cirúrgico da síndrome do túnel do carpo

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Abstract

Objective To evaluate the open surgical treatment for carpal tunnel syndrome as a risk factor for the development of stenosing tenosynovitis that results in trigger finger and De Quervain disease.

Materials and Methods A retrospective study analyzing the medical records of patients submitted to open surgical release of carpal tunnel syndrome between 2010 and 2021 in a secondary- and tertiary-level hospital. The following data were collected: pathological history, duration of the follow-up after the surgical treatment for carpal tunnel syndrome, development of trigger finger or De Quervain tenosynovitis, affected fingers, and the interval between the end of surgery and symptom onset.

Results We evaluated 802 patients of both genders and with a mean age of 50.1 (± 12.6) years. The mean follow-up was of 13 (± 16.4) months. The mean time until the

Keywords
- carpal tunnel syndrome
- trigger finger
- De Quervain disease

* *Study developed at the Department of Orthopedics and Anesthesiology, Hospital das Clínicas, Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo (HC-FMRP-USP), Ribeirão Preto, SP, Brazil.*

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development of trigger finger was of 61.4 months, and of 73.7 months for De Quervain disease. The incidence of development of De Quervain disease was of 4.12%, and for trigger finger it was of 10.2%. The most affected digits were the thumb (47.6%), the middle (24.4%), and the ring finger (8.54%). Age was the only factor that showed an association with the risk of developing trigger finger, with an increase of 2% for each increase in age of 1 year.

Conclusion The incidence rates for the development of De Quervain disease (4.12%) and trigger finger (10.2%) after the surgical treatment for carpal tunnel syndrome were like those described in the literature. Only age was a factor that influenced the development of trigger finger.

Resumo

Objetivo Avaliar o tratamento cirúrgico aberto da síndrome do túnel do carpo como fator de risco para o desenvolvimento das tenossinovites estenosantes formadoras do dedo em gatilho e da doença de De Quervain.

Materiais e Métodos Estudo retrospectivo com análise dos prontuários de pacientes submetidos a liberação cirúrgica aberta da síndrome do túnel do carpo entre 2010 e 2021 em hospital de níveis secundário e terciário. Os seguintes dados foram coletados: histórico patológico, tempo de acompanhamento após o tratamento cirúrgico da síndrome do túnel do carpo, desenvolvimento de dedo em gatilho ou tenossinovite de De Quervain, dedos acometidos, e tempo decorrido entre o fim da cirurgia e o aparecimento dos sintomas.

Resultados Foram avaliados 802 pacientes de ambos os gêneros e com média de idade de 50,1 ($\pm$ 12,6) anos. O tempo médio de seguimento foi de 13 ($\pm$ 16,4) meses. O tempo médio de desenvolvimento de dedo em gatilho foi de 61,4 meses, e o da doença de De Quervain, de 73,7 meses. A incidência de desenvolvimento da doença de De Quervain foi de 4,12% e a de dedo em gatilho, de 10,2%. Os dedos mais acometidos foram o polegar (47,6%), o médio (24,4%) e o anular (8,54%). A idade foi único fator que demonstrou associação com o risco de desenvolvimento de dedo em gatilho, com aumento de 2% a cada ano a mais de idade.

Conclusão As taxas de incidência de desenvolvimento de doença de De Quervain (4,12%) e de dedo em gatilho (10,2%) após tratamento cirúrgico da síndrome do túnel do carpo foram semelhantes às descritas na literatura. Apenas a idade se apresentou como fator influenciador no desenvolvimento de dedo em gatilho.

Palavras-chave
- síndrome do túnel do carpo
- dedo em gatilho
- doença de De Quervain

Introduction

Carpal tunnel syndrome (CTS) is the most common peripheral nerve compression pathology, with a prevalence of 3.8%.[1] Compression of the median nerve occurs at the level of the wrist due to increased pressure within the osteofibrous tunnel.[2] The procedure for carpal tunnel decompression is in the specialty of hand surgery, and it involves opening of the transverse ligament of the carpus, increasing the width of the tunnel.[3]

In turn, trigger finger is characterized by pain and a palpable nodule at the level of the A1 pulley, which clinically presents as a locking of the flexor tendons in the attempt to move the finger.[4] De Quervain disease is a stenosing tenosynovitis of the first extensor compartment, which contains the tendons of the long abductor and short extensor of the thumb. Clinically, it presents with pain in the radial side of the wrist associated with edema and uncomfortable palpation of the first dorsal compartment.[5]

The presence of trigger finger associated with CTS suggests the possibility of a common pathological process.[6] However, the association between carpal tunnel decompression and the development of trigger finger has not been well established yet.[7]

Therefore, a considerable number of studies[7–10] have been able to identify the incidence of first-pulley stenosis, as well as the mean time until the onset of symptoms in patients undergoing surgical decompression of the median nerve in the wrist, with rates ranging from 5.2% to 31.7% and 4 to 6 months respectively.

In the context of the development of stenosing tenosynovitis of the first extensor compartment, the rates found were much lower, with an approximate incidence of 0.5% after the surgical release of the transverse carpal ligament.[11]

Table 1 Mean, median and standard deviation (SD) values for age, duration of the outpatient follow-up, and onset of pathologies after the surgical treatment for carpal tunnel syndrome

Variable	Average (± standard deviation)	Median [minimim–maximum]
Age (years)	50.1 (12.6)	50.0 [5.00–89.0]
Follow-up (months)	13.0 (16.4)	6.00 [0.07–108]
Time until the development of De Quervain disease (months)	11.6 (15.4)	6.00 [0.07–84.0]
Time until the development of trigger finger (months)	11.6 (15.4)	6.00 [0.07–84.0]

The present study evaluated the open surgical treatment for CTS as a risk factor for the development of stenosing tenosynovitis that results in trigger finger and De Quervain disease.

Methods

The present work was approved by the institutional Ethics in Research Committee (CAAE- 45203921.0.0000.5440).

We conducted a retrospective cross-sectional study of patients undergoing open surgical treatment for CTS in a secondary- and tertiary-level hospital.

All of the patients selected were operated on between January 2010 and December 2020, except for those previously treated for trigger finger or De Quervain disease, or those with a diagnosis concomitant to the CTS surgery, which were the only exclusion criteria.

Based on the analysis of the medical records of the patients, we collected sociodemographic data such as age, gender, pathological history, duration of the follow-up, development of trigger finger or De Quervain tenosynovitis after the open release of the transverse ligament of the carpus, the affected fingers, and the time between the end of the surgery and the onset of symptoms.

Statistical analysis

An exploratory data analysis was performed using summary measures (frequency, percentage, mean, standard deviation, minimum, median, and maximum). The factors associated with the time until the development of diseases after the surgical treatment for CTS were analyzed through Cox regression.

Survival analysis was used to study the time until the development of trigger finger and De Quervain tenosynovitis after the open treatment for compression of the median nerve in the wrist, but some patients did not develop either, and they were censored.

The Cox regression or the proportional risk model demonstrate the failure rate between covariates, and the interpretation of the coefficients is made through relative risk (RR). In the case of the present study, the objective was to model the rate of disease development in relation to age and isolated pathologies.

The level of significance adopted was of 5%.

Results

We collected data from 873 patients in total, and 71 of them (8.13%) were excluded because they had a diagnosis of trigger finger and/or De Quervain tenosynovitis concomitant with CTS.

Thus, 802 patients of both genders aged between 5 and 89 years were selected. ►**Table 1** shows the age in years, the duration of the follow-up, and the time until the development of the pathologies after the surgical release of the transverse carpal ligament, the last two in months. The mean age was of 50.1 years; the mean follow-up was of 13months, and the mean time until the onset of De Quervain disease and trigger finger was of 11.6 months.

►**Table 2** shows the variables of gender and affected side. There was a predominance of female patients in the initial population submitted to the surgical treatment for CTS (87%), and the most affected side was the right side (55.2%).

Regarding the pathological history at the time of the surgery, there was a higher prevalence of systemic arterial hypertension (SAH; 29.7%), followed by smoking (12.8%), and type-2 diabetes mellitus (DM2; 11.1%) (►**Fig. 1**).

Table 2 Distribution in frequency and percentage of gender and affected side

	Gender	Affected side
	Female = 698 (87.0%)	Right = 443 (55.2%)
	Male = 104 (13.0%)	Left = 359 (44.8%)
Total	100%	100%

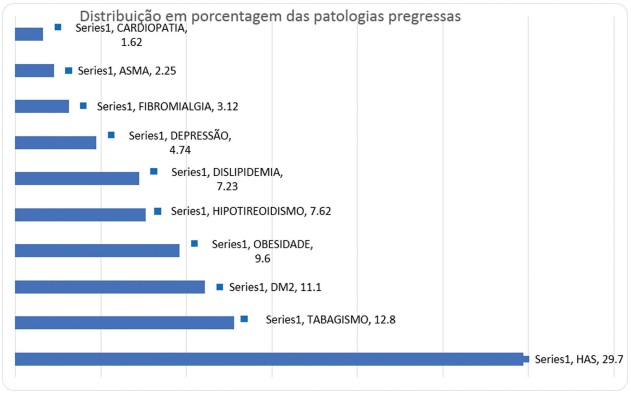


Fig. 1 Distribution of the previous pathologies in terms of frequency and percentage.

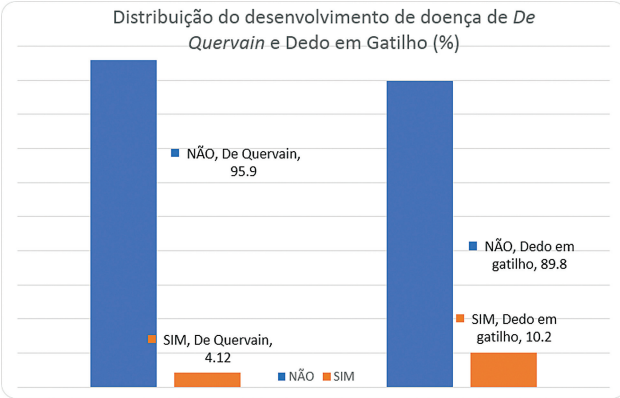


Fig. 2 Distribution, in terms of frequency and percentage, of the development of De Quervain tenosynovitis and trigger finger after the surgical treatment for carpal tunnel syndrome (CTS).

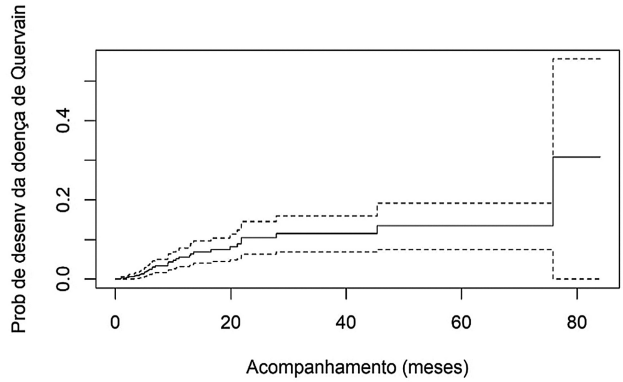


Fig. 3 Kaplan-Meier curves for the probability of developing De Quervain disease after the surgical treatment for CTS. The values of the estimates and their confidence intervals for P25, median, and P75 of the survival time are displayed using the "quantile" function.

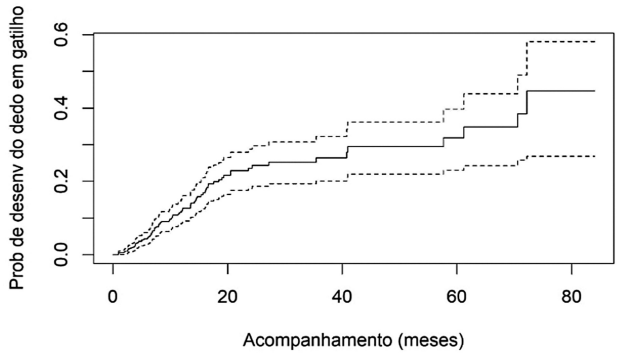


Fig. 4 Kaplan-Meier curves for the probability of developing trigger finger after the surgical treatment for CTS throughout time. The values of the estimates and their confidence intervals for P25, median, and P75 of the survival time are displayed using the "quantile" function.

The incidence of the development of tenosynovitis was of 4.12% for De Quervain disease, and of 10.2% for trigger finger (►**Fig. 2**).

Regarding the distribution of fingers affected by trigger after the surgery (►**Table 3**), there was a higher incidence for the thumb, both isolated (47.6%) and combined with other fingers (52.48%). The second most affected digit was the middle finger, with a value of 24.4% isolated and of 36.6% associated with other fingers. The third digit with the highest incidence was the ring finger, with a rate of 8.54% isolated, and of 14.64% combined with other fingers. The most common combination of affected digits was that of the middle and ring fingers: 6.1%.

►**Fig. 3** shows the Kaplan-Meier curves for the probability of developing De Quervain tenosynovitis after the surgery throughout the follow-up; after the analysis of the censored data, the mean tome was of 73.7 months (±2.08), and the probability of developing the disease in 12, 24, 36, 48 and 60 months was of 5.5%, 10.5%, 11.5%, 13.5%, and 13.5% respectively.

►**Fig. 4** shows the Kaplan-Meier curves for the probability of developing trigger finger after the surgery throughout the follow-up; after the analysis of the censored data, the mean time was of 61.4 months (±2.37), and the probability of developing the disease in 12, 24, 36, 48 and 60 months was of 11.9%, 23.6%, 26.5%, 29.5%, and 31.9% respectively.

Table 3 Distribution in frequency and percentage of the digits affected by trigger after the surgical treatment for carpal tunnel syndrome

Digit	N (%)
Thumb	39 (47.56%)
Thumb and index finger	1 (1.22%)
Thumb and middle finger	3 (3.65%)
Index finger	3 (3.65%)
Index and middle fingers	2 (2.44%)
Middle finger	20 (24.4%)
Middle and ring fingers	5 (6.10%)
Ring finger	7 (8.54%)
Pinkie or fifth finger	2 (2.44%)
Total	82 (100%)

The simple Cox regression was used to evaluate the influence of age, gender, and isolated pathologies on the risk of development of the two diseases (►**Table 4**). Neither age, gender, nor other pathologies were individually associated with the risk of developing De Quervain disease after CTS treatment. Regarding trigger finger, we observed that for each increase in one year in age, the risk of developing trigger finger increases by 2%. It was not possible to estimate the model for heart disease in the outcome of De Quervain disease, since none of the patients who developed this condition had heart disease.

For each disease, the multiple (multivariate) model was also calculated with age, gender, and pathologies. Considering the outcome of De Quervain disease, no variable remained in the model, that is, age, gender, and pathologies do not individually influence (as seen in ►**Table 4**) the risk of developing this disease after the open release of the transverse carpal ligament, nor if they are present in combination. In the model for trigger finger, after surgery for CTS, the only

Table 4 Cox regression to evaluate the factors associated with De Quervain disease and trigger finger after the surgical treatment for carpal tunnel syndrome

Variable	De Quervain disease			Trigger finger		
	RR	95%CI (RR)	*p*-value	RR	95%CI (RR)	*p*-value
Age	0.98	0.95–1.01	0.240	1.02	1.01–1.04	**0.012**
SAH	0.94	0.45–1.99	0.879	1.38	0.88–2.15	0.159
DM2	0.57	0.17–1.87	0.353	1.17	0.65–2.08	0.600
Obesity	0.52	0.12–2.18	0.371	1.00	0.50–2.01	0.992
Depression	2.28	0.69–7.48	0.175	1.52	0.61–3.76	0.365
Hypothyroidism	0.46	0.11–1.94	0.288	1.06	0.56–2.07	0.856
Dyslipidemia	0.98	0.30–3.21	0.968	1.80	0.98–3.33	0.059
Asthma	2.21	0.53–9.26	0.280	0.42	0.06–2.99	0.382
Fibromyalgia	1.53	0.36–6.42	0.561	0.61	0.15–2.50	0.496
Heart disease		–	–	1.52	0.49–4.84	0.477
Smoking	1.58	0.71–3.50	0.264	0.99	0.56–1.77	0.981
Gender	0.78	0.24–2.62	0.709	1.23	0.65–2.32	0.534

Abbreviations: 95%CI, 95% confidence interval; DM2, type-2 diabetes mellitus; RR, relative risk; SAH, systemic arterial hypertension.

variable that remained was age, that is, the gender of the patient or the fact that they presented any of the pathologies does not increase the risk of developing the disease.

►**Fig. 5** shows the Kaplan-Meier curve with the probability of developing trigger finger after the surgical treatment for CTS over time in two age groups; the groups were separated by the median (50 years), and we observed that the probability of developing this disease was higher in the group of patients older than 50 years.

Discussion

In their study, Hombal and Owen[7] identified an incidence of 22% of trigger finger in patients undergoing carpal tunnel decompression. The mean time until the onset of symptoms was of four to six weeks, with the thumb, ring and middle fingers being the most affected digits. According to these authors, the opening of the transverse carpal ligament enables the flexor tendons to snap back, increasing tension in the proximal pulleys.

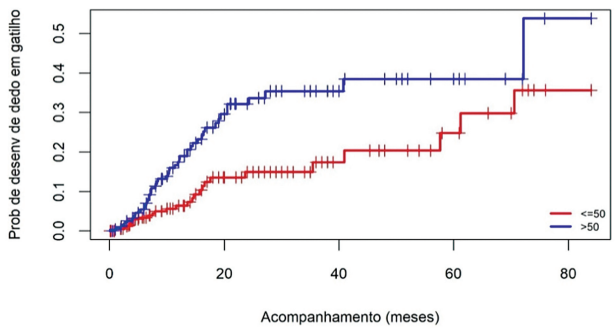


Fig. 5 Kaplan-Meier curve for the probability of developing trigger finger after the surgical treatment for CTS throughout time by age.

Hayashi et al.[8] found a rate of association of 31.7% between the development of trigger finger and the surgical treatment for CTS. The mean time until the occurrence was of 5.6 months, with the thumb being the most affected digit. In this study,[8] the researchers excluded patients with DM, rheumatoid arthritis, and chronic renal failure due to dialysis. According to Goshtasby et al.[9], the incidence of the development of trigger finger in patients with chronic diseases who underwent hand surgery was of 6.3%. The time until onset was of 4 months on average, with the thumb being the most affected digit (48.3%), followed by middle finger and index fingers.

After a systematic review, Lin et al.[2] found the mean prevalence of trigger finger after carpal tunnel release of 8.5%, and an incidence ranging from 5.2% to 31.7%. Added to this, the development of trigger finger can be diagnosed during the evolution of CTS. The time until the diagnosis of trigger finger after carpal tunnel release was of up to six months. The most affected digit was the thumb, with a reported incidence of up to 50%.[10]

For patients previously submitted to the surgical treatment for CTS, in the present study we found a rate compatible with those reported in the literature for the incidence of trigger finger (10.2%), which is approximately 5 times higher than the incidence reported in the literature for non-diabetic patients (2.2%).[11] This discrepancy draws attention to a possible positive correlation between the onset of triggering secondary to the surgical approach.

The mean time until the development observed was longer than previously reported (61.3 months), and the most affected digit was the thumb (47.6%), followed by the middle (24.4%) and ring (8.54%) fingers. Regarding the associations of digits, the most common was between the middle and ring fingers, with an incidence of 6.1%, followed by the thumb and middle finger (3.66%), and the index finger and middle fingers (2.44%).

The only variable that was shown to influence the development of trigger finger after open surgical release of CTS was age ($p = 0.012$). It has been shown that for every one-year increase in age, the risk of developing trigger finger increases by 2%. It is worth questioning whether the increase in this incidence is due to postoperative time or the natural increase in prevalence with aging.

Still within the chronological scope of the question, we observed that the average time until the development of the cases of tenosynovitis was much higher than the average of 13 months of follow-up of the patients evaluated in the present study, which leads us to wonder whether studies with longer follow-ups may yield different results.

In the context of the presence of previous pathologies and the gender of the patient, there was no influence on the development of trigger finger.

Regarding the incidence of De Quervain tendosynovitis after the surgical treatment for CTS, the literature reports a rate of 0.5%. For King et al.,[12] the release of the transverse carpal ligament is not a risk factor for the development of De Quervain tenosynovitis.

The incidence found in the present study for the development of De Quervain disease was of 4.12%, a rate substantially higher than that reported in scientific texts and higher than the overall incidence of the disease (0.5% to 1.3%).[13] The origin of this dissimilarity turns out to be difficult to determine due to the difficulty in identifying patients with tenosynovitis of the first compartment in early stages and those asymptomatic or little symptomatic, who may have undergone treatment for compression in the carpal tunnel without prior knowledge of this comorbidity.

The mean time until the development of this tenosynovitis was of 73.7 months, with no studies in English or Portuguese to make a comparison with this variable.

Conclusion

The incidence of trigger finger after the open surgical release of CTS found (10.2%) was equivalent to the rates already described in the literature, and the incidence found (4.12%) for the development of De Quervain disease under the same conditions was notably higher than that reported in the literature, but with no apparent association between the treatment and the phenomenon.

No relationship was observed involving gender and the comorbidities evaluated for both types of tenosynovitis, with age being the only variable that affected the incidence of trigger finger.

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

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Measurement of Clavicular Symmetry in Healthy Subjects Using Tomographic Database of Public Hospitals*

Mensuração de simetria clavicular em indivíduos saudáveis utilizando-se de banco de dados tomográficos de hospitais públicos

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Abstract

Objective This study aimed to perform an imaging evaluation to prove the existence or not of symmetry between the clavicles of healthy subjects from Curitiba, Paraná, Brazil, and identify potential factors influencing the clavicular length.

Method The study analyzed chest computed tomography (CT) scans of 211 patients with no clavicular fracture or malformations (100 women and 111 men). We measured the greatest clavicular diagonal on both sides, and the software automatically generated the maximum distance in millimeters. Relative and absolute frequencies described qualitative variables and mean values; quantitative variables used a 95% confidence interval. Value comparisons employed the student's t-test, and correlations determinations used Pearson's correlation coefficient. The significance level adopted was 5%.

Results There was a significant difference between the clavicular length (right clavicle, 143.58 mm; left clavicle, 145.72 mm; $p = 0.037$), indicating asymmetry. On average, the left clavicle was 3.71 mm larger. Asymmetry was significant for both men

Keywords
- anatomy, regional
- anthropometry
- clavicle
- tomography

* *Study developed at the Orthopedics and Traumatology Department, Hospital Universitário Evangélico Mackenzie, Curitiba, PR, Brazil.*

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and women ($p < 0.001$). The average difference was 4.13 mm for men and 3.23 mm for women. Seventy-three percent of the sample had < 5 mm of asymmetry, 23.7% had 5 to 10 mm, and 3.3% had > 10 mm of asymmetry.

Conclusion The studied population did not present clavicular symmetry. On average, the left clavicle was longer than the right clavicle, with differences of 3.71 mm in the general sample, 3.23 mm in women, and 4.13 mm in men. The only significant factor was gender since men presented longer clavicles and higher differences than women.

Resumo

Objetivo Realizar avaliação imagiológica com intuito de comprovar a existência ou não de simetria entre as clavículas de indivíduos saudáveis da cidade de Curitiba/PR, aliada à identificação de possíveis fatores de influência no comprimento clavicular.

Método Foram analisadas tomografias computadorizadas de tórax de 211 pacientes sem fratura ou malformações na clavícula (100 mulheres e 111 homens). A maior diagonal clavicular foi medida em ambos os lados e o software gerou automaticamente a máxima distância em milímetros. Foram utilizadas frequências relativas e absolutas para descrever variáveis qualitativas e a média e intervalo de 95% de confiança para as quantitativas. As comparações foram feitas com o teste t de Student e correlações calculadas pelo coeficiente de correlação de Pearson. O nível de significância adotado foi de 5%.

Resultados Verificou-se diferença significativa entre o comprimento das clavículas (direita 143.58mm e esquerda 145.72mm, $p = 0.037$), indicando assimetria. Em média, o lado esquerdo é 3.71mm maior. A assimetria foi significativa tanto para homens quanto para mulheres ($p < 0.001$). A diferença média foi de 4.13mm para homens e 3.23mm para mulheres. 73% da amostra apresentou <5mm de diferença, enquanto 23.7% apresentaram 5-10mm e 3.3% apresentou >10mm de assimetria.

Conclusão Não foi possível encontrar simetria nas clavículas da população de Curitiba/PR. Em média, a clavícula esquerda é maior que a direita, com diferenças de 3.71mm na amostra geral, 3.23mm para mulheres e 4.13mm para homens. O único fator significativo foi o sexo, com homens tendo maiores comprimentos claviculares e maiores diferenças em comparação às mulheres.

Palavras-chave
- anatomia regional
- antropometria
- clavícula
- tomografia

Introduction

The clavicle is the only horizontally oriented long bone in the human body. Researchers have been analyzing clavicular morphology due to a paradigm shift regarding its treatment. The surgical approach is the gold standard in fractures with diastasis that hinder consolidation or deviations that compromise function. In a 2005 meta-analysis with a systematic review of 2,144 fractures, Zlowodziki et al.[1] showed an 86% reduction in the relative risk of pseudarthrosis after primary fixation compared with conservative treatment. A clavicle fracture is a common injury, affecting mainly young, active adults. It accounts for approximately 2.6% of all fractures. The middle third of the clavicle is the most affected region in up to 85% of cases. The current literature does not present absolute indications for surgical treatment, and relative criteria include fragment deviation or shortening higher than 2 cm, comminution, and imminent bone exposure.[2]

Concerning the significance of 'bone shortening' for injury treatment and prognosis, a measurement method for this deviation has not yet been standardized. The two methods most used today are the 'overlapping fragments' method, based on the injured clavicle,[3,4] and the 'length difference' method, based on the length difference to the contralateral clavicle.[5] Thorsmark et al.[6] compared these methods in 2017 and showed that the most reliable technique is 'length difference.' However, these authors also reported an increase in the final length of the injured bone as a postoperative complication. They inferred that the main issue resides in the clavicular length symmetry concept in the same subject, indicating potential methodological errors in both approaches.

In light of the above, we propose to evaluate the validity of the allegations from Thorsmark et al.[6] by performing an imaging assessment to confirm the existence or not of clavicular symmetry in healthy subjects from the city of Curitiba, Paraná, Brazil, and identify potential factors influencing the clavicular length.

Methodology

The study received ethical approval from Plataforma Brasil (CAAE 60958022.8.0000.0103) and the Ethics Committee of Hospital Universitário Evangélico Mackenzie per the

attributions defined in the Brazilian National Health Council (CNS, for its acronym in Portuguese) Resolution n° 466 of 2012 and its complements (opinion n° 5.601.178).

This study used chest computed tomography (CT) scans from a computerized image visualization system for public hospitals. File retrieval occurred from January to December 2020. We downloaded DICOM files for clavicular measurement and allocated them to a database adopting a data anonymization protocol. The inclusion criterion for the collection process was all scans completely covering the clavicles, showing both the lateral and medial joint surfaces. The exclusion criterion was the presence of any evidence of malformation, fractures, or previous surgical procedures in this topography. As such, we included 250 subjects. Next, we reviewed all scans to find collection errors, resulting in a final sample of 211 people, including 111 males and 100 females.

Measurements occurred at the image visualization software DICOM Arya/PACS Aurora (©Pixeon, 2022), version 20.11.0. Using the 3D Ruler tool, an examiner determined the largest diagonal of the clavicle of each subject by demarcating pre-established points, such as the midpoint of the articular surface of the clavicle to the acromioclavicular joint (1) and the midpoint of the joint surface of the clavicle to the sternoclavicular joint (2) on each both sides of axial chest CT scans. The software processed these points and automatically generated the bilateral distance in millimeters (mm) (►**Fig. 1**).

The length difference (LD) between clavicles corresponded to the right clavicle (RC) length minus the left clavicle (LC) length, per the formula LD = RC – LC.

According to this formula, a length difference greater than zero (positive) demonstrates clavicular asymmetry because the right clavicle is longer than the left one; in contrast, a

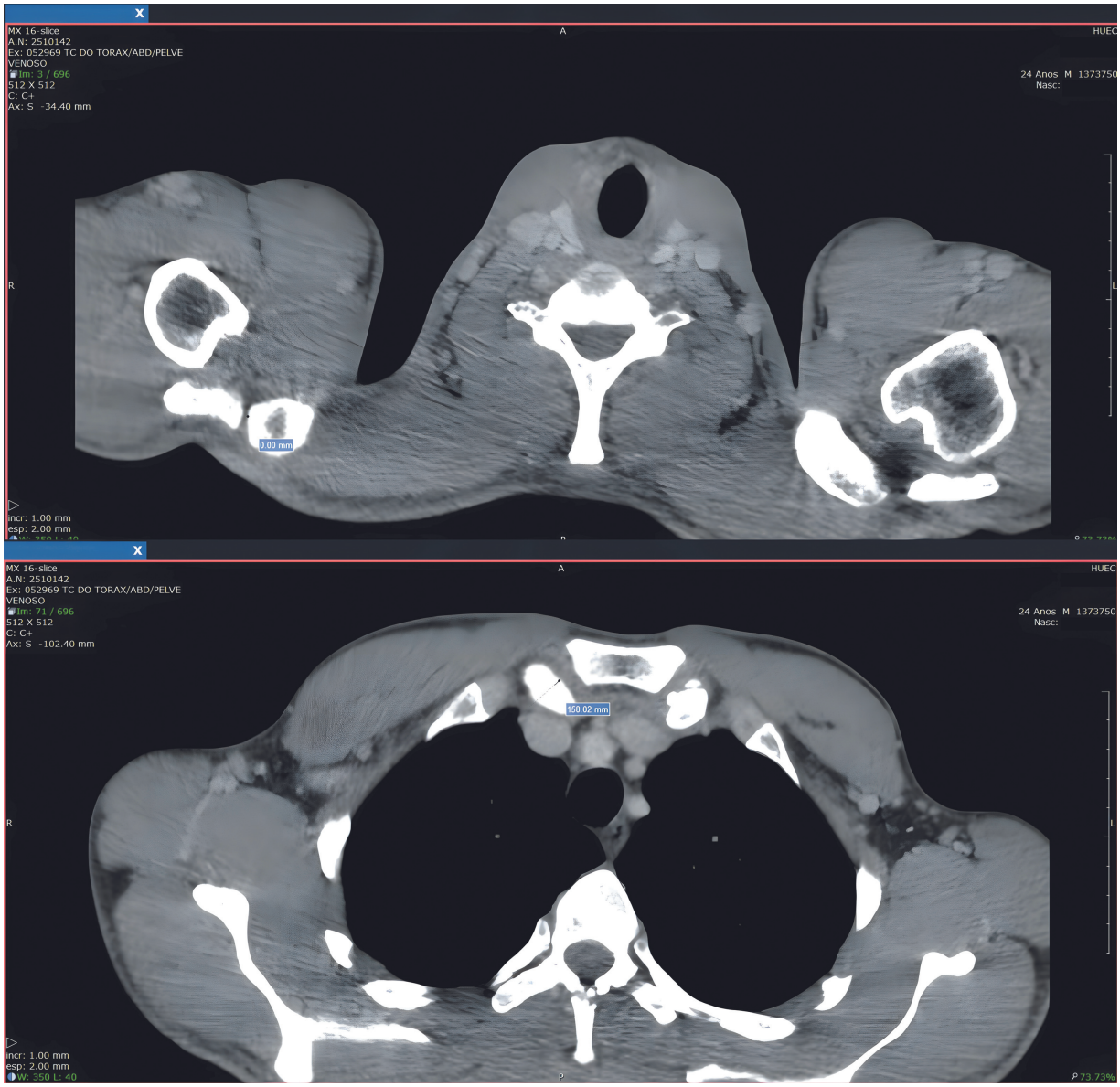


Fig. 1 Demonstration of the DICOM Arya/PACS Aurora software (©Pixeon, 2022) and the method for clavicular length measuring with the '3D Ruler' tool. The upper panel identifies the midpoint of the joint face of the clavicle to the acromioclavicular joint (Point 1). The lower panel shows the midpoint of the joint face of the clavicle to the sternoclavicular joint (Point 2).

difference smaller than zero (negative) indicates the opposite. The variable considering positive/negative values was called the 'normal difference'. It helped to determine the laterality of the asymmetry, if any. To assess the actual asymmetry, we created a quantitative variable called 'absolute difference', which does not consider the positivity/negativity of the number, only its value.

The R software (©The R Foundation, 2022) performed the following analysis. Qualitative variables (gender) analysis employed relative and absolute frequencies. Quantitative variables (age, clavicle measurement, measurements differences, and absolute differences between measurements) analysis used mean values and 95% confidence intervals. Quantitative variables comparisons employed Student's t-tests. Age correlation determinations used Pearson's correlation coefficient.

All analyses considered a 5% significance level.

A Student's t-test for paired samples compared measurements from both sides within the same subject. A Student's t-test for independent samples compared measurements between genders.

Model adjustments considered age and gender as explanatory variables for clavicle measurement. In addition, we created an identifier to indicate if the values referred to the left or right clavicle.

Results

Descriptive and Comparative Analysis

Our data indicate that, regardless of gender, our sample presented an average length of 143.58 mm for the right clavicle and 145.72 mm for the left clavicle. The mean length difference was statistically significant ($p < 0.001$).

A 'normal' difference lower than zero (-2.15) indicates that, on average, the left clavicle was longer than the right clavicle. The 'absolute' difference showed an average distance between clavicles of 3.71 mm in healthy subjects, regardless of gender.

Considering gender differences, both females and males had negative 'normal' differences between the clavicles (females = -1.63 / males = -2.61). These differences indicated that the left clavicle is longer than the right clavicle in both genders. The mean 'absolute' difference was 3.23 mm for women and 4.13 mm for men ($p < 0.001$).

Lastly, when grouping the subjects per the amount (in mm) of absolute difference between clavicles, most (73%) present less than 5 mm of difference between these bones. However, it is worth noting that 27% of the sample had an absolute difference above 5 mm, and 3.3% had a difference greater than 10 mm (►**Table 1**).

Correlations

We calculated the Pearson's correlation coefficients between age and left and right clavicle measurements separately for both genders and disregarding the separation between them. There was no significance for the calculated correlation values, indicating the lack of association between patient age and clavicle measurements (►**Table 2**).

Model Analysis and Adjustment

The descriptive analysis reveals a difference between the measures of the left and right clavicle; the left clavicle tends

Table 1 Summary of the descriptive and comparative analysis of the study

Variables			Observations	Proportion	Mean value (95% CI)	p-value
Gender	Female		100	47.4%	–	–
	Male		111	52.6%	–	–
Age			211	100.0%	54 (17; 91)	–
Clavicle measurement	Right		211	50.0%	143.58 (123.40; 163.76)	**0.037**
	Left			50.0%	145.72 (124.59; 166.86)	
	Female gender	Right	100	50.0%	136.77 (122.62; 150.93)	0.116
		Left		50.0%	138.40 (124.03; 152.77)	
	Male	Right	111	50.0%	149.71 (132.69; 166.73)	**0.029**
		Left		50.0%	152.32 (134.70; 169.95)	
Difference between clavicle measurements		General	211	100.0%	-2.15(-2.54; -1.75)	<**0.001**
		Female gender		47.4%	-1.63(-2.15; -1.10)	**0.013**
		Male gender		52.6%	-2.61(-3.20; -2.03)	
Absolute difference between clavicle measurements		General	211	100.0%	3.71 (3.44; 3.97)	<**0.001**
		Female gender		47.4%	3.23 (2.89; 3.58)	<**0.001**
		Male gender		52.6%	4.13 (3.74; 4.53)	
Grouping of the absolute difference between clavicle measurements		< 5 mm	154	73.0%		
		5 mm to 10 mm	50	23.7%		
		> 10 mm	7	3.3%		

CI 95%, 95% confidence interval

Table 2 Pearson's correlation coefficients between age and clavicle measurements in general and per gender

	Measurement (right clavicle)	Measurement (left clavicle)
Age	-0.009 (p = 0.895)	-0.019 (p = 0.787)
Age (female gender)	-0.119 (p = 0.239)	-0.058 (p = 0.567)
Age (male gender)	0.024 (p = 0.800)	0.017 (p = 0.863)

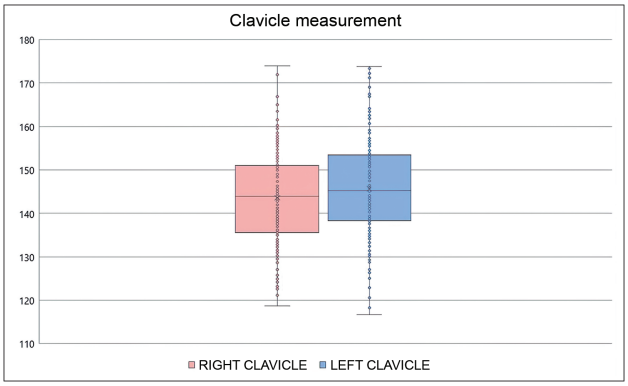


Fig. 2 Boxplot demonstrating the variation of clavicular measurements regarding the right or left side, indicating a greater length of the left clavicle compared with the contralateral one.

to be longer. In addition, the extreme values from the left side can be higher compared with the right side (►**Fig. 2**).

Regarding gender, male subjects had higher absolute length measurements than their female counterparts (►**Fig. 3**).

Moreover, there was a value dispersion between the left and right clavicle measurements in subjects from all age groups, with no indication of an association between variables (►**Fig. 4**).

As for model adjustment, given the laterality effect, we estimated a 2.15-mm increase in the mean size of the left clavicle compared with the right clavicle. Regarding gender, we inferred an increment of 13.43 mm in the average clavicle length in males compared with females (►**Table 3**).

The estimated age effect showed that a mean length difference of −0.1 mm (0.1 mm decrease) per year but with no statistical significance.

Next, we noticed the behavior of the values predicted by the model, which we adjusted per the observed covariates and the clavicle measurements. The behavior without large deviations from the main diagonal indicates a good model adjustment (►**Fig. 5**).

Discussion

Clavicle shortening is one of the most significant surgical criteria for fractures; the size of the contralateral clavicle is often used to plan the approach.[2] In an article published in 2006, Lazarides e Zafiropoulos[5] stated that, after evaluating 132 patients undergoing conservative treatment for clavicle fracture, shortening resulting from the union without

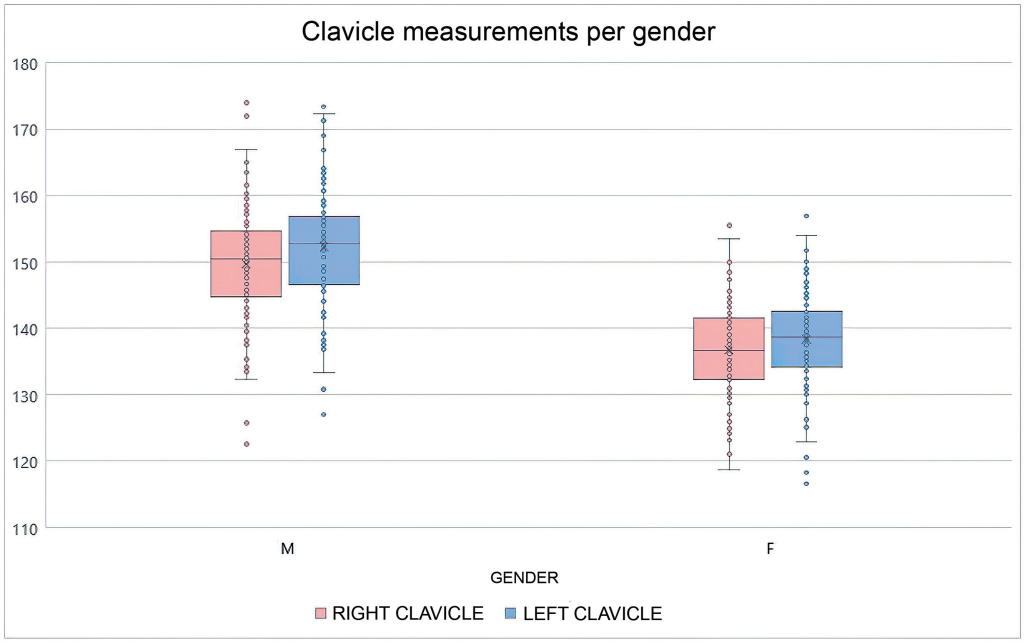


Fig. 3 Boxplot showing the range of clavicular measurements per gender, indicating longer clavicles in males than females and a longer left clavicle compared with the right clavicle.

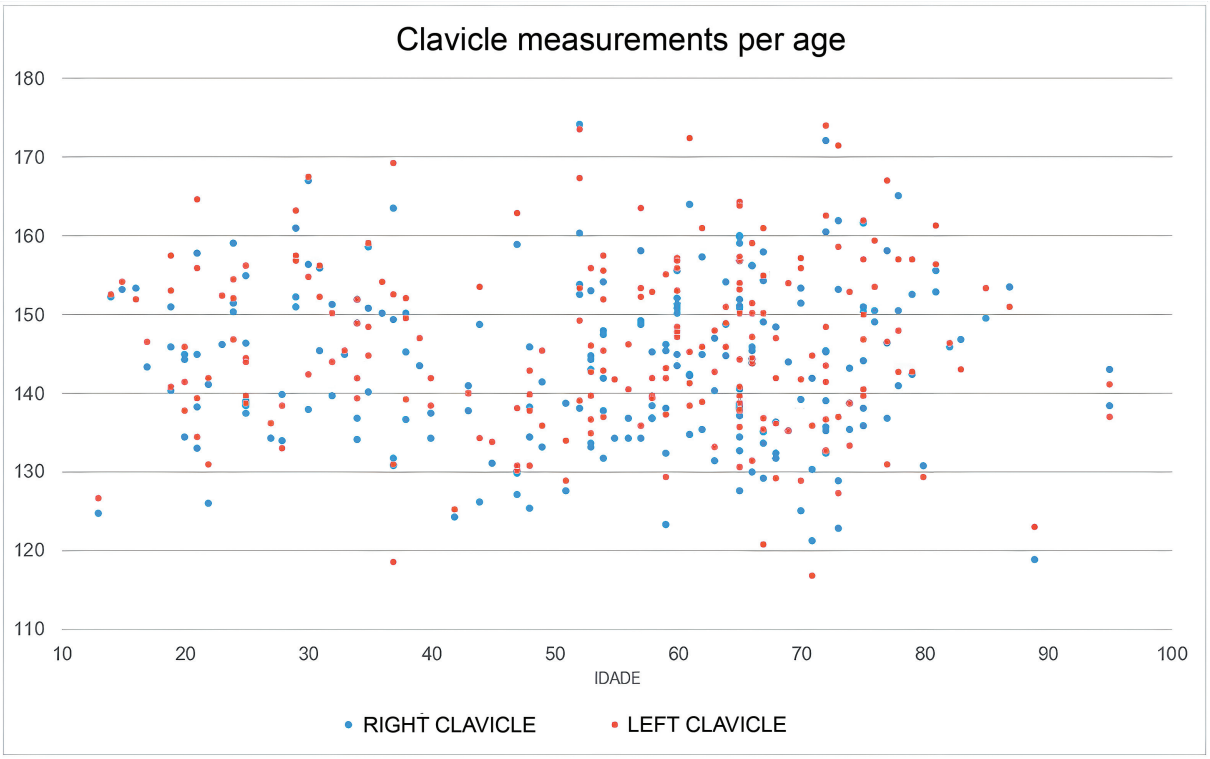


Fig. 4 The scatterplot shows data dispersion indicating the lack of association between age and clavicular length.

Table 3 Summary of the fixed effects and their statistical significances

Fixed effects	Parameters	Coefficients	95% CI	p-value
	Intercept	137.049	(133.616;140.482)	<0.001
	(Left) clavicle	2.145	(1.585;2.706)	<**0.001**
	Age	-0.100	(-0.066;0.046)	0.730
	Gender (male)	13.432	(11.288;15.756)	<**0.001**

CI 95%, 95% confidence interval

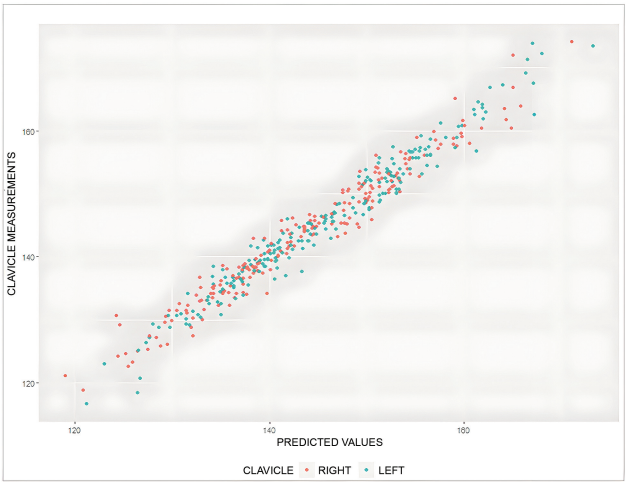


Fig. 5 The distribution of observed and predicted values reveals a good model adjustment.

intervention above 14 mm for women and 18 mm for men led to unfavorable evolution and dissatisfaction with the outcome.

These findings emphasize the critical role of applying a method to maximize satisfactory outcomes for clavicle fractures. Therefore, it is crucial to infer the presence or absence of clavicular symmetry in healthy subjects, allowing the safe use of these data to define the proposed treatment.

Hoogervorst et al.[7] used a methodology equivalent to ours to infer the existence of clavicular symmetry. Their study assessed 100 subjects (42% males and 58% females), revealing a significant difference between clavicle sizes and a mean length difference of 0.88 mm (-2.47 mm – +4.48 mm). The authors selected patients with a mean age of 55.5 years, founding that the right clavicle was, on average, 1.79 mm smaller than the contralateral one and that the mean absolute length difference was 3.74 mm. Thirty percent of the evaluated sample presented at least 5 mm in the absolute

difference between the clavicles (28% between 5 and 10 mm and 2% > 10 mm). In addition, they reported that gender is a determinant factor for the absolute size of the clavicles, with men having longer bones.

In 2013, another similar study by Cunningham et al.[8] evaluated 102 subjects (39.2% males and 60.8% females) with a mean age of 53.6 years old.

This study also showed similar results, with a mean length difference of 4.25 ± 3.8 mm. The authors reported that the discrepancy was < 5 mm in 71.5% of the evaluated subjects, from 5 to 10 mm in 21.5%, and > 10 mm in 7% of the sample. As such, 28.5% of the subjects presented a length variation > 5 mm.

In contrast to the previous study and observations in the Brazilian population, Cunningham et al.[8] did not find a statistically significant relationship between the patient's gender and clavicular length.

In parallel with our data, there is a statistical equivalence when comparing Brazilian findings and the reported studies, showing that results remain similar even when doubling the sample size (100 vs. 102 vs. 211). This similarity indicates that such equivalence persists even when comparing populations from different continents (Americas x Europe), corroborating the findings. Here, we emphasize the crucial role of the heterogeneity of the Brazilian population. In addition, it is necessary to expand this type of evaluation to other regions to assess the existence of morphological differences resulting from populational characteristics and confirm the maintenance of this similarity.

The analysis of the literature data and their comparison with ours highlights the evidence of clavicular asymmetry in the Brazilian population as in other samples; the mean difference between clavicular dimensions ranged from 0.88 to 4.25 mm, with the right clavicle comparatively smaller than the left clavicle in two out of the three studies. Cunningham et al.[8] reported a significant correlation between the patient's dominant side and a shorter clavicular length, but this information requires further studies for corroboration.

In 2016, Sehrawat and Pathak[9] highlighted the importance of this topic in the forensic literature, considering the clavicular anthropometric evaluation as a robust tool to infer gender in unidentifiable remains and listing several papers on clavicular length assessment presenting the same asymmetry pointed out by the orthopedic literature. The authors stated that the determinism of this asymmetry is multifactorial and due to genetic factors, intrauterine development, hormonal influences, socioenvironmental factors, and physical activity. However, they said that the asymmetry resulting from dominance did not constitute a factor for reliable determination in post-mortem forensic analysis.

Thus, we observed that the lack of information about the dominance of the evaluated patients is a limitation in our study. We recommend introducing this data in future studies with the Brazilian population to better structure the potential influence of this variable.

Our data may indicate a potential methodological error in the decision-making algorithm regarding conservative versus surgical treatment based on clavicular symmetry and using length difference as a reference. This error could be even more significant in the male population, which presented the highest mean values of comparative difference. This makes it even more difficult to assess the 'symmetry' factor as decisive in the orthopedic management of clavicle fractures.

This study aimed to form a database for developments regarding clavicular symmetry assessment, either using larger samples to corroborate our findings or evaluating additional data that may influence the asymmetry (such as the assessment of the dominant limb performed by Hoogervorst et al.[7])

By bringing these results to the debate, we expect to discuss the methods used to measure symmetry and clavicular shortening and the usefulness and practical effectiveness of algorithms for patient treatment. With this, we wish to enable better decision-making so that the expected outcome of clavicle fractures is as satisfactory as possible.

Conclusion

Our findings show that it is not possible to infer the anatomical symmetry between the bone structures of the clavicles within a single subject in the population from Curitiba, Paraná, Brazil. The average clavicle length difference was 3.71 mm in the general sample, 3.23 mm in females, and 4.13 mm in males. Furthermore, the discrepancy was at least 5 mm in 27% and greater than 10 mm in 3.3% of the subjects.

The only factor with a statistically significant influence contributing to this disparity was gender since males presented the highest absolute values of clavicular length and higher length differences than females.

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Conflict of Interests
The authors declare no conflict of interests.

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Is Shoulder Imbalance a Useful Parameter in the Screening of Idiopathic Scoliosis? A Preliminary Study*

O desequilíbrio do ombro é um parâmetro útil na triagem da escoliose idiopática? Um estudo preliminar

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Abstract

Objective The present study aims to analyze the use of shoulder imbalance as a parameter for scoliosis screening as well as its relationship with other parameters of physical examination.

Methods This study assesses a smartphone application that analyzes several parameters of the physical examination in adolescent idiopathic scoliosis. Medical and non-medical examiners applied the screening tool in students in a public school and in a private sports club. After data collection, interobserver correlation was done to verify shoulder imbalance and to compare shoulder imbalance with Adam's bending test and with trunk rotation.

Results Eighty-nine participants were examined, 18 of whom were women and 71 of whom were men. Two subjects were excluded from the analysis. The mean age of subjects from the public school was 11.30 years and, for those from the sports club, it was 11.92 years. The examiners had poor-to-slight interobserver concordance on shoulder asymmetry in the anterior and posterior view. No significant statistical correlation was found between shoulder asymmetry and positive Adam's forward bending test.

Keywords
- congenital abnormalities
- public health
- spine
- scoliosis
- mass screening

* *Study conducted at the Hospital Mater Dei, Belo Horizonte, Minas Gerais, Brazil.*

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Conclusion Our preliminary study shows that the shoulder asymmetry has a poor correlation with the Adam's forward bending test and measuring trunk rotation using a scoliometer. Therefore, the use of shoulder imbalance might not be useful for idiopathic scoliosis screening.
Level of Evidence III; Diagnostic Study

Resumo

Objetivo O objetivo deste estudo é analisar o uso da assimetria de ombros como parâmetro para a triagem de escoliose e sua relação a outros parâmetros do exame físico.
Métodos Este estudo avalia um aplicativo para *smartphone* que analisa diversos parâmetros do exame físico de adolescentes com escoliose idiopática. Examinadores médicos e não médicos utilizaram o instrumento de triagem em alunos de uma escola pública e de um clube esportivo privado. Após a coleta de dados, a correlação interobservador foi determinada para verificar a assimetria de ombros e compará-la ao teste de inclinação de Adam e à medição de rotação do tronco.
Resultados Oitenta e nove participantes foram examinados, sendo 18 do sexo feminino e 71 do sexo masculino. Dois indivíduos foram excluídos da análise. A média de idade dos participantes da escola pública foi de 11,30 anos e do clube esportivo, 11,92 anos. Os examinadores apresentaram concordância interobservador baixa a branda quanto à assimetria de ombros em incidência anterior e posterior. Não houve correlação estatística significativa entre a assimetria de ombros e o resultado positivo no teste de inclinação do tronco de Adam.
Conclusão Nosso estudo preliminar mostra que a assimetria de ombros tem baixa correlação com o teste de inclinação de Adam e assim como com a medição de rotação do tronco com escoliômetro. Portanto, o uso da assimetria de ombros pode não ser útil na triagem da escoliose idiopática.
Nível de Evidência III; Estudo Diagnóstico

Palavras-chave
- anormalidades congênitas
- saúde pública
- coluna vertebral
- escoliose
- programas de rastreamento

Introduction

Adolescent idiopathic scoliosis (AIS) is a structural, lateral, rotated curvature of the spine that arises in otherwise healthy children at or around puberty.[1] It is the most common spinal disorder in adolescents, with a prevalence of 1 to 4%.[2] Early diagnosis of scoliosis allows timely treatment of the condition in its initial stages, avoiding surgical treatment and deformity progression.[3] Consequently, scoliosis screening has been advocated for early detection of reversible spinal curves before their progression.[4]

The screening of idiopathic scoliosis is widely discussed in the medical literature.[5] It involves different types of assessment methods, including visual inspection, forward bending tests, scoliometer measurements, and individual Moiré topography, which are straight forward and easily accessible.[6] The main findings of scoliosis on physical examination are asymmetry of the shoulders, scapulae, pelvis, trunk, and ribcage.[3] The Adam's forward bend test is used to assess the presence of a hump and quantify the lateral curvature; it is considered essential for the screening of scoliosis in schools.[1,7,8] In Hong Kong, Netherlands and Singapore, countries with strong scoliosis screening programs, the most frequent parameter are the Adam's forward bending test and the measuring of trunk rotation using a scoliometer.[5,9,10]

Among all parameters on physical examination, shoulder imbalance has received a great deal of attention among spine surgeons and researches alike.[11,12] The normal healthy population is considered to have level shoulders.[13] In any measured biological parameter, it is of prime importance that the variability of what is classified as 'normal' is known, especially if surgery is planned to correct that parameter from what is judged as 'abnormal' back to being 'normal'.[14] In an attempt to define what is normal, Kuklo et al.[11] proposed shoulder balance as a lower than 1 cm side-to-side difference between the shoulders on clinical examination in adolescent idiopathic scoliosis patients.

The deficiencies of the traditional assessment methods for screening scoliosis remain unresolved.[15] Regardless, an even more effective method is still crucial for reducing morbidities associated with scoliosis. The present study aims to analyze the use of shoulder imbalance as a parameter for scoliosis screening and its relationship with other parameters of physical examination.

Methods

Type of Study

We performed a cross-sectional study to assess idiopathic scoliosis among students aged 8 to 17 years in a public and a private school as well as in an athletic club.

The project was approved by the ethics committee (CAAE 07926919.5.0000.5128. The confidentiality and privacy of the patients will be guaranteed throughout all stages of the study, according to the principles of medical ethics.

Eligibility Criteria

Inclusion Criteria

1. Students at a public school, a private school, and members of an athletic club, aged 8 to 17 years, who accepted to participate willingly in the study and signed an informed consent document were included in the present study. The participants' guardians also needed to sign an informed consent form.

Exclusion Criteria

1. Previous spine surgery.
2. Previous diagnosis and treatment of scoliosis.
3. Diseases of the nervous system that compromise ambulation.
4. Understanding or cognitive problems.

Sample Size Calculation

The posthoc sample size calculation was done using the software R utilizing the Cohen Kappa coefficient (IRR) with a concordance level of 5% and a confidence interval of 95%. Considering the shoulder imbalance parameter in frontal and posterior view and the comparison of each examiner, the average number of participants was 74 (minimum 62 and maximum 87).

Study Locations

The locations were selected based on those that were the most representative of the sample: a public municipal school and a private athletic club. The data was first collected in the public school. Due to bureaucratic difficulties in the public school and also to have a more heterogeneous sample, we extended the locations to the athletic club and to a private school. In these two locations, we had a more controlled environment. In the sport club, we started the survey with the boys, all basketball players, but before we could enroll the female group in the analysis, we had to interrupt our study because of the coronavirus disease 2019 (COVID-19) pandemic. We could not evaluate the students at the private school for the same reason.

Selection and Training of Examiners

The examiners were selected aiming to include at least one examiner who was experienced in the evaluation of individuals with adolescent idiopathic scoliosis (gold-standard examiner), one orthopedist specialized in spinal surgery (inexperienced medical examiner), and one non-medical examiner.

The examiners were trained for this activity and supervised by the main researcher specialized in scoliosis. The team of examiners was composed of one orthopedist specialized in spinal surgery (ExL), one surgical instrument technician (Ex1), and one orthopedist in the 1st year of training in spinal surgery (Ex2).

Description of the Application

The children and adolescents were evaluated by the Scoliosis Screen mobile app, available for iOS or Android (see electronic attachment: https://youtu.be/fs3aNbNf404). The application was developed at our university and is available in the Brazilian Apple and Google stores. The evaluators were trained to use the software app and its tutorials.

Analyzed Variables

The application assesses the following variables: head, shoulder, waist, ribcage, and pelvic asymmetry in anterior and posterior view, the presence of kyphosis and of a hump (Adam's test); and, finally, the measurement of upper, mid, and lower thoracic scoliosis using the scoliometer (included in the sequence of evaluation utilizing the smartphone accelerometer). The interobserver correlation of these variables between the examiners was analyzed as well as the correlation of shoulder imbalance with the Adam's test, scoliometer measure, and presence of a hump. The definition of shoulder imbalance was visual, as seen in ►**Figs. 1** and **2**.

Phases of the Evaluation

The examination of each subject was conducted by two alternate examiners in the following manner: - Ex1–ExL; Ex1–Ex2. The subjects wore a short-sleeved T-shirt and shorts or a jersey jacket. The examination was conducted



Fig. 1 Shoulder asymmetry parameter in posterior view.

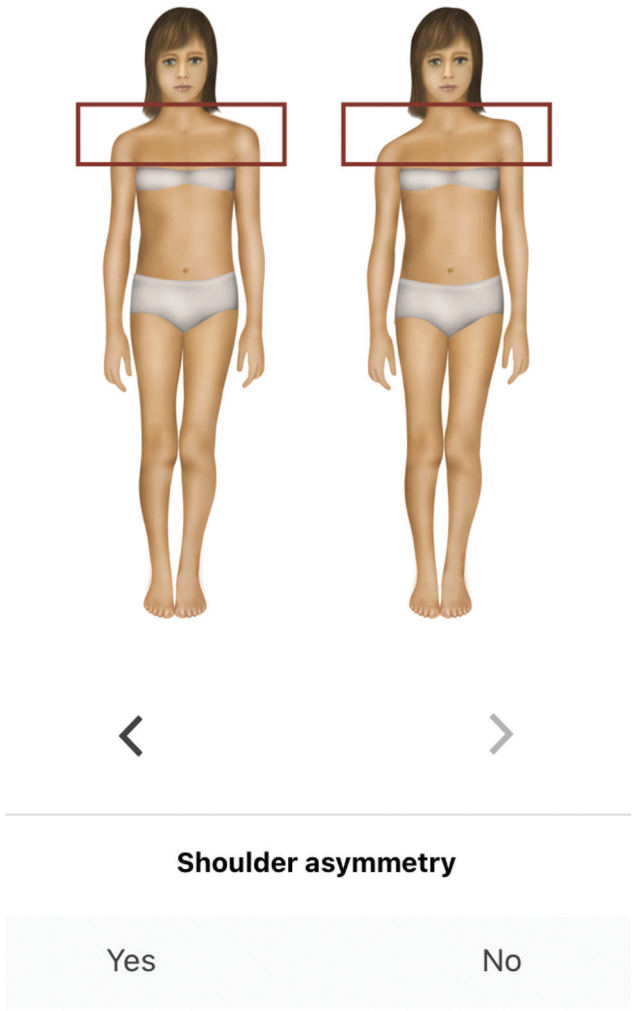


Fig. 2 Shoulder asymmetry parameter in anterior view.

in a reserved and quiet environment. The subjects who presented with positive Adam's test, shoulder asymmetry, and a reading superior to 2° on the scoliometer were invited to attend a free consultation with the leading researcher. This clinical criterion was chosen to assess the use of shoulder imbalance as a parameter for further investigation. The leading researcher receives an email from the application whenever the alterations are detected and sends a letter to the guardians inviting them to the specialized medical consultation.

Statistical Analysis

The data collected were initially entered into an Excel spreadsheet (Microsoft Corp., Redmond, WA, USA) spreadsheet and subsequently analyzed using the IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA) statistical package. The normality of the continuous data was assessed using the Shapiro-Wilk test. The anthropometric data were expressed as means, standard deviations, medians, and minimum and maximum values. The changes observed on physical examination were presented in contingency tables and expressed as absolute (n) and relative (%) frequencies. The agreement between the researcher and the examiner was assessed with the Kappa test. The level of significance was set at 5% ($p < 0.05$) in all analyses.

Table 1 Description of age and anthropometric profile of the adolescents from the public school by different examiners

	Mean	SD	Median	Minimum	Maximum
Age of the adolescent (years)	11.3	1.5	11.0	9.0	16.0
Weight (kg)	39.0	8.5	38.0	23.0	57.00
Height (cm)	150.0	10.0	152.0	130.0	163.0
BMI	17.9	2.2	17.5	14.3	21.6

Abbreviations: BMI, body mass index; SD, standard deviation

Results

Anthropometric Data

The data were collected between August and December 2019. The number of participants was 89. Of these, 18 were women and 71 were men. Two subjects were excluded from the analysis, namely one subject who had already been diagnosed with neuromuscular scoliosis and one with adolescent idiopathic scoliosis under medical monitoring. The mean age of subjects from the public school was 11.3 years, the mean weight 39,0 Kg, the mean height 1,5 meters, and a BMI (body mass index) of 17,9 (►**Table 1**). In the athletic club, the mean age was 11.92 years, the mean weight 61,2 Kg, the mean height 1,71 meters, and a mean BMI of 20,3 (►**Table 2**).

Interobserver and Parameters Correlations

The ExL evaluated 54 individuals and referred 11 for re-assessment. Nine of these had shoulder asymmetry and 2 had a curvature with a rotation > 2°. The Ex1 evaluated 87 individuals and referred 24 for re-assessment. Twenty-four of these had shoulder asymmetry, 5 had a hump, and 5 had changes in the scoliometer readings. The Ex2 evaluated 33 individuals and referred 11 of these, all with shoulder asymmetry. The ExL and Ex1 achieved poor concordance in shoulder asymmetry in anterior and posterior view and had slight agreement in posterior shoulder asymmetry, but poor concordance in anterior shoulder imbalance. ►**Tables 3** and **4** show

Table 2 Description of age and anthropometric profile of the adolescents from the athletic club by different examiners

	Mean	SD	Median	Minimum	Maximum
Age of the adolescent (years)	11.9	1.4	12.0	8.0	14.0
Weight (kg)	61.2	19.1	56.0	34.0	99.0
Height (cm)	171.0	13.0	171.0	147.0	191.0
BMI	20.3	4.2	19.8	15.5	30.3

Abbreviations: BMI, body mass index; SD, standard deviation

Table 3 Analysis of the agreement on shoulder asymmetry in posterior and anterior view between the examiners ExL and Ex1

	ExL n (%)	Ex1 n (%)	Total	*Kappa*	*P-value*
Shoulder asymmetry (posterior)	9 (16.7)	12 (22.2)	21 (19.4)	0.0	1.00
Shoulder asymmetry (anterior)	14 (25.9)	13 (24.1)	27 (25.0)	0.16	0.23

Abbreviations: %, relative frequency; Ex1, examiner surgical instrument technician; ExL, examiner orthopedist specializing in spine surgery; *Kappa,* Kappa test; n, absolute frequency; na, not applicable

Table 4 Analysis of the agreement on shoulder asymmetry in posterior and anterior view between the examiners Ex1 and Ex2

	Ex1 n (%)	Ex2 n (%)	Total	*Kappa*	*P-value*
Shoulder asymmetry (posterior)	11 (33.3)	11 (33.3)	22 (33.3)	0.32	0.06
Shoulder asymmetry (anterior)	12 (36.4)	8 (24.2)	20 (30.3)	0.15	0.35

Abbreviations: %, relative frequency; Ex1, examiner surgical instrument technician; Ex2 orthopedist in the first year of training in spine surgery; *Kappa,* Kappa test; n, absolute frequency.

the analysis of the agreement on shoulder asymmetry in posterior and anterior view between the examiners.

The parameters that were found to have significant statistic association with shoulder asymmetry in posterior view, between ExL and Ex1, are waist and pelvis (posterior and frontal), ribcage (frontal) and shoulder frontal asymmetry. Between Ex1 and Ex2, the parameters that were found to have significant statistic association with shoulder asymmetry in posterior view are scapular, waist (anterior and posterior), pelvis (anterior and posterior), frontal ribcage, and shoulder anterior asymmetry and increased kyphosis. ►**Tables 5** and **6** show the analysis of comparison between shoulder asymmetry and other changes in physical examination.

►**Table 7** shows the relation between the presence of hump and shoulder asymmetry in frontal and posterior view. No significant statistical correlation between the parameters was found.

Discussion

Shoulder asymmetry is a common parameter used in the clinical evaluation of adolescent idiopathic scoliosis. Our findings show that shoulder asymmetry has a poor-to-slight interobserver correlation. We also did not find a strong association between the presence of a hump and shoulder imbalance. However, the presence of a hump had a strong

Table 5 Results of the comparison between shoulder asymmetry (posterior) and the other changes on physical examination

	Shoulder asymmetry n (%)		*P-value**
	No	Yes	
Head asymmetry (posterior)	0 (0.0)	0 (0.0)	na
Scapular asymmetry (posterior)	9 (10.3)	10 (47.6)	< 0.001
Waist asymmetry (posterior)	9 (10.3)	10 (47.6)	< 0.001
Pelvic asymmetry (posterior)	9 (10.3)	8 (38.1)	0.002
Increased kyphosis	7 (8.0)	3 (14.3)	0.37
Reduced kyphosis	9 (10.3)	4 (19.0)	0.27
Increased lordosis	16 (18.4)	5 (23.8)	0.57
Reduced lordosis	5 (5.7)	0 (0.0)	0.26
Head asymmetry (anterior)	0 (0.0)	1 (4.8)	0.04
Shoulder asymmetry (anterior)	15 (17.2)	12 (57.1)	< 0.001
Ribcage asymmetry (anterior)	4 (4.6)	4 (19.0)	0.02
Waist asymmetry (anterior)	11 (12.6)	9 (42.9)	0.001
Pelvic asymmetry (anterior)	10 (11.5)	9 (42.9)	0.001
Upper thoracic scoliometer	2 (2.3)	1 (4.8)	0.53
Mid-thoracic scoliometer	2 (2.3)	1 (4.8)	0.53
Lower thoracic scoliometer	3 (3.4)	1 (4.8)	0.77

Abbreviations: %, relative frequency; *Chi-squared test; n, absolute frequency; na, not applicable.

Table 6 Results of the comparison between shoulder asymmetry (posterior) and the other changes on physical examination among Ex1 and Ex2

	Shoulder asymmetry n (%)		*P-value*[*]
	No	Yes	
Head asymmetry (posterior)	0 (0.0)	1 (4.5)	0.15
Scapular asymmetry (posterior)	6 (13.6)	13 (59.1)	< 0.001
Waist asymmetry (posterior)	6 (13.6)	11 (50.0)	0.001
Pelvic asymmetry (posterior)	6 (13.6)	8 (36.4)	0.03
Increased kyphosis	5 (11.4)	7 (31.8)	0.04
Reduced kyphosis	2 (4.5)	0 (0.0)	0.31
Increased lordosis	9 (20.5)	7 (31.8)	0.31
Reduced lordosis	2 (4.5)	1 (4.5)	1.00
Presence of hump (anterior)	0 (0.0)	1 (4.5)	0.15
Head asymmetry (anterior)	0 (0.0)	1 (4.5)	0.15
Shoulder asymmetry (anterior)	5 (11.4)	15 (68.2)	< 0.001
Ribcage asymmetry (anterior)	4 (9.1)	10 (45.5)	0.001
Waist asymmetry (anterior)	10 (22.7)	15 (68.2)	< 0.001
Pelvic asymmetry (anterior)	11 (25.0)	13 (59.1)	0.007

Abbreviations: %, relative frequency; [*]Chi-squared test; n, absolute frequency.

Table 7 Results of the comparison between presence of hump and shoulder asymmetry in posterior and anterior view

	Presence of hump n (%)		*P-value*[*]
	No	Yes	
Shoulder asymmetry (posterior)	20 (19.6)	1 (16.7)	0.86
Shoulder asymmetry (frontal)	25 (24.5)	2 (33.3)	0.62

Abbreviations: %, relative frequency; [*]Chi-squared test; n, absolute frequency.

correlation with trunk asymmetry—scapular (posterior), waist and pelvis (posterior and frontal), ribcage (frontal), and shoulder frontal asymmetry.

The Adam's forward bend test is considered essential for the screening of scoliosis in schools.[1,7,8] In Hong Kong, Netherlands and Singapore, countries with a strong scoliosis screening program, the most frequent parameters are the Adam's forward bending test and the measurement of trunk rotation using a scoliometer.[5,9,10] However, Fong et al.[5] demonstrated that screening performed using only Adam's forward bend test is insufficient and results in a high rate of false positives. It is necessary to add other parameters to increase the quality of scoliosis screening. The combination of the scoliometer, Adam's forward bend test, and Moiré topography has a sensitivity and specificity close to 94% and 99%, respectively.[15] Even so, Moiré topography is not a widely used tool, and its application is restricted to a few centers.

Our study aims to evaluate the other physical parameters for scoliosis screening. We had a greater number of pupils with shoulder asymmetry than with positive result in the Adam's test. This parameter needs an outpatient clinic's assessment to be validated. The subjects still need the next step of the evaluation with a specialized medical consultation and radiological images.

An important point is the definition of what constitutes shoulder asymmetry. Kuklo et al.[11] proposed shoulder symmetry as a side-to-side difference of less than 1 cm between the shoulders on clinical examination in adolescent idiopathic scoliosis patients. However, the study was done in patients with the diagnosis of scoliosis. Gardner et al.[14] demonstrated that a degree of asymmetry in shoulder and torso is also seen in a group of children and adolescents who do not have scoliosis. Akel et al.[13] demonstrated that healthy adolescents may have a difference of up to 27 mm between their shoulders without a change in their body image perception.

The difficulty in defining what is, in fact, shoulder asymmetry may be the cause of the low rate of interobserver concordance in our study. In our analysis, shoulder asymmetry was based on a visual observation of the patient comparing with an image of the application (►**Figs. 1** and **2**). The definition of shoulder asymmetry was subjective. Because of that, we found that an improvement of our application was needed to have a better concordance between the observers.

We did not find a significant difference in the prevalence of shoulder asymmetry between the school group and the athletic club group. The athletes analyzed in our study were all basketball players. Basketball is a sport that involves symmetrical effect on muscle structure. However, when first starting in the sport, the predominant use of the dominant side could lead to hypertrophy of the muscles involved. Despite that, our study did not show any difference between the groups.

The difficulty of data collection was one of the study's limitations. There was also greater difficulty because of COVID-19. Since this is a screening study, our sample is still not sufficiently representative, and another study will be required for further assessment and interpretation of the data.

The quality of the comparative analysis will improve once we obtain the data from the paired comparison between the leading examiner and other non-medical examiners (considering that the data collected so far were provided by only one non-medical examiner). It is important to analyze the results of the physical examination and X-ray after referral of individuals in whom the application showed alterations to a specialist. We will, then, be able to validate or not the use of shoulder imbalance as a useful parameter in the screening method.

Conclusion

In conclusion, screening for idiopathic scoliosis is a public health concern. Our preliminary study showed a poor correlation between shoulder asymmetry, Adam's forward bending test, and measurement of trunk rotation using a scoliometer. Therefore, the use of shoulder imbalance might not be useful for scoliosis screening. However, this is a preliminary study, and the referred subjects still need the next step of the evaluation with a specialized medical consultation and radiological images.

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

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Modified Dunn Technique for Unstable Slipped Capital Femoral Epiphysis: A Midterm Single Center Experience*

Técnica de Dunn modificada no escorregamento da epífise femoral proximal com instabilidade: Experiência unicêntrica de médio prazo

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Abstract

Objective To evaluate the safety and reproducibility of the surgery for unstable slipped capital femoral epiphysis (SCFE) through the modified Dunn technique in a single center cohort from Brazil.

Methods We retrospectively analyzed a cohort of patients submitted to this procedure by a single surgeon who was a hip preservation specialist. Demographic data and radiographic angles were evaluated for the relative risk (RR) of avascular necrosis (AVN) using a log-binomial regression model with simple and random effects.

Results Among the 30 patients (30 hips) with a mean age of 11.79 years at the time of the operation, there were 17 boys and 18 left hips, which were operated on in a mean of 11.5 days after the slip. The mean follow-up was of 38 months. The preoperative Southwick angle averaged 60.69° against 4.52° postoperatively ($p < 0.001$). A larger preoperative slip angle was associated with the development of AVN (RR: 1.05; 95% confidence interval [95%CI]: 1.02–1.07; $p < 0.01$). The overall AVN rate was of 26.7%. Function was good or excellent in 86% of uncomplicated hips, and poor in 87.5% of the partients who developed AVN, as graded by the Harris Hip Score. There was no statistical relationship between epiphyseal bleeding and AVN development ($p = 0.82$).

Keywords
- slipped capital femoral epiphysis
- femoral head necrosis
- osteotomy
- hip

* *Study conducted at Hospital Estadual da Criança, Rio de Janeiro, RJ, Brazil.*

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Conclusion The modified Dunn technique is associated with restoration of the femoral alignment and function after unstable SCFE, when uncomplicated. Moreover, it was shown to be reproducible in our population, with a rate of 26% of femoral head necrosis.

Resumo

Objetivo Avaliar a segurança e a reprodutibilidade da cirurgia para escorregamento da epífise femoral proximal (EEPF) com instabilidade por meio da técnica de Dunn modificada em uma coorte unicêntrica no Brasil.

Métodos Analisamos de forma retrospectiva uma coorte de pacientes submetidos a esse procedimento por um único cirurgião especialista em preservação do quadril. Avaliamos os dados demográficos e os ângulos radiográficos quanto ao risco relativo (RR) de necrose avascular (NAV) por meio do modelo de regressão log-binomial com efeitos simples e aleatórios.

Resultados Entre os 30 pacientes (30 quadris) com idade média de 11,79 anos no momento da cirurgia, havia 17 meninos e 18 quadris esquerdos. O procedimento ocorreu em média 11,5 dias após o escorregamento. O tempo médio de acompanhamento foi de 38 meses. O ângulo de Southwick pré-operatório foi, em média, de 60,69° contra 4,52° após o procedimento ($p < 0{,}001$). O maior ângulo de escorregamento pré-operatório foi associado ao desenvolvimento de NAV (RR: 1,05; intervalo de confiança de 95% [IC95%]: 1,02–1,07; $p < 0{,}01$). A frequência geral de NAV foi de 26,7%. De acordo com a Escala de Quadril de Harris (Harris Hip Score), a função foi boa ou excelente em 86% dos quadris sem complicações, e ruim em 87,5% dos casos com NAV. Não houve relação estatística entre sangramento epifisário e desenvolvimento de NAV ($p = 0{,}82$).

Conclusão A técnica de Dunn modificada restaura o alinhamento femoral e a função articular após o EEPF com instabilidade na ausência de complicações. Além disso, mostrou-se passível de reprodução em nossa população, com frequência de necrose da cabeça femoral de 26%.

Palavras-chave
- escorregamento das epífises proximais do fêmur
- necrose da cabeça do fêmur
- osteotomia
- quadril

Introduction

Slipped capital femoral epiphysis (SCFE) is characterized by an anterior and lateral displacement of the proximal femoral metaphysis in relation to the epiphysis. An important functional impact can derive from the secondary deformity, or from avascular necrosis (AVN) of the femoral head, which is the worst complication related to the slip.[1–3] According to Loder et al.,[4] unstable SCFE is one in which the patient is not able to stand up with aid, even without bearing weight on the affected limb. These authors[4] have also related the instability with a risk of up to 47% of developing AVN. This relationship has been recently reviewed, and the incidence of AVN in unstable slips remained high, ranging from 22% to 50%.[2,5,6] On the other hand, in cases of stable SCFE there is virtually no risk of developing AVN.[5,7,8]

Different surgical techniques have been developed to minimize the functional impairments of the slip and its complications. Subcapital realignment osteotomy, known as the modified Dunn technique, has been gaining popularity since its description in 2007 by a group of surgeons from Switzerland.[9] The possibility of protecting the vascular supply of the femoral head while correcting the deformity to restore the prelesion anatomy has been the main reason for this change in the management of SCFE. Many papers have been published[5,10–16] on the experience of specialized centers internationally with AVN incidence varying from lower than 10% to higher than 50%. However, reports of the experience of Brazilian centers are lacking in the literature, and we aim to describe the midterm results of the first 30 cases operated on through this technique in our hip preservation unit.

Material and Methods

After approval by the institutional Ethics Committee (CAAE 80941816.1.0000.5249), we prospectively followed the first 31 patients (31 hips) who were submitted to the modified Dunn technique for unstable SCFE, performed by the same professional, a pediatric orthopedic surgeon specialized in hip preservation. All parents signed the informed consent form for the surgical treatment and participation in the project. The operations were performed from January 2015 to July 2018, in patients with unstable slips according to the classification by Loder et al.[4] and with moderate or severe slips according to the Southwick angle.[17] The operation followed the technique described by Leunig et al.,[9] except for the fact that we did not use Doppler flowmetry to assess the vascularity of the femoral head intraoperatively. We also used a different fixation method, consisting of

a 7.0-mm cannulated screw (Synthes, Oberdorf, Solothurn, Switzerland) associated with a 2.0-mm threaded pin in the first 22 cases, and 2 7.0-mm cannulated screws in the next 9 cases.[9] We determined the vascularity of the femoral head by the presence of bleeding from 1 or 2 holes drilled in the anterior portion of the head with a 1.5-mm smooth Kirschner wire, before retinacular flap dissection and after reduction of the epiphysis.

Mild and stable slips, as well as moderate or severe SCFE with a closed physis, were excluded from the analysis. Patients with a radiographic aspect of AVN before the treatment at our institution and those with endocrine abnormalities or other comorbidities were also excluded from the study group.

The preoperative data included age, gender, laterality, time from symptom onset until operative treatment, stability according to Loder et al.,[4] and magnitude of the slip according to Southwick.[17] Postoperatively, we recorded the quantitative correction of the Southwick angle, the duration of the follow-up, the incidence of complications, and the functional status through the Harris Hip Score (HHS).[18] The main demographic data are described in ►**Table 1**. One patient was lost to follow up before 1 postoperative year, and was excluded from the final analysis, comprising 97% of initial sample retention.

The slip angle as described by Southwick[17] was measured in preoperative anteroposterior (AP) and lateral (frog leg or cross table) hip radiographs by the main author (FCMV), and further classified, as per Boyer et al.,[19] as mild for slips below 30°, moderate, between 30° and 50°, and severe for slips above 50° on lateral view. The magnitude of the slip correction was calculated by subtracting the postoperative Southwick angle form its preoperative value. The radiographic diagnosis of AVN was based on the presentation of one or more of the following: subchondral bone sclerosis, subchondral fracture, radiolucency of the subchondral bone, and resorption or collapse of the subchondral bone with flattening of any portion of the femoral head (►**Fig. 1**). Chondrolysis was determined as a reduction of the joint space to less than 50% of the contralateral hip or 3 mm in bilateral cases, associated with joint stiffness. The postoperative complications were graded according to the modified Clavien-Dindo classification, in which grade I comprises complications that do not require a change in the normal postoperative routine, grade II requires an outpatient-based change in the postoperative care, grade III requires radiological or surgical intervention, grade IV is associated to long-term morbidity or risk of death, and grade V results in the death of the patient.[20,21]

The postoperative protocol included the absence of weight-bearing for the first six weeks, followed by partial weight-bearing if the initial signs of healing (closure of the proximal femoral physis or callus formation in three out of four corticals bridging the physis in two orthogonal radiographic views) were present at the appointment at six weeks (►**Fig. 2**). Unrestricted weight-bearing was allowed when full healing occurred, and return to full activities was allowed after six months in uncomplicated cases. Strengthening exercises for the abductor muscles started after healing of the greater trochanteric osteotomy. Cases complicated by AVN were kept without bearing weight and submitted to early femoral head decompression via multiple drilling of the physis with a 4.3-mm cannulated drill and revision of the fixation when needed. Chondrolysis was treated by manipulation under anesthesia associated with intra-articular corticosteroid injection. The functional status was determined by the main author at the one-year follow-up appointment using the HHS.[18]

The data were described by absolute frequencies and percentages for qualitative variables, and by means, standard deviations, and minimum, median, and maximum values for quantitative variables. To estimate the relative risk (RR) of complications, we used the log-binomial regression model with simple and multiple random effects. The statistical analysis was performed using the SAS software (SAS Institute, Cary, NC, United States), version 9.2, and the graphics, using the R software (R Foundation for Statistical computing, Vienna, Austria), version 3.4.1. A significance level of 5% was used for all comparisons ($\alpha = 0.05$).

Table 1 Demographics of the study population

Patients (hips)	30 (30)
Average age (years)	11.79
Gender (male**:**female**)**	17:12
Side (right**:**left**)**	12:18
Average ΔT (days)	11.53
Avascular necrosis (cases/%)	8/26.67%
Mean follow-up (months)	38.07
Average preoperative Southwick angle (degrees)	60.69
Average postoperative Southwick angle (degrees)	4.52

Notes: Southwick angle – posterior slippage angle of the proximal femoral epiphysis; ΔT, time between the traumatic event and the surgical procedure.

Results

The final sample consisted of 30 patients (30 hips), 56.6% (17) of whom were male, and 60% (18) of left hips. The mean age at operation was of 11.79 (range: 9 to 15) years, and the mean delay from the slip and the surgical procedure was of 11.53 (range: 5 to 45) days (►**Table 1**). In 9 (56.25%) out of 16 cases in which we evaluated femoral head bleeding before the periosteal flap dissection and after epiphyseal reduction, there was bleeding before the dissection. In 13 (81.25%) of these 16 cases, there was bleeding after the reduction of the epiphysis, which may indicate recovery of the head vascularity in 4 cases with the technique. However, we found no relationship between bleeding and the final outcome of AVN (RR: 0.89; 95% confidence interval [95%CI]: 0.32–2.45; $p = 0.82$).

The mean preoperative slip was of 60.69° degrees (range: 44° to 90°), and the mean postoperative angle was of 4.52°

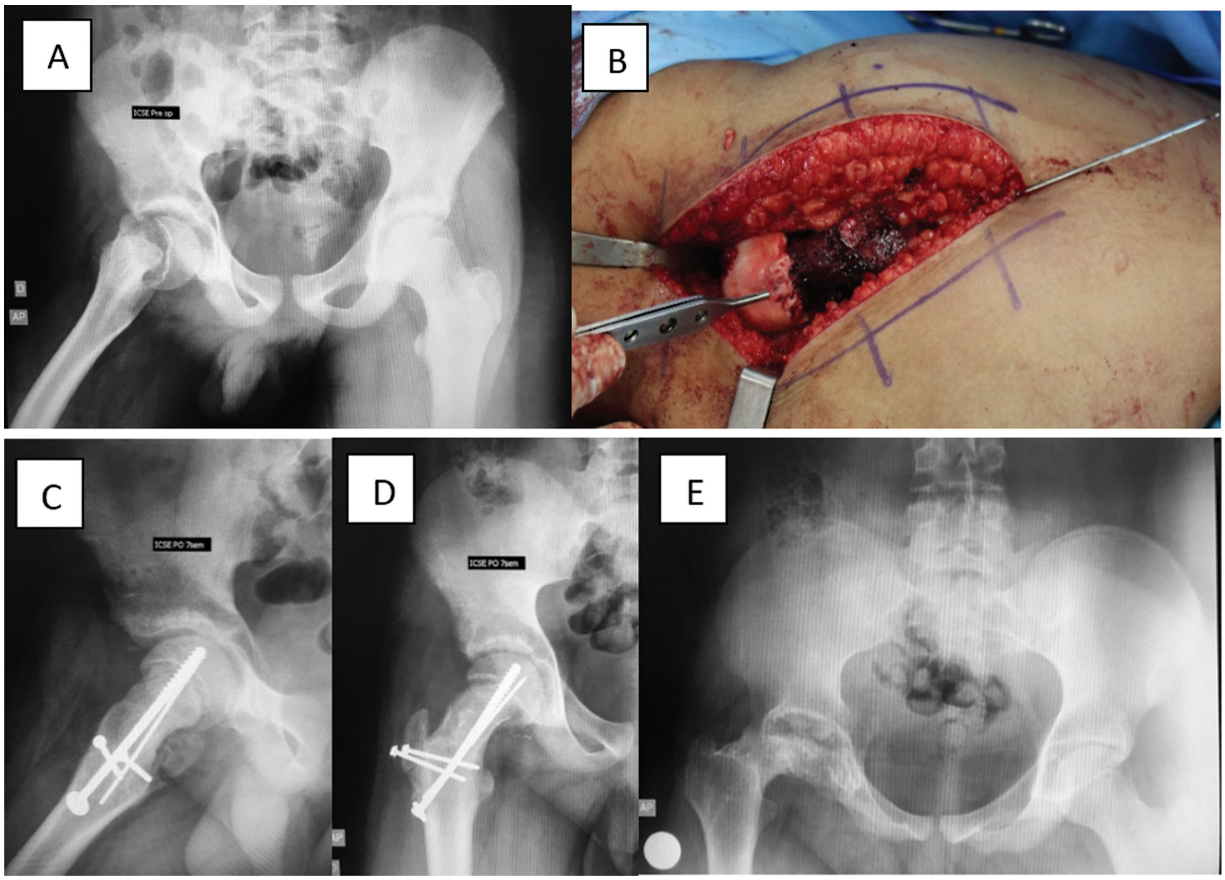


Fig. 1 Preoperative period (**A**); intraoperative aspect of the footprint of the retinacular vessels in the epiphysis demonstrating its potential avulsion due to the slip (**B**); immediate postoperative period (**C**,**D**); and final (**E**) radiographic aspect of a severe unstable slip developing avascular necrosis of the femoral head.

(ramge: -9° to 12°). Therefore, all cases had moderate or severe angulation according to Boyer et al.[19] Among the 30 operated hips, 73.3% (22) had a satisfactory radiographic evolution, with healing within the first 3 months after surgery, and without major complications. The incidence of AVN at the final follow-up was of 26.7% (8 cases). All but one patient developed AVN within the first six postoperative months. The exception was one boy who showed signs of healing at the outpatient appointment at six months, but he returned to the visit at nine months with severe pain after falling during a soccer game and presented with radiographic subchondral fracture and collapse.

Correlating the degree of deformity to the occurrence of AVN, we observed a statistically significant relationship, with a bigger slip being related to a higher risk of AVN (RR: 1.05; 95% CI: 1.02–1.07; $p < 0.01$) (►**Table 2** and ►**Fig. 3**). Moreover, we identified that for every degree of increase in the Southwick angle, the AVN risk had a 4.5% increase. Similarly, a higher degree of the Southwick angle correction was directly proportional to the development of AVN (RR: 1.05; 95%CI: 1.007–1.1; $p = 0.02$). On the other hand, the gender of the patient and the affected hip side had no influence on the development of AVN ($p = 0.17$ and 0.16 respectively), nor had the age at presentation, after adjusting for confounding factors ($p = 0.6$).

The mean HHS score was of 75.7 (range: 35.3 to 96.7) points. After stratification between the cases that developed complications or not, specially AVN, we observed a mean score of 86.6 points (good outcome) in the group without AVN, with 86% (19 hips) having good or excellent function, while the AVN group had a mean HHS score of 48.7 points (poor result), with 87.5% (7 cases) presenting a poor outcome. Two cases of chondrolysis occurred, both Clavien-Dindo III, requiring surgical revision for a steroid injection. They were self-limited, with radiological resolution of the chondral damage after 2 years, one presenting a final HHS score of 86.3 points and the other, 71.8 points. All AVN cases were considered Clavien-Dindo IV, with important functional impairment in the midterm follow up. They were all submitted to femoral head decompression as soon as radiographic signs of AVN were identified. Moreover, two of the AVN cases underwent proximal femoral valgus osteotomy but have remained functionally poor and will be submitted to a total hip arthroplasty (THA). One patient was submitted to arthrodiastasis with an external fixator at the same time of the head decompression, and albeit a bad radiographic outcome, is clinically stable, not yet willing to undergo THA. Three more patients have been submitted to the removal of the fixation devices and will be submitted to THA. The remaining two patients with AVN are functionally satisfied, currently in outpatient follow-up. One Clavien-Dindo II complication

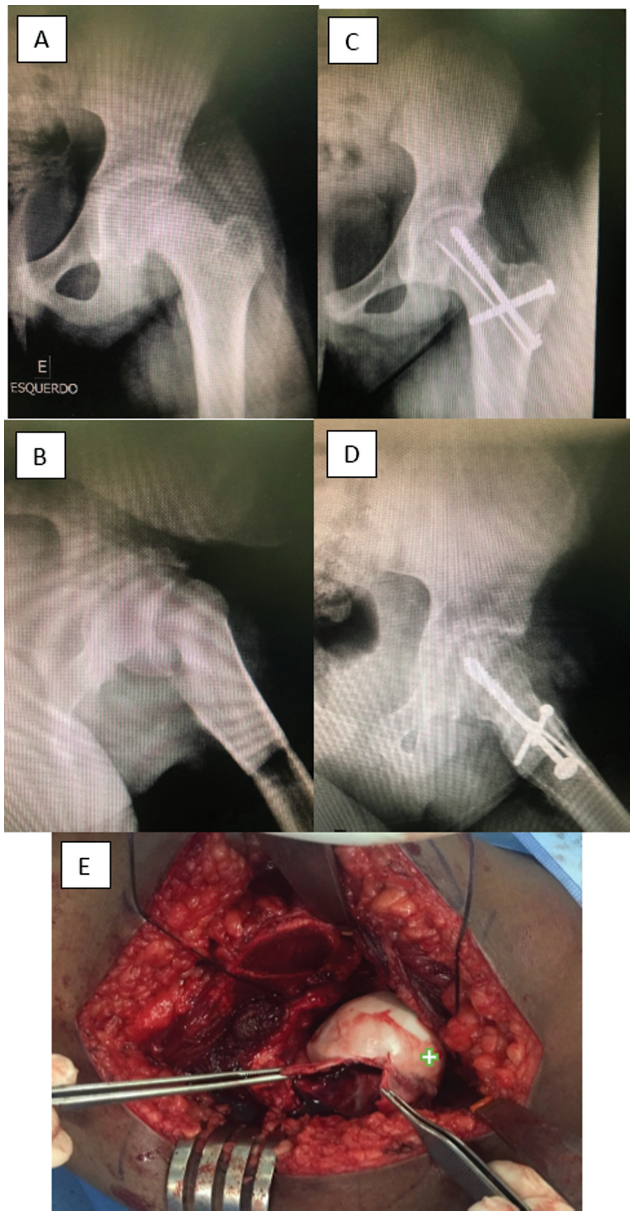


Fig. 2 Radiographic aspect, preoperatively (**A**,**B**) and 27 months postoperatively (**C**,**D**), of a severe unstable slip with uneventful healing. Note: [+]Demonstrates the intact softspot, where retinacular vessels penetrating the epiphysis (**E**).

occurred, consisting of a superficial wound infection, which was successfully treated with oral antibiotics.

Discussion

In its unstable form, SCFE is associated with AVN in up to 47% of the cases.[2,4,5] Therefore, the acceptance of surgical techniques combining anatomical realignment with little secondary deformity while minimizing the risk of AVN, specially the modified Dunn technique, has increased internationally in the last decade.[9,14] The international experience with this technique has been published[5,11,16,22–25] since its description, but limited data are available for the Latin American population. In the present study, the largest

Table 2 Correlation of qualitative variables and avascular necrosis

	no AVN	*AVN*
ΔT (days)	13.22	9
Average age (years)	11.57	12.38
gender (male:female)	14:07	03:05
Mean preoperative Southwick angle (degrees)[*]	58.24[*]	67.13[*]
Mean Southwick angle correction (degrees)[*]	54.14[*]	61.5[*]
Mean Harris Hip Score (points)[*]	86.67[*]	48.75[*]

Abbreviations: AVN, avascular necrosis; Notes: Southwick angle – posterior slippage angle of the femoral epiphysis; ΔT, time between the traumatic event and the surgical procedure; [*]$p < 0.05$ by the log-binomial regression model with simple and multiple random effects.

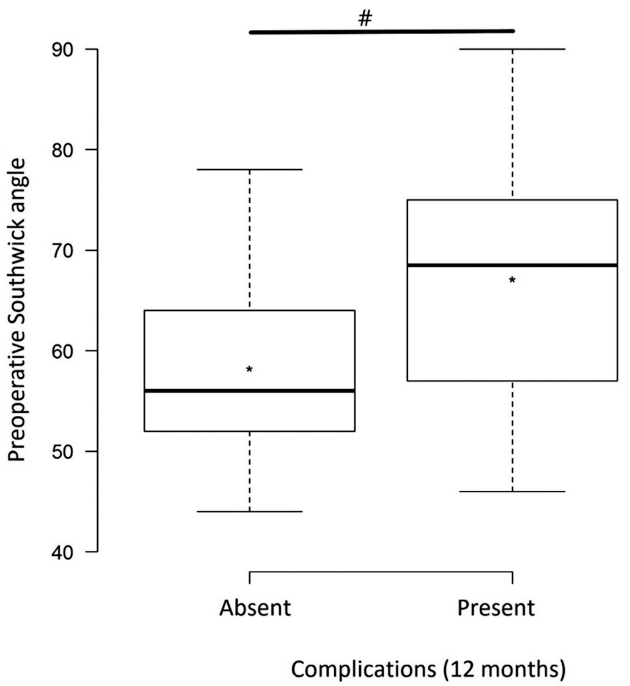


Fig. 3 Relationship between the magnitude of the slip measured by the Southwick angle preoperatively and the occurrence of complications (avascular necrosis). Notes: [#]RR: 1.05; 95%CI: 1.025–1.076; $p < 0.01$ by the log-binomial regression model with simple and multiple random effects. [*]Mean value.

Latin-American single center cohort of unstable SCFE treated through the modified Dunn technique to date, we have shown that the technique is reproducible in the Brazilian population, with a risk of AVN of 26% (8 cases).

Our sample presented demographics similar to what has been previously described for age at presentation, higher prevalence in boys, and predominance of left hips.[26] The main factors previously related to the development of AVN were the magnitude of the slip and younger age.[26–28] We have also found a significant relationship between a more severe Southwick angle and a higher risk of AVN. In our

sample, the probability of AVN increased by 4.5% for every degree of increase in the Southwick angle. On the other hand, in our sample, there were more cases of AVN among older patients than younger ones, however, without statistical significance. We believe that this might be related to the thinner periosteum found in older patients, which may be more fragile and susceptible to rupture in an acute unstable SCFE or during the operative procedure (►**Fig. 1**).

In 16 of our cases, we recorded whether there was bleeding through drilled holes in the femoral head. Among the AVN cases, 5 (62.5%) had this evaluation and 3 (60% of the evaluated) had active bleeding after reduction of the epiphysis. We did not find this test to be accurate in determining the head vascularity, but our sample was underpowered for this variable. Previous studies have used different methods for the identification of epiphyseal viability, with Doppler flowmetry being the most accurate, even though the reading the result may take two minutes.[29] Moreover, bleeding through epiphyseal drilled holes has been shown to be as accurate as intracranial pressure catheter monitorization for the purpose of detecting a disruption in the blood flow, and it is still our method of choice for subsequent assessments of larger populations.[30] There is still doubt as to whether the femoral head might be avascular before the operation. A French study[31] using perfusion magnetic resonance imaging (MRI) showed that avascular heads before capital realignment can revascularize after the operation. Superselective angiogram of the medial circumflex artery has also identified the revascularization with surgery; therefore, using a technique that enables the safe reorientation of the femoral epiphysis instead of pinning unstable slips in situ is important.[32,33]

The prevalence of AVN ranges from 6.5% to 53% in unstable cases in multiple studies found in the literature.[2,5,6,10,16,23,24,34] Our sample presented a rate of AVN of 26% (8 hips), which is comparable to a previously published multicentric American study published in 2013,[11] which only evaluated unstable slips. In a Brazilian SCFE cohort recently published by Valenza et al.,[34] an overall AVN rate of 25% was found among stable and unstable slips, which is also compatible with our sample, even though we only studied unstable cases. It is important to mention that different techniques for capital realignment are used internationally to treat SCFE. For instance, a French multicentric study[23] showed that the preferred technique in that country is a cuneiform osteotomy performed through the Hueter approach without periosteal flap dissection, with a rate of AVN of only 13.3% in 45 unstable slips.[23] Treating slips before 24 hours of evolution with gentle reduction and anterior capsulotomy enabled a single German center[35] to achieve a rate of AVN of 4.7% in 60 unstable slips during a 19 year period. Unfortunately, the logistics of the Brazilian health system does not enable us to admit patients in such an acute setting, and the results of the latter technique were not reproducible. In unstable cases, in situ fixation presents an AVN rate that ranges from 22% to 47%.[2,5] Therefore, we believe that a technique that is reproducible and has a rate of AVN of 26% or maybe less, depending on the learning curve, is very useful and must be considered for the treatment of unstable slips. We also believe that these cases should be referred to a high-volume surgeon, as this has been related to a lower complication rate.[36]

The present study has some limitations, and the most important is related to the absence of a control group treated through in situ fixation, which would show, in our population, the impact of instability and the modified Dunn technique on the development of AVN. On the other hand, the present study was prospective, with all cases of unstable slips treated by the same surgeon, a specialist in hip preservation, thus avoiding a selection bias and complications related to low-volume surgeons. We aim to publish future results on the subsequent cases, to evaluate the impact of the learning curve on the complications, as well as the expansion of indications for severe stable slips.

Finally, we conclude that the modified Dunn technique is efficient in restoring the anatomy of the proximal femur and justifiable due to its AVN rates in unstable SCFE, and is reproducible in our population when compared with international cohorts.

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

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Does Acetabulum Remodel Following Varus Derotation Osteotomy for Perthes' Disease?

O acetábulo sofre remodelamento após a Osteotomia Derrotatória Varizante em pacientes com Doença de Perthes?

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Abstract

Objective We investigated the effect of disease stage, patient's age and final contour of femoral head on acetabulum contour following varus derotation osteotomy of proximal femur (VDRO) in unilateral Perthes's disease.

Methods The study is a retrospective analysis of case records of 23 children aged $\geq$6 years with unilateral Perthes' disease who underwent primary VDRO procedure for containment. Acetabular index (AI) and center edge angle (CEA) were calculated bilaterally in preoperative and follow-up radiographs and compared statistically.

Results There were 15 boys and 8 girls. Six hips were in Ib, 8 in IIa and 9 in IIb modified Waldenström stage while undergoing VDRO. The mean age at surgical intervention was 8.7 years. The mean follow-up duration was 3.5 years. All femoral heads were healed at final follow-up and the final Stulberg grades were I = 3, II = 8, III = 7, IV = 5. A significant acetabular dysplasia on the affected side was present preoperatively. At follow-up, the patients operated had significantly raised AI and reduced CEA. There was no significant acetabular remodeling of the affected hips at follow-up even in children operated at younger age ($<$ 8 years) or early stages (stage Ib or IIa). The acetabulum remodeling did not correspond to the final Stulberg grade as well.

Conclusion Acetabulum was found involved in early stages of Perthes' disease. Varus derotation femoral osteotomy for the diseased hip showed no significant improvement in acetabular dysplasia even when operated in early disease stages or younger age group. Residual acetabular changes were also noted even with favorable Stulberg grades.

Keywords
- acetabulum
- child
- hip joint
- legg-calve-perthes disease

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Resumo

Objetivo Investigamos o efeito do estágio da doença, idade do paciente e contorno final da cabeça femoral no contorno do acetábulo após a osteotomia derrotatória varizante (VDRO) do fêmur proximal na doença de Perthes unilateral.

Métodos O estudo é uma análise retrospectiva de prontuários de 23 crianças com idade $\geq$ 6 anos com doença de Perthes unilateral que foram submetidas ao procedimento primário de VDRO para contenção. O índice acetabular (AI) e o ângulo da borda central (CEA) foram calculados bilateralmente em radiografias pré-operatórias e de acompanhamento e submetidos à comparação estatística.

Resultados Os pacientes eram 15 meninos e oito meninas. À VDRO, seis quadris estavam no estágio de Waldenström modificado Ib, oito no estágio IIa e nove no estágio IIb. A média de idade à intervenção cirúrgica foi de 8,7 anos. A duração média do acompanhamento foi de 3,5 anos. Todas as cabeças femorais estavam consolidadas no último acompanhamento e os graus finais de Stulberg foram I = 3, II = 8, III = 7 e IV = 5. Havia displasia acetabular significativa do lado acometido no período pré-operatório. No acompanhamento, os pacientes operados apresentaram elevação significativa de AI e redução de CEA. Não houve remodelamento acetabular significativo nos quadris acometidos durante o acompanhamento, mesmo em crianças operadas em idade menor ($<$ 8 anos) ou estágios iniciais (estágio Ib ou IIa). O remodelamento do acetábulo também não correspondeu ao grau final de Stulberg.

Conclusão A VDRO do fêmur do quadril acometido não levou à melhora significativa da displasia acetabular, mesmo quando a cirurgia foi realizada nos estágios iniciais da doença ou em pacientes mais jovens. Alterações acetabulares residuais também foram observadas mesmo com graus de Stulberg favoráveis.

Palavras-chave

- acetábulo
- articulação do quadril
- criança
- doença de legg-calve-perthes

Introduction

There is ample evidence that acetabulum is significantly altered in addition to changes in proximal femur in Perthes' disease.[1–6] The acetabular changes begin early with abnormal growth of its cartilage and increased medial joint space. In late stages, a dysplastic lateral acetabulum is often seen associated with an enlarged, laterally displaced femoral head.[5]

A key treatment in Perthes' disease involves seating the femoral head as fully inside the acetabular socket so that it may retain its sphericity during the period of subsequent revascularization and remodelling.[7,8] Containment with proximal femur varus derotation osteotomy (VDRO) is one of the preferred surgical procedures recommended for this purpose. Many studies report the improvement in sphericity and radiological outcome of proximal femur following the use of VDRO procedure.[9–15] Since the acetabular changes closely follow the changes in femoral head morphology during the disease process, one might expect that a femoral containment osteotomy will also produce a congruent acetabulum at disease healing.[5] Others have raised concerns against this hypothesis since VDRO intervention is most commonly offered at a time when remodelling potential of the acetabulum is already limited.[5]

There is limited literature specifically evaluating acetabular remodelling following containment procedures in Perthes' disease in children.[1,3] We therefore conducted this study to further understand acetabular changes following VDRO intervention for Perthes' disease. Specifically, we investigated the effect of disease stage, patient's age and final contour of femoral head on acetabulum following the surgical intervention.

Methods

The retrospective study (2010–2020) was performed at a tertiary care pediatric center. Ethical clearance from Institutional Ethics Committee was obtained for the study and written informed consent was obtained from all patients and/or families. We included children $\geq$6 years with unilateral Perthes' disease in stages Ib to IIb (modified Waldenström classification) who underwent primary VDRO and trochanteric epiphyseodesis for containment.[8,16,17] We excluded patients with follow-up less than 1 year and inadequate records. Twenty-three children fulfilled above criteria and formed the subjects for this study.

According to the modified Waldenström classification for Perthes' disease, the femoral head fragmentation starts at IIa and progresses till stage IIb (late fragmentation).[8,16,17] The procedure of VDRO is generally indicated in stage I and II disease. With available evidence that there will be likely extrusion of the epiphysis and subsequent deterioration in children over the age of 7 years, the procedure is also recommended in patients without extrusion.[4,13,17,18] The practiced procedure of VDRO at our institute is an open

lateral wedge subtrochanteric osteotomy to achieve containment of femoral head with lower limit of final neck shaft angle of ~110–115 degrees, derotation of ~15–20 degrees and stabilized with a molded dynamic compression plate.[7]

Evaluation

The radiographic evaluation was based on anteroposterior plain X-rays. As above, initial stage and severity of hip involvement was determined using modified Waldenström classification.[8,16] Acetabular index (AI) and center edge angle (CEA) were calculated for both hips preoperatively.[19] In subsequent follow-up radiographs, hip was evaluated for the presence of acetabular dysplasia and sphericity. Acetabular dysplasia was radiologically assessed by AI and CEA. Overall head sphericity was assessed by Stulberg grade.[20]

The stage of disease at presentation, patient's age and final head sphericity are the key factors postulated to decide the final outcome in Perthes' disease.[2,7,8,14,21] Accordingly, to enable analysis of acetabular results, children were subgrouped into those with early (Ib and IIa) and late fragmentation (IIb) disease stage at presentation; age $\leq$8 and >8 years and those who achieved Stulberg grade upto 2 (considered as good results) versus those with grade 3 or more.

Statistical Analysis

Preoperative AI and CEA on both sides were compared using paired student *t*-test to determine the approximate dysplasia on affected side. The indices were again compared at follow-up to determine the residual acetabular dysplasia. P value of <0.05 was considered significant. The statistical analysis was done using online 'MedCalc' statistical software.[22]

Results

Twenty-three children comprised 15 boys and 8 girls. Six hips were in Ib, 8 in IIa and 9 in IIb stage before undergoing VDRO (►**Table 1**). The mean patient's age at surgical intervention was 8.7 (SD 1.5) years (range, 6.6–11.7 years). Lateral extrusion of the femoral head was present in 18 hips preoperatively. The mean duration of follow-up was 3.5 (SD 2.2) years and mean age at final follow-up was 12.2 (SD 2.4) years. All femoral heads were healed at final follow-up and of these, 48% hips were Stulberg grade I and II (Stulberg grade I = 3, II = 8, III = 7, IV = 5).

The preoperative radiographs showed significant acetabular dysplasia on the affected side compared with unaffected side. The affected hip showed a mean AI of 16.6 (SD 4.3) degrees and CEA of 25.8 (SD 4.8) degrees whereas for the unaffected side, the values were 11.7 (SD 2.4) degrees and 32.8 (SD 5.3) degrees respectively. Additionally, this dysplasia was also demonstrated in all analyzed subgroups (►**Table 2**).

Patients operated in both early and late fragmentation disease stages had significant persistent acetabular dysplasia on the affected side at follow-up (►**Table 2**). For disease stage Ib and IIa at presentation, AI on unaffected side was 12.8 (SD 3.9) degrees versus affected side 17.5 (SD 4.5) degrees ($p = 0.0004$). Corresponding CEA values on unaffected side were 37 (SD 6.5) degrees versus affected side 29 (SD 5.1) degrees ($p = 0.002$) (►**Fig. 1**). The observations for hips operated in late fragmentation stage IIb were similar (►**Fig. 2**). In the intergroup analysis, the acetabular dysplasia comparison of the affected side between the two groups (Ib/IIa and IIb), at the preoperative stage and at the final follow-up, was not significantly different ($p > 0.05$).

The acetabulum failed to remodel, and persistent dysplasia was present in both early (operated till 8 years) and late age groups (operated after 8 years) at final follow-up. Significant difference ($p < 0.001$) in AI and CEA values were noted between non affected and affected hips at follow-up. Also, the intergroup analysis between two age groups showed comparable AI and CEA for the affected hips, both preoperatively and at follow-up.

The acetabulum remodelling did not correspond to the final Stulberg grade as well. The hips with final Stulberg grade I and II group also had significantly altered acetabulum parameters compared with the unaffected side at follow-up. The degree of acetabular dysplasia showed no significant difference when observations of two groups (Stulberg I/II and ≥III) were compared both at preoperative stage and at follow-up.

Discussion

Perthes' disease is a disorder of childhood characterized by avascular necrosis of the femoral head. Acetabulum changes in Perthes' disease is a long recognized phenomenon.[1–6] Of the various morphological changes occurring in acetabulum, the most noted is acetabular dysplasia along with osteopenia of roof and irregularity.[5] The various factors analyzed in our study viz. initial stage of the disease, age of the child at surgical intervention and final radiological outcome have been a subject of much debate in Perthes' disease but the discussion is largely directed to the proximal femoral characteristics.[7,8] Our study focused on acetabulum relationship to these factors wherein patients were subjected to a uniform containment method i.e., VDRO. The study of acetabulum holds considerable importance because its incongruity persisting in older children after disease healing might cause early degenerative arthritis of the hip joint.[3,5]

Our study revealed presence of significant acetabular dysplasia even in early stages (stage I and II) of Perthes' disease or younger age children. Both AI and CEA were abnormal when compared with unaffected side preoperatively. This early dysplasia indicated that Perthes' disease is a global joint pathology rather than just proximal femoral involvement. It is therefore emphasized that the other side of hip joint may be given due consideration during the preoperative work up/ late reconstructions of Perthes' disease.

In the preventive intervention strategy for Perthes' management, as postulated by Joseph and associates, VDRO was typically indicated for stage IIa (stage of early fragmentation). However, in later research it was shown that VDRO was somewhat useful even for hips in late fragmentation (IIb).[8,14] Five out of nine (55%) patients with preoperative stage IIb

Table 1 Acetabular parameters preoperatively and at follow up

S.NO.	SEX	SIDE	AGE (MONTHS)	AGE AT F/U (YEARS)	F/U (MONTHS)	DISEASE STAGE	EXTRUSION	PREOPERATIVE PARAMETERS (DEG.)				FOLLOW UP (DEG.)				STULBERG GRADE
								UNAFFECTED	UNAFFECTED	AFFECTED	AFFECTED	UNAFFECTED	UNAFFECTED	AFFECTED	AFFECTED	
								AI	CEA	AI	CEA	AI	CEA	AI	CEA	
1	M	R	81	9	20	2b	PRESENT	12	28	22	23	15	30	22	27	II
2	M	R	132	16.6	120	2a	PRESENT	12	30	16	23	18	32	23	26	III
3	M	L	96	12.5	54	1b	ABSENT	11	34	15	26	6	42	12	37	III
4	M	L	122	14.5	51	2a	ABSENT	13	31	15	24	13	44	23	22	III
5	M	R	140	16	54	2b	PRESENT	15	27	16	26	15	36	24	6	IV
6	M	R	102	14.5	60	2b	PRESENT	14	30	16	14	14	30	21	8	IV
7	F	L	96	9.5	14	2b	PRESENT	11	38	15	32	10	39	14	39	II
8	F	R	108	14	55	1b	ABSENT	11	39	28	28	16	45	23	34	II
9	M	L	91	12.5	58	2a	PRESENT	12	33	15	34	15	39	21	22	II
10	F	L	76	10.5	49	2b	PRESENT	7	33	11	27	12	43	17	35	II
11	F	L	96	11.2	38	1b	PRESENT	16	32	20	25	19	32	19	24	III
12	M	R	120	12.6	32	1b	ABSENT	6	34	13	30	9	41	12	29	II
13	M	R	108	17	93	1b	PRESENT	12	30	22	21	11	45	21	30	III
14	M	R	96	12.7	51	2b	PRESENT	15	31	24	18	12	34	13	22	IV
15	M	L	132	14	34	2b	PRESENT	10	33	9	32	12	52	26	32	II
16	M	L	79	10	33	2a	PRESENT	13	34	18	24	6	31	14	32	I
17	F	L	120	11	14	2a	PRESENT	12	52	18	32	13	41	19	39	IV
18	M	L	96	10.5	22	2a	PRESENT	10	38	15	33	9	45	15	24	III
19	F	R	120	11	14	2a	PRESENT	12	26	15	24	16	29	12	34	I
20	M	L	115	11.5	36	1b	PRESENT	13	27	14	23	14	28	15	31	I
21	F	R	84	9.5	17	2b	PRESENT	14	32	20	23	15	26	24	17	II
22	F	L	103	10	17	2b	PRESENT	10	31	14	23	9	34	14	32	III
23	M	L	87	9.5	14	2a	ABSENT	9	32	11	28	11	30	11	26	IV

Abbreviations: AI, Acetabular Index; CEA, Centre Edge Angle; DEG.-Degrees; F, Female; F/U, FOLLOW UP; L, Left; M, Male; R, Right; VDRO, Varus Derotation Osteotomy.

Table 2 Comparison between various subgroups

Groups	Preoperative		Significance*	Preoperative		Significance*	Follow up		Significance*	Follow up		Significance*
	Unaffected AI (in degrees)	Affected AI (in degrees)		Unaffected CEA (in degrees)	Affected CEA (in degrees)		Unaffected AI (in degrees)	Affected AI (in degrees)		Unaffected CEA (in degrees)	Affected CEA (in degrees)	
Initial stage of disease												
Ib, IIa	11.6 (2.1)	17.1 (4.2)	0.0001	33.3 (6.1)	26.5(4.0)	0.0008	12.8(3.9)	17.5(4.5)	0.0004	36.9 (6.5)	29.1 (5.14)	0.002
IIb	12 (2.6)	16.3(4.6)	0.006	31.4 (3.0)	24.2(5.6)	0.002	12.7 (2.1)	19.4(4.8)	0.0007	36 (7.4)	24.2 (11.1)	0.008
Age at time of surgery												
≤8 years	11.8 (2.6)	16.9 (4.3)	<0.001	33.2 (2.9)	26.6 (4.9)	0.0001	11.8 (4.0)	16.5 (4.4)	0.0006	35.5 (6.3)	27.7 (7.0)	0.003
>8 years	11.6 (2.2)	16.3(4.5)	0.007	32.5 (6.7)	25 (4.9)	0.001	13.4 (2.6)	19.4 (4.7)	0.0001	38 (7.3)	27 (9.8)	0.005
Stulberg stage at follow up												
I andII	11 (2.4)	16.3(5.1)	0.004	32.4 (4.0)	27.2(4.0)	0.001	12.7 (3.1)	18.2(4.9)	0.003	36.6 (8.0)	30.2 (6.0)	0.027
III and IV	12.4 (2.1)	16.8(3.5)	0.0001	33.2 (6.2)	24.4(5.1)	0.0001	12.5 (3.6)	17.9(4.5)	0.0003	37.1 (5.7)	24.7 (9.5)	0.0008

Abbreviations: AI, Acetabular Index; CEA, Centre Edge Angle.
Standard deviation values expressed in brackets.
*Student *t*-test.

disease achieved a final Stulberg grade of II in our series and an overall congruent hip joint. However, the follow-up acetabular indices didn't normalize in these patients as healing occurred.

The age cut off of 8 years for better femoral outcomes as an indication for VDRO has been established by multiple series.[8,14,23] Yet similar findings were not replicated for acetabulum. A possible explanation for this observation may lie in the fact that even though triradiate cartilage may not be completely fused by 8 years, the remodelling capacity of acetabulum declines considerably by this time due to loss of biological plasticity or the disease process. Corroborative evidence to above postulate may be seen with the use of VDRO for pathologies other than Perthes'. Shore et al studied the effect of VDRO on 56 children (103 hips) with cerebral palsy operated at the mean age of 7.7 years and with mean follow-up of 7.8 years.[24] They found no significant improvement of AI in children older than 6 years and mean improvement of 2.3 degrees in children ≤6 years. Thus, modification of plan/ concomitant acetabular procedure is suggested as early as age 6 years in Perthes' disease, if there is significant preoperative dysplasia of acetabulum.

Lastly, the patients who had good radiological results (Stulberg grade I and II) at follow-up also had residual deformed acetabular configurations in our study. Similar observations were also noted by Kamegaya et al who demonstrated that position of femoral head determines the final acetabular cover at maturity rather than sphericity, shape of head or age of the child.[1] This study comprised 33 unilateral Perthes's hips out of which 29 hips were analyzed based on acetabular head index (AHI), sphericity of femoral head, age at primary healing and amount of subluxation. Only 13 hips (48.8%) had more than 10% improvement in AHI at healing. Overall, no significant correlation of AHI was found with femoral head sphericity or age at primary healing. It however, correlated to reduction of subluxation. Authors for this series however, recommended delaying acetabular procedures, if needed till maturity, as some of their patients showed acetabular remodelling. We found that changes in acetabulum in children who underwent VDRO after age of 6 years in Perthes' disease did not remodel significantly despite improved contour of femoral head.

Majority of our children were skeletally immature at final follow-up. According to observations of Shah et al, the shape of the femoral head and congruity of the hip was largely static post healing and further changes at achieving skeletal maturity were unlikely.[3] Thus, the possibility that final radiological results may change significantly at maturity is limited. Other limitations were a retrospective study design, different ages at which VDRO was performed, and the dissimilar follow-up period. Additionally, there were differences in preoperative Perthes' disease stages and severity of acetabular dysplasia. The plain radiographs formed the basis of both initial and final evaluation and had an inherent limitation as acetabulum has an overall complex shape. The statistical results need a careful interpretation being based on a relatively small number of patients and univariate analysis. However, our series cut down various biases of management,

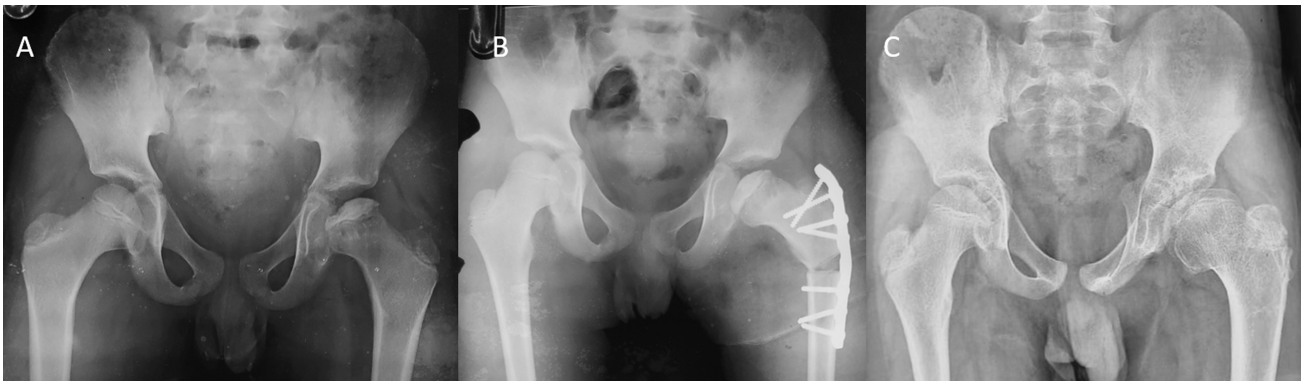


Fig. 1 (A) The 10.1 year old patient presented with Perthes' disease of left hip in stage 2a (patient 4); (B) The open wedge varus derotation osteotomy was performed to contain the hip; C) At follow-up 51 months, the disease healed. The head was enlarged and the final Stulberg grade was III. There was persistent acetabular dysplasia on the affected side (AI, 23 degrees) compared with unaffected (AI, 13 degrees).

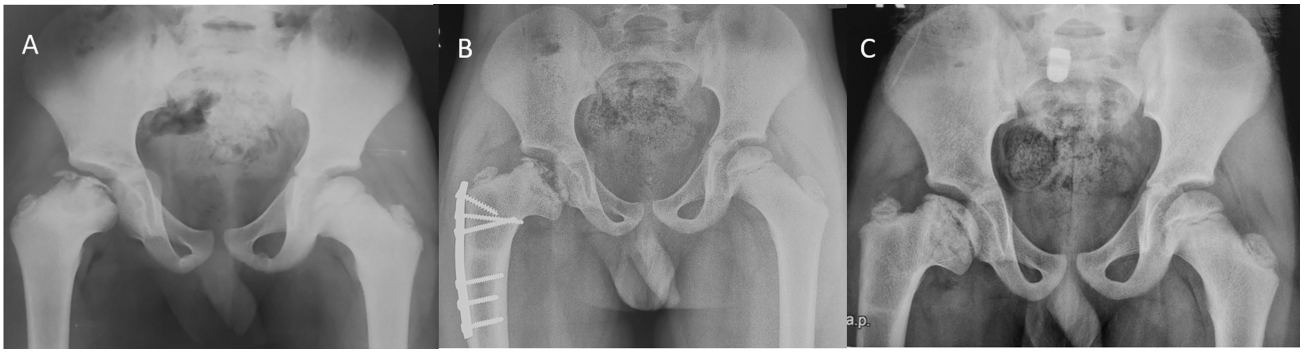


Fig. 2 (A) The 6.7 year old presented with stage 2b disease and extrusion of right hip (patient 1) with increased AI on affected side (22 degrees) compared with unaffected side 12 degrees); (B) The open wedge varus derotation osteotomy was performed to contain the hip; (C) At follow-up 20 months, the final Stulberg grade was II. There was persistent acetabular dysplasia on the affected side (AI, 22 degrees) compared with unaffected (AI, 15 degrees).

it being a uniform cohort of unilateral Perthes' cases operated upon with a common technique. Since a normal reference in form of unaffected acetabulum was available, both preoperatively and at follow-up for all comparisons, it accounted for physiological changes occurring in the acetabulum over the follow-up period. A follow-up till disease healing was available for all cases. We could quantitatively establish that acetabulum deformed early in Perthes' disease and its restoration was incomplete following VDRO possibly because of the limited remodelling potential at the time of performance of surgical procedure. Contrary to common belief, VDRO procedure performed in early disease stages may not always yield favorable acetabular outcomes. Finally, the acetabulum remodelling might not corroborate with the final femoral head shape at healing. We would however, like to suggest further studies on acetabular remodelling following VDRO with a larger number of cases and longer follow-up till skeletal maturity to decipher such changes with greater precision.

Conclusions

Acetabulum was found involved in early stages of Perthes' disease. Varus derotation femoral osteotomy for of the diseased hip showed no significant improvement in acetabular dysplasia even when operated in early disease stages or younger age group. Residual acetabular changes were also noted even with favorable Stulberg grades.

Authors' Contributions

Each author contributed individually and significantly to the development of this article: NBD: Methodology, investigation, writing original draft; AA: conceptualization, supervision, editing.

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Conflict of Interest

The authors have no conflict of interests to declare.

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Block of the Pericapsular Nerve Group of the Hip with and without Ultrasound Guidance: Comparative Cadaveric Study*

Bloqueio do grupo de nervos pericapsulares do quadril com e sem auxílio de ultrassonografia: Estudo cadavérico comparativo

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Abstract

Objective To evaluate the technical reproducibility of a block of the pericapsular nerve group (PENG) of the hip aided or not by ultrasound in cadavers.

Materials and Methods The present is a randomized, descriptive, and comparative anatomical study on 40 hips from 2 cadaver groups. We compared the PENG block technique with the method with no ultrasound guidance. After injecting a methylene blue dye, we verified the dispersion and topographical staining of the anterior hip capsule through dissection. In addition, we evaluated the injection orifice in both techniques.

Results In the comparative analysis of the techniques, there were no puncture failures, damage to noble structures in the orifice path, or differences in the results. Only 1 hip from each group (5%) presented inadequate dye dispersion within the anterior capsule, and in 95% of the cases submitted to either technique, there was adequate dye dispersion at the target region.

Keywords
- analgesia
- anesthesia
- hip joint
- nerve block
- cadaver
- peripheral nerve injuries

* *Study performed at the Hip Group, Department of Orthopedics and Traumatology, Faculdade de Ciências Médicas, Santa Casa de Misericórdia de São Paulo (FCMSCSP), São Paulo, SP, Brazil.*

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Conclusion Hip PENG block with no ultrasound guidance is feasible, safe, effective, and highly reliable compared to its conventional counterpart. The present is a pioneer study that can help patients with hip pain from various causes in need of relief.

Resumo

Objetivo Propor e avaliar a reprodutibilidade técnica do bloqueio do grupo de nervos pericapsulares (*pericapsular nerve group*, PENG, em inglês) do quadril sem o auxílio da ultrassonografia, em cadáveres, de forma comparativa à realização do bloqueio guiado pela ultrassonografia em outro grupo de cadáveres.

Materiais e Métodos Estudo anatômico randomizado, descritivo e comparativo, realizado em 40 quadris divididos em 2 grupos amostrais de cadáveres. Fez-se uma comparação da técnica do bloqueio do PENG à técnica não guiada por ultrassonografia injetando-se corante azul de metileno, seguida de dissecção para verificação da dispersão e da coloração topográfica da cápsula anterior do quadril, além de avaliação do pertuito das injeções entre as técnicas.

Resultados Na análise comparativa das técnicas, não houve falha na punção, lesão de estruturas nobres no pertuito, ou diferença nos resultados. Não houve adequada dispersão do corante pela cápsula anterior somente em 1 quadril de cada grupo (5%), e em 95% dos casos submetidos a qualquer uma das técnicas observou-se dispersão adequada do corante pela região alvo.

Conclusão O bloqueio do PENG do quadril sem auxílio de ultrassonografia é factível, seguro, eficaz, e com alta confiabilidade quando comparado à sua realização guiada pelo aparelho de imagem. Este estudo é pioneiro, e pode ajudar muito os pacientes que têm dor no quadril por diversas causas e necessitam alívio.

Palavras-chave
- analgesia
- anestesia
- articulação do quadril
- bloqueio nervoso
- cadáver
- traumatismos dos nervos periféricos

Introduction

The anterior joint capsule of the hip receives most of the sensory innervation from the entire joint.[1] Anatomical studies[2–4] have revealed that this sensory innervation comes from branches of the femoral, obturator, and accessory obturator nerves.

In 2018, Girón-Arango et al.[5] described, a technique to block the pericapsular nerve group (PENG) of the hip, which consists of the infusion of an anesthetic agent guided by ultrasound (US). Using some anatomical reference points and US images, this technique aims to reach the anterior capsule of the hip and its sensory nerve branches for anesthetic dispersion.[1]

The PENG block has been described for pain management, either for analgesia after proximal femur fractures, or pain control after hip surgeries. With a low cost and good outcomes, it prevents the use of opioids and their side effects.[5–8]

Although originally aided by US to guide the injection and anesthetic infusion, one of the orthopedist's challenges with the PENG block technique is the availability of the US equipment in all sectors and levels of care.

Therefore, we propose a PENG block with no US guidance. Our objective was to analyze the outcomes of the PENG block based only on anatomical parameters and compare them to the conventional, US-guided technique.

A PENG block with no US guidance could be part of several strategies, including preoperative care, pain management, follow-up, and postoperative care with less need for special equipment.

Materials and Methods

The present is a randomized, descriptive, and comparative anatomical study conducted at the Hip Group of a teaching hospital and performed in the Capital City's Death Verification Service (Serviço de Verificação de Óbitos da Capital, SVOC, in Portuguese), of the City of São Paulo, Brazil. The study team is duly registered at SVOC under number 18/2022, and the study followed its guidelines. The institutional ethics committee approved the study (CAAE 58212220.9.0000.5479).

The present study included a sample of 20 cadavers, with 40 hips not preserved with formalin. We excluded four subjects with skeletal immaturity from the analysis.

Procedures

In a parallel study, Tran et al.[9] performed a technical comparison of infusions of 10 mL and 20 mL of methylene blue dye in cadaveric hips. They concluded that, although the dispersion of 20 mL was more extensive, both injections stained the entire region between the iliopsoas and the anterior capsule of the hip, in which Gerhardt et al.[1] identified nociceptive nerve branches.

In the present study, we used 20 mL of methylene blue dye to also mimic the anesthetic block originally described by

Girón-Arango et al.[5] Next, we performed an anatomical dissection to determine the appearance and dye dispersion within the anterior capsule region and compare both methods.

In group 1 (G1), which was randomly composed of the first 10 cadavers (20 hips), we followed the proposed anesthetic block technique,[5] but taking as parameters only the local anatomical structures herein described, with no direct visualization of adjacent structures using a US equipment. In group 2 (G2), which was also composed of 10 cadavers (20 hips), we performed the conventional US-guided infiltration technique.

Infiltration Technique

We placed the cadaver in horizontal dorsal decubitus (HDD), with no traction, and the hip in a neutral position. The G1 underwent infiltration with no US guidance as follows:

- Identification by palpation of the anterosuperior iliac spine (ASIS) and the pubic symphysis (PS), drawing a straight line between these points.
- Segment division in three equal portions and marking of the midpoint of the lateral third as the needle entry point (►**Fig. 1**).
- Positioning of a disposable needle for spinal anesthesia (0.7 × 88 mm, 22 G x 3.5", Spinocan, B. Braun, Melsungen, Germany) at the demarcated point, approximately 1 cm from the medial edge of the ASIS. The needle was inclined at 70° in the inferior medial direction and towards the midpoint of the line connecting the ASIS to the PS (►**Fig. 2**).
- The needle is introduced until it touches the bone.
- Needle is receded for about 1 mm and slow, continuous infiltration of 20 mL of methylene blue is performed.



Fig. 1 Demarcated segment between the anterosuperior iliac spine (ASIS) and the pubic symphysis (PS).

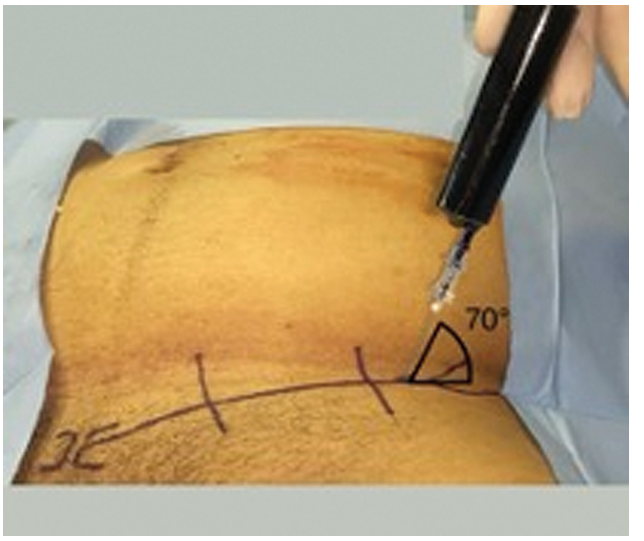


Fig. 2 Needle insertion at a 70° of inclination at the midpoint of the lateral third.

The US-assisted technique, to which the G2 was submitted, consists of the following:

- With the patient in HDD, we positioned a low-frequency (2–5 MHz) convex US probe (Sonosite Edge II, Fujifilm Healthcare, Lexington, MA, United States) over the midpoint of the lateral third of the segment marked in ►**Fig. 1** in a transverse plane with 45° counterclockwise rotation of the PS (►**Fig. 3**).
- Visualizing the iliopsoas tendon and muscle, and the femoral artery and vein, we inserted a needle with the same specification up to the plane between the iliopsoas structures anteriorly and the iliopubic branch, with the iliopectineal eminence posteriorly (►**Fig. 4**).
- We infused 20 mL of methylene blue in the region.
- We dissected the region and analyzed the correlation and distance between the needle and local significant structures in both techniques.



Fig. 3 Probe positioning in the midpoint of the demarcated segment, with the PS at 45° of inclination.

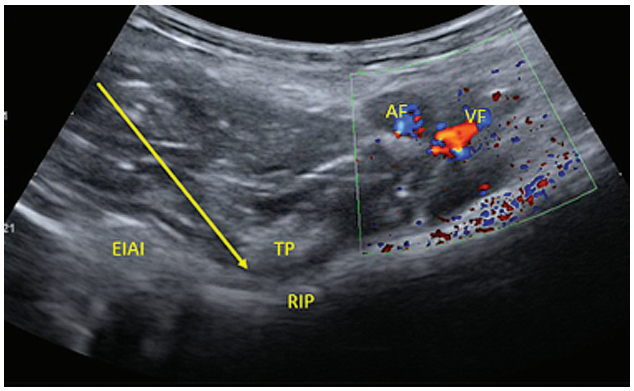


Fig. 4 Ultrasonographic image of the needle path (arrow). Abbreviations: ASIS, anteroinferior iliac spine; FA, femoral artery; FV, femoral vein; IPB, iliopubic branch; PT, iliopsoas muscle tendon.

Infiltration Analysis

We determined the reliability of the injection per the number of puncture attempts to reach the expected location of the needle at the iliopectineal eminence of the iliopubic branch.

We dissected the anterior region of the hip using a quadrangular skin flap whose apex is on the line from the ASIS to the PS and the base is between the inferior gluteal fold and the midline of the thigh, extending along the anterolateral aspect of the hip (►**Fig. 5**). After dissection, we identified the ASIS, the anteroinferior iliac spine (AIAI), the inguinal ligament, the femoral neurovascular bundle, the joint capsule, and the iliopsoas tendon and muscle.

After identifying the aforementioned anatomical structures, we evaluated the integrity of the neurovascular bundle due to potential lesions related to a path error and their correlations with the orifice. In addition, we determined the dispersion of the methylene blue dye within the desired plane and the anterior capsule staining to compare the effectiveness of both techniques (►**Fig. 6**).

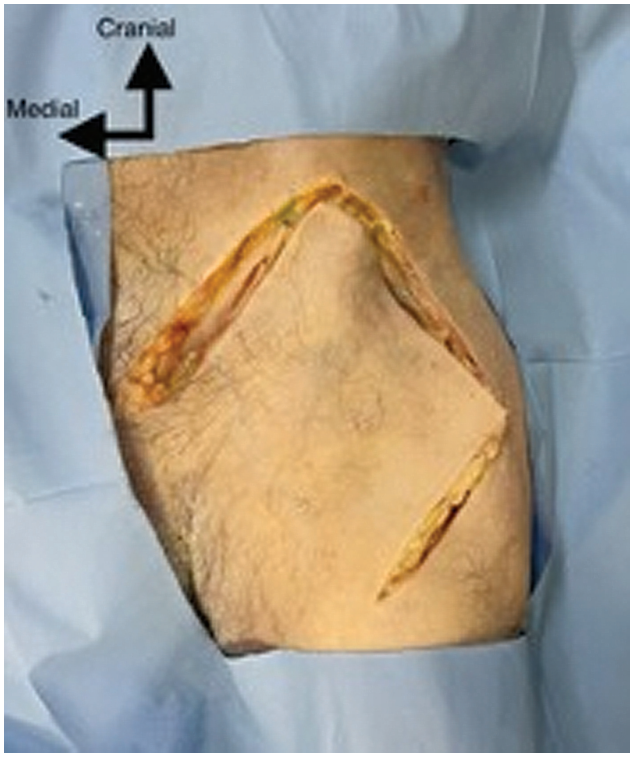


Fig. 5 Quadrangular skin flap for dissection.



Fig. 6 Rectus femoris (RF) muscle retracted for better visualization of the methylene blue dispersion and anterior capsule staining..

Results

The G1 consisted of 8 male (80%) and 2 female (20%) cadavers with a mean age of 70 years and 2 months, a mean weight of 59 Kg, and a mean height of 168 cm. ►**Table 1** shows the data from this analysis (►**Figs. 7** and **8**).

Table 1 Anthropometric data from the group submitted to the technique with no ultrasound guidance

Identification	Gender	Age (years)	Height (meters)	Weight (kilosg)
C1	Male	70	1.73	46
C2	Female	77	1.44	44
C3	Male	69	1.76	85
C4	Male	93	1.63	49
C5	Male	64	1.68	55
C6	Female	62	1.73	60
C7	Male	48	1.66	69
C8	Male	52	1.7	71
C9	Male	78	1.76	68
C10	Male	89	1.7	43

Abbreviation: C, cadaver.

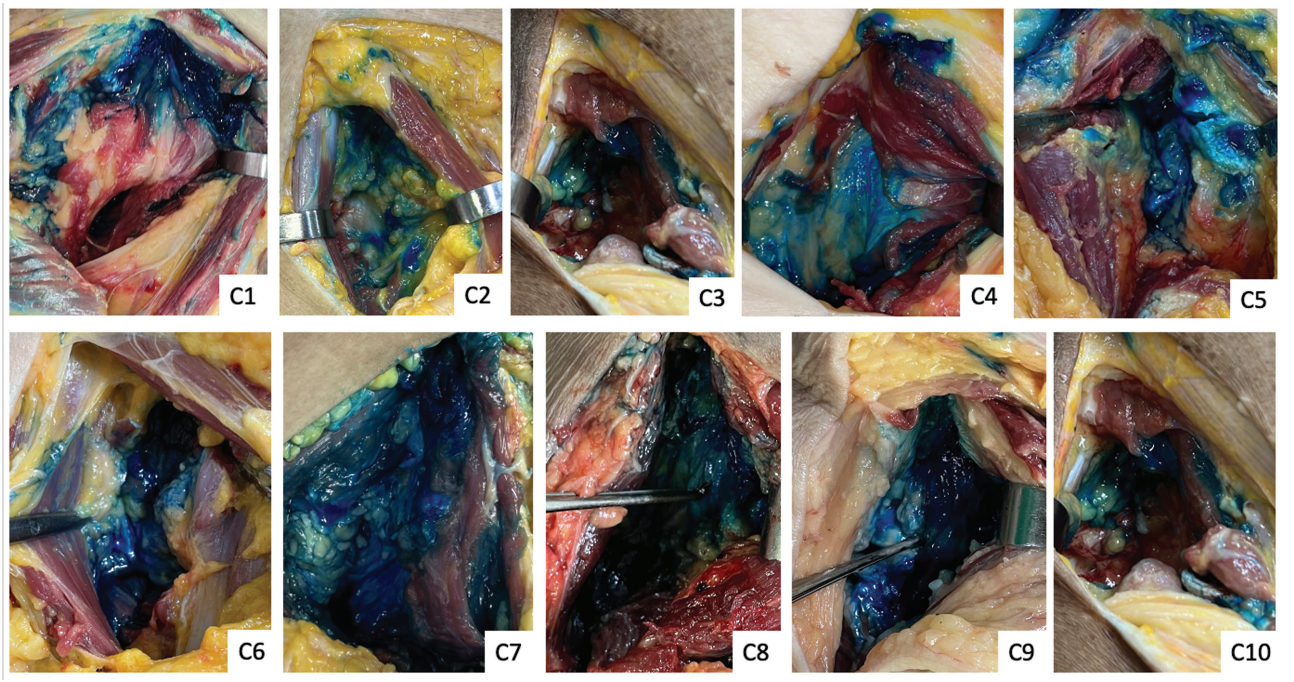


Fig. 7 Right hips from the group submitted to the technique with no ultrasound guidance, showing all capsules stained. Abbreviations: C1 to C10, cadavers 1 to 10.

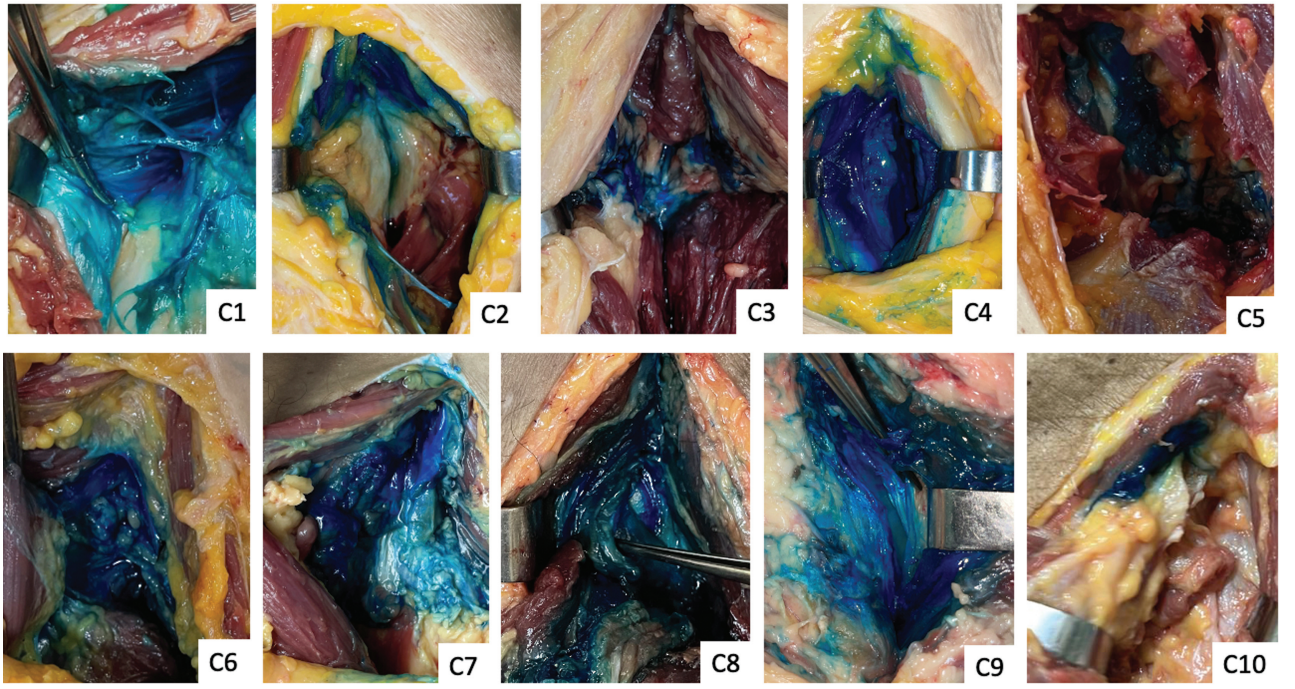


Fig. 8 Left hips from the group submitted to the technique with no ultrasound guidance, showing all capsules stained. Abbreviations: C1 to C10, cadavers 1 to 10.

The G2 consisted of 6 male (60%) and 4 female (40%) cadavers with a mean age of 68 years and 6 months, a mean weight of 72.6 Kg, and a mean height of 169 cm. ►**Table 2** shows the data from this analysis (►**Figs. 9** and **10**).

In the comparative analysis of the dissections, 1 hip from each group (5%) did not show adequate dye dispersion within the anterior capsule. Both techniques led to the expected location of the needle next to the iliopectineal eminence in the first puncture. There was no lesion, transfixion, or dye staining in neurovascular structures adjacent to the anterior capsule. ►**Tables 3** and **4** show the data from this analysis.

There was no difference between the techniques regarding these parameters. We obtained an adequate dye dispersion at the expected region in 95% of the cases in each group.

Table 2 Anthropometric data from the group submitted to the technique with ultrasound guidance

Identification	Gender	Age (years)	Height (meters)	Weight (kilos)
C11	Male	70	1.72	69
C12	Female	94	1.55	45
C13	Male	45	1.77	57.6
C14	Male	71	1.77	102
C15	Female	79	1.67	87
C16	Male	82	1.75	75
C17	Male	49	1.71	74
C18	Female	50	1.71	72
C19	Male	65	1.71	81
C20	Female	81	1.55	64

Abbreviation: C, cadaver.

Discussion

The proposed technique with no US guidance showed similar results to the PENG block technique aided by US, with no variations between them.

The failure in staining a single anterior capsule in each group occurred in the specimens with the lowest weight (43 Kg and 45 Kg) and oldest ages (89 and 94 years) among the remaining cadavers. This finding may result from the tissue atrophy inherent to advanced age and the smaller space between tissue planes in subjects with lower weights, which impair the effectiveness of the block using a liquid anesthetic dispersion.[3]

The pioneer study can help patients with hip pain of various causes in need of relief. It is worth mentioning that the technique with no US guidance is technically easy and cheap. Since it can be performed with basic hospital

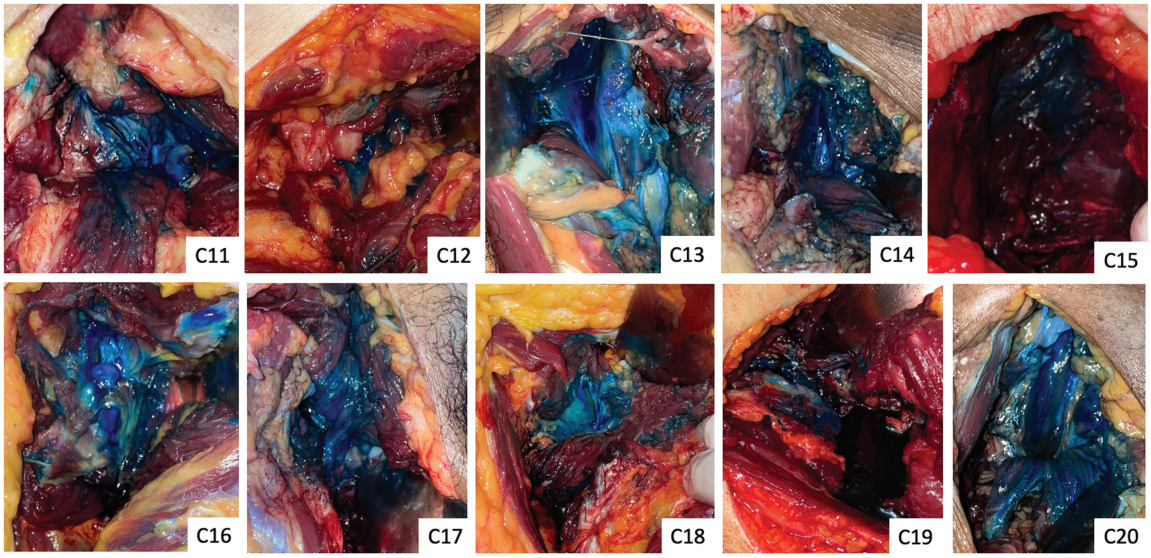


Fig. 9 Right hips from the group submitted to the technique with ultrasound guidance, showing no capsule staining. Abbreviations: C11 to C20, cadavers 11 to 20.

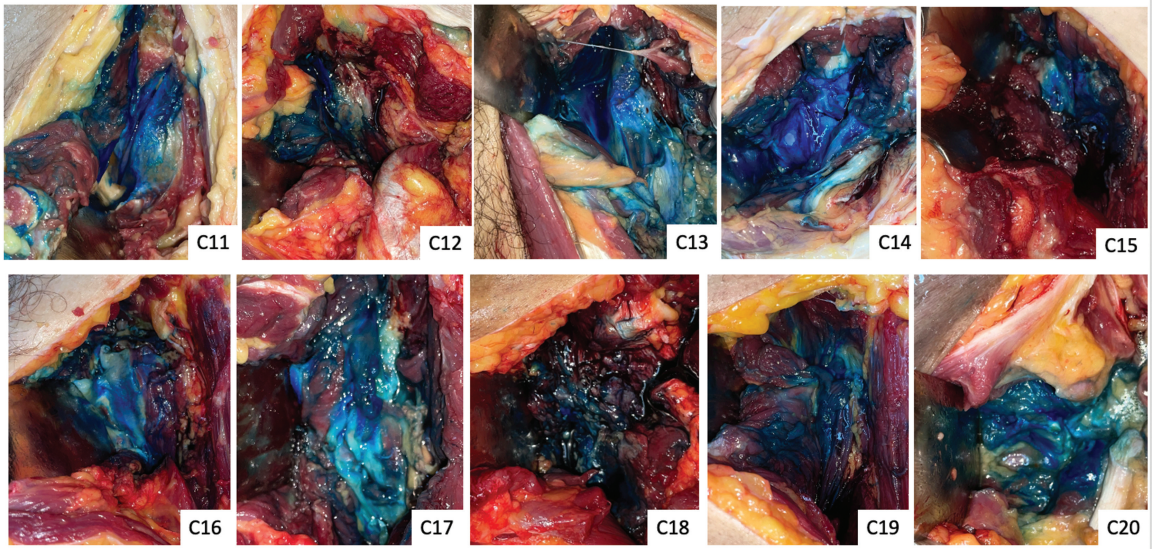


Fig. 10 Left hips from the group submitted to the technique with ultrasound guidance, showing no capsule staining. Abbreviations: C11 to C20, cadavers 11 to 20.

Table 3 Puncture data and dissection analysis from the group submitted to the technique with no ultrasound guidance

Identification	Bone reached at first puncture	Neurovascular bundle hit	Right anterior capsule staining	Left anterior capsule staining
C1	Yes	No	Yes	Yes
C2	Yes	No	Yes	Yes
C3	Yes	No	Yes	Yes
C4	Yes	No	Yes	Yes
C5	Yes	No	Yes	Yes
C6	Yes	No	Yes	Yes
C7	Yes	No	Yes	Yes
C8	Yes	No	Yes	Yes
C9	Yes	No	Yes	Yes
C10	Yes	No	Yes	No

Abbreviation: C, cadaver.

Table 4 Puncture data and dissection analysis from the group submitted to the technique with ultrasound guidance

Identification	Bone reached at first puncture	Neurovascular bundle hit	Right anterior capsule staining	Left anterior capsule staining
C11	Yes	No	Yes	Yes
C12	Yes	No	No	Yes
C13	Yes	No	Yes	Yes
C14	Yes	No	Yes	Yes
C15	Yes	No	Yes	Yes
C16	Yes	No	Yes	Yes
C17	Yes	No	Yes	Yes
C18	Yes	No	Yes	Yes
C19	Yes	No	Yes	Yes
C20	Yes	No	Yes	Yes

Abbreviation: C: cadaver.

materials and supplies, it constitutes a viable alternative in situations with limited access to US equipment in different sectors and levels of care. In addition, it may be a good option for analgesia, preventing the use of oral opioids and their side effects.[5,6]

The limitation of the present study is the use of cadaveric specimens, which may present tissue and anatomical plane changes despite the recent post-mortem period.

Conclusion

The proposed method of hip PENG block with no US guidance is reproducible, safe, effective, and highly reliable when compared with the US-guided technique.

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

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Fracture in Irradiated Rat Femur: A Description of an Experimental Model and Evaluation of its Effectiveness

Fratura em fêmur irradiado de rato: Descrição de um modelo experimental e avaliação de sua eficácia

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Abstract

Objective We aim to describe an experimental model for studying femoral fractures in rats after exposure to ionizing radiation, demonstrating a way to apply a substance for analysis, the method for patterning fracture and irradiation, and how to evaluate its effectiveness based on radiographic studies.

Methods We used 24 rats divided into 2 groups of 12 animals each. The STUDY group was exposed to ionizing radiation and treated with saline solution, and the CONTROL group was not exposed to radiation and was treated with saline solution. All animals were subjected to standardized fracture of the right femur that was fixed with intramedullary wire. The efficiency of the bone union was assessed by radiographic exam.

Results Fracture healing was more efficient in bones not exposed to ionizing radiation ($p = 0.012$). All fractures met the criteria of being simple, diaphyseal, transverse or short oblique.

Conclusion The experimental model presented is an efficient alternative for the study of fractures in irradiated bones in rats.

Keywords
- fracture healing
- radiation effects
- radiotherapy
- fractures, spontaneous

Resumo

Objetivo Nosso objetivo é descrever um modelo experimental para estudo de fraturas de fêmur em ratos após exposição a radiação ionizante, demonstrando uma forma de aplicação de uma substância para análise, o método de padronização de fratura e irradiação e a forma de avaliação de sua eficácia com base em estudos radiográficos.

Métodos Utilizamos 24 ratos divididos em dois grupos de 12 animais cada. O grupo ESTUDO foi exposto à radiação ionizante e tratado com soro fisiológico, enquanto o grupo CONTROLE não foi exposto à radiação e foi tratado com soro fisiológico. Todos os animais foram submetidos à fratura padronizada do fêmur direito e sua fixação

Palavras-chave
- consolidação da fratura
- efeitos da radiação
- fraturas espontâneas
- radioterapia

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com fio intramedular. A eficácia da consolidação óssea foi determinada por exame radiográfico.

Resultados A cicatrização de fraturas foi mais eficiente em ossos não expostos à radiação ionizante ($p = 0,012$). Todas as fraturas atenderam aos critérios de serem simples, diafisárias, transversas ou oblíquas curtas.

Conclusão O modelo experimental apresentado é uma boa alternativa para o estudo de fraturas em ossos irradiados em ratos.

Introduction

Radiotherapy is an important therapeutic tool, especially for local control of tumors. It is used in the treatment of several oncological pathologies, contributing to their cure. However, its use is not free of complications. Healthy tissues exposed to its field of action undergo changes in their physiology, which can lead to complications that are of difficult resolution.[1]

Specifically in skeletal tissue, radiotherapy can lead to necrosis, actinic osteitis, osteomyelitis, and pathological fractures that can progress to nonunion. Although these complications are frequently described, little is known about their etiology and how to solve these problems.[1]

There are some studies that address fractures in irradiated bones.[2,3] However, they do not describe the method used to perform the fractures and irradiation. An experimental model must be reproducible and patternable as much as possible the variables to be studied.

We aim to describe an experimental model for studying femoral fractures in rats after exposure to ionizing radiation, demonstrating a way to apply a substance for analysis, the method for patterning fracture and irradiation, and how to evaluate its effectiveness based on radiographic studies.

Method

The present study was initiated after authorization from the Animal Use Ethics Committee (CEUA) under opinion number 40/2014.

In our study, we used 24 female Wistar rats, 3 months old, which were divided into 2 groups of 12 animals. The animals in the STUDY group underwent a radiotherapy session and received 0.3ml of saline solution at the fracture site. The CONTROL group was not submitted to radiotherapy, and also received 0.3ml of saline solution in the fracture focus.

Any procedure with potential physical or emotional suffering for the animals was performed under anesthesia. For this, they received an intraperitoneal dose of Ketamine Hydrochloride at a dose of 60 mg/kg and Xyliazine Hydrochloride at a dose of 15 mg/kg.

Irradiation

Irradiation was performed at the Gamma Irradiation Laboratory of the Nuclear Technology Development Center / National Nuclear Energy Commission (LIG–CDTN/CNEN, in the Portuguese acronym). The laboratory uses a category II multipurpose panoramic radiator, manufactured by MDS Nordion (Canada), Model/serial number IR-214 and type GB-127, equipped with a Cobalt-60 (60Co) dry-storage source with maximum activity of 2,200 TeraBequerel (TBq) or 60,000 Curio (Ci) (►**Fig. 1**)

The focus of the radioactive beam was directed to the area of the right femur. The irradiation dose, with exposure of the area to be studied to the 60Co source in the dosage, was 18 Gy (2), in a single dose at a depth of 1.5 cm. The animals were placed 30 cm away from the radioactive source and exposed for 77 seconds.

As it is a panoramic radiator, the radiation was directed to the rat's right femur through lead shields developed specifically for this purpose. The lead shields have holes of five centimeters in diameter, which directed the radiation exclusively to the right femur of the animals (►**Fig. 1**).

Femoral Shaft Fracture

Two weeks after irradiation, the animals underwent a diaphyseal fracture of the right femur. To standardize the type of fracture, we used a guillotine developed specifically for this purpose, which produces a transverse or short oblique, diaphyseal fracture, similar in all animals (►**Fig. 2**).

The guillotine is composed of a stainless steel weight of 1.3 kg, which runs along a 50 cm rail, accelerated by the force of gravity. The impact is dampened by a 6.0-cm high spring, also in stainless steel. The impact is transmitted to the femur of the animals by the guillotine blade, which has a blunt tip. The femur is positioned on supports, also made of steel, with a distance between them of 2.5 cm.

Femoral Fracture Fixation

The animals were anesthetized and underwent surgical reduction of the femoral diaphyseal fracture. After anesthesia, surgical site trichotomy and skin asepsis were performed with an alcoholic solution of 5% Chlorhexidine Digluconate. Longitudinal surgical access was performed on the lateral aspect of the thigh, opening the skin and the musculature of the thigh of the animal. With the opening of the musculature, the fracture was exposed.

The fracture was fixed with a Kirschner wire measuring one millimeter in diameter and closed by suturing in layers. Initially, the muscular plane was closed and then the skin suture. After closure, infiltration was performed with 0.3 ml of 0.9% saline solution. The saline solution can be substituted

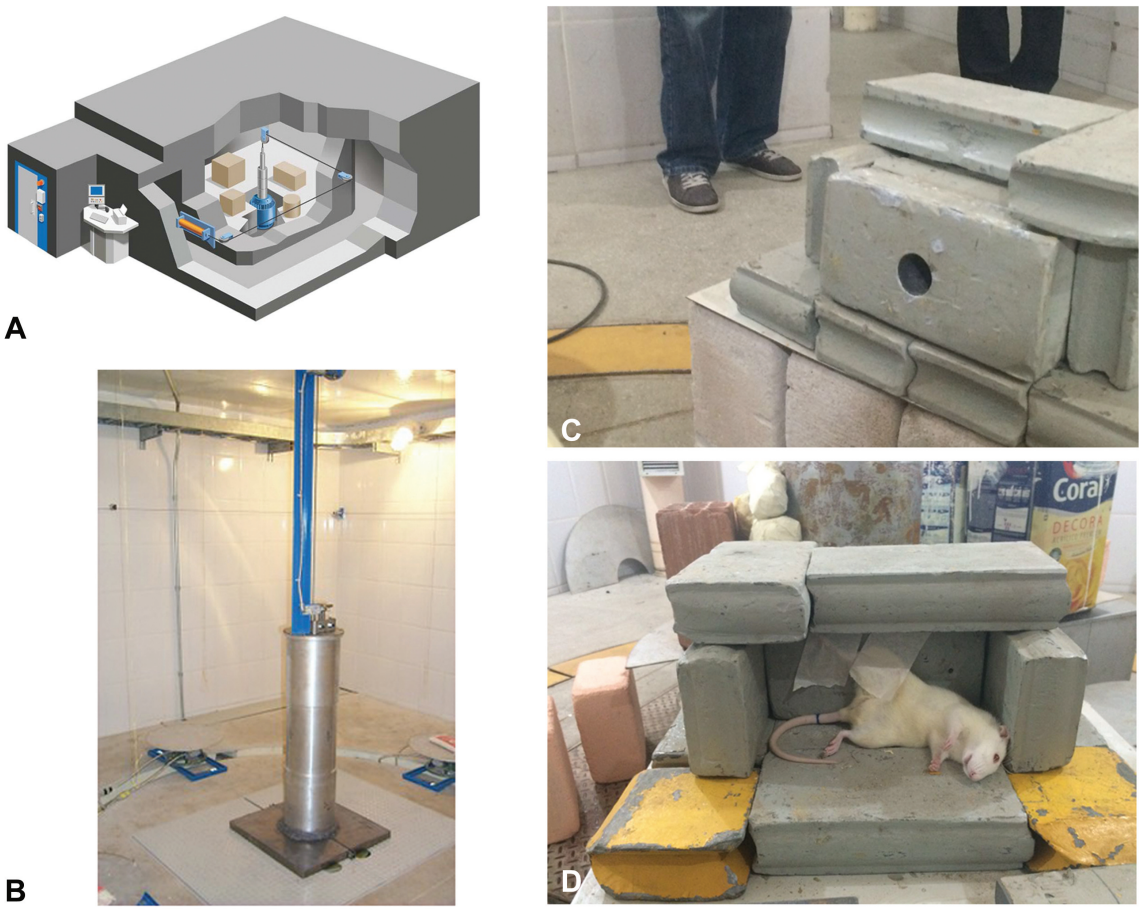


Fig. 1 Method for irradiation. (A) 3D plan of the collimator room; (B) Cobalt 60 Source; (C) Lead blocks for directing the radioactive beam; (D) Anesthetized animal, positioned for procedure.



Fig. 2 Guillotine developed for femoral diaphyseal fractures. On the left, the entire structure can be seen. In the center, a detail of the weight at the end of the track. On the right, the tip of the guillotine with a simulation of fracture production.

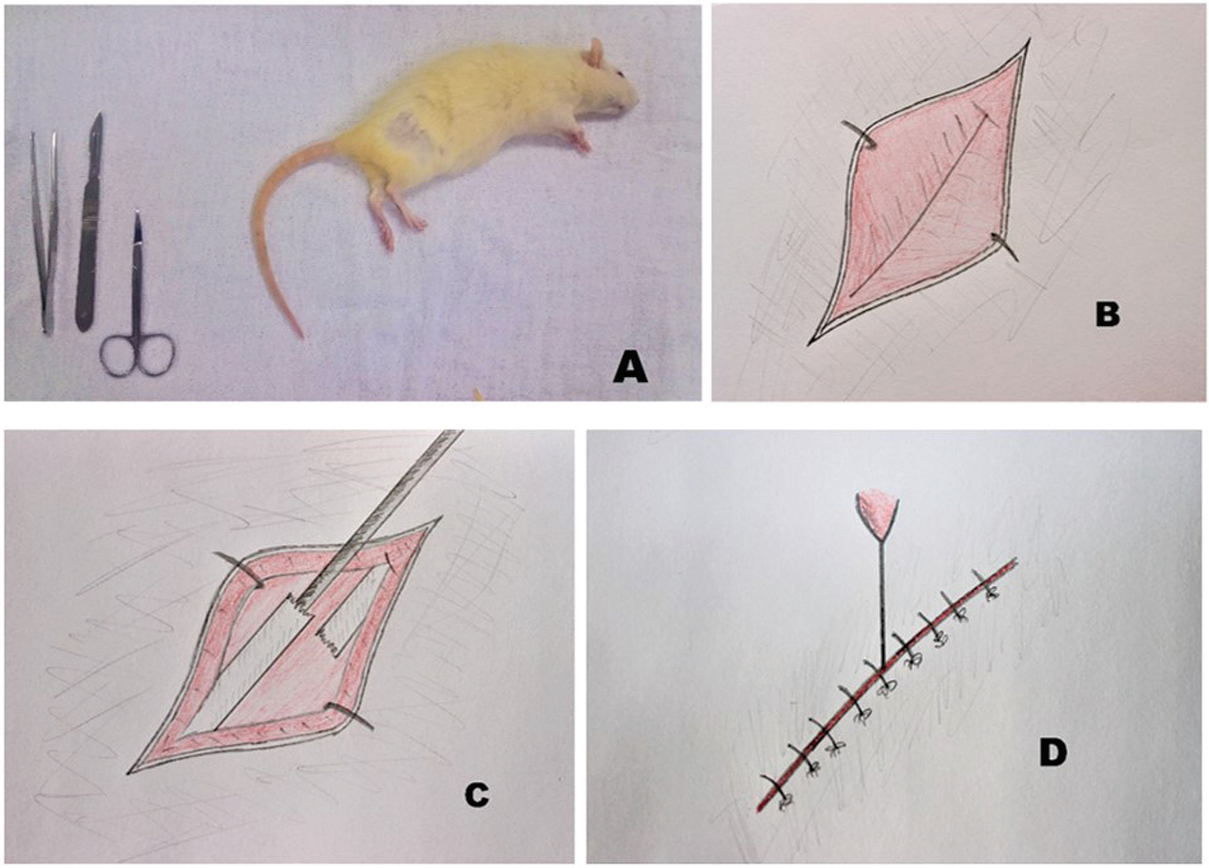


Fig. 3 Example of a surgical procedure performed on animals. (A) Anesthetized animal, after trichotomy, prepared for surgical procedure. (B) Schematic representation of surgical access in cutaneous and muscular planes. (C) Schematic representation with an open fracture focus, being fixed with a smooth intramedullary wire. (D) Schematic representation of wound after closure receiving saline treatment.

for any substance to be studied. ►**Fig. 3** demonstrates the surgical procedure schematically.

Radiographic Study

Three weeks after the fracture, the animals were euthanized and the right femurs were removed. Imaging exams were performed using digital radiographs. The removed right femur was placed in a 10% buffered formalin solution for 5 days, being radiographed after this time.

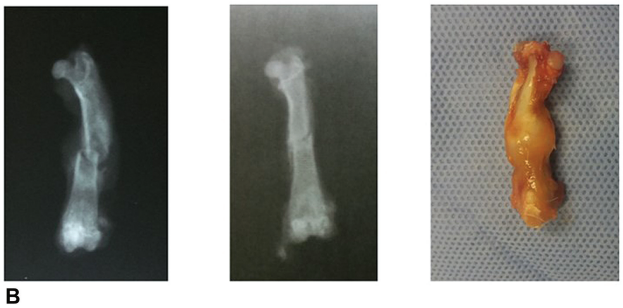
Digital radiographs were taken using a radiographic device (Raiotécnica, model 30 × 60, series 2577) coupled to an AGFA processor (model CR30X). Images were printed by an OKI printer (model C911 MDI). The radiographs were taken at a dose of 40 kilovolts (kV), 2mAs at 1 m away from the X-ray source, in an air-conditioned environment at 20°C.

The radiographs were evaluated for the presence of the fracture, the degree of fracture comminution, the location of the fracture, and its evolution to bone union. Comminuted or segmental fractures would be excluded, and only simple, transverse, or short oblique fractures would be included in the study.

To measure the degree of consolidation of fractures on radiography, we used the Lane–Sandhu classification[4,5]: (0) complete absence of consolidation; (1) initial callus formation; (2) initial ossification; (3) initial disappearance of the fracture line; (4) complete consolidation of the fracture. ►**Fig. 4** discriminates the classification used.

Lane–Sandhu Scoring System		
Type	**Description**	**Consolidation**
0	Complete absence of healing	Insufficient
1	Initial callus formation	Insufficient
2	Initial ossification	Sufficient
3	Initial disappearance of the fracture line	Sufficient
4	Completer fracture healing	Sufficient

A



B

Fig. 4 Classificação radiográfica para consolidação de fraturas em ratos (A) Exemplo radiográfico da consolidação (B) À esquerda, a radiografia do animal número 20, classificado como tipo "1," ou seja, consolidação Insuficiente. Ao centro, a radiografia do animal número 4, classificado como tipo "3," ou seja, consolidação Suficiente. A direita a peça anatômica no momento da radiografia.

For statistical purposes, types 0 and 1 were grouped under "Insufficient Consolidation" and types 2, 3 and 4 under "Sufficient Consolidation."

Statistical Analysis

Data comparison was performed using IBM SPSS Statistics for Windows version 22 (IBM Corp., Armonk, NY, USA). Data were compared using the chi-squared test with Fisher correction. We established a test power of 80%, with a 5% confidence interval (CI). We consider differences for $p < 0.05$.

To assess the effectiveness of the method for studying fractures in irradiated bone, we compared the union between the groups. A group with a higher concentration of samples with inefficient consolidation indicates that the method is effective. To evaluate the fracture standardization method, we will evaluate the frequency with which we obtained comminuted fractures, as we want short transverse or oblique fractures.

Results

Fracture healing, assessed by radiographic examinations, was more efficient in bones not exposed to ionizing radiation ($p = 0.012$). In the STUDY group, of the 12 animals, 10 had insufficient consolidation. In the CONTROL group, 3 of the 12 animals had insufficient consolidation (►**Table 1**, ►**Fig. 5**).

All fractures met the criteria of being simple, diaphyseal, transverse or short oblique.

Discussion

Fractures are frequent complications of radiotherapy treatments. However, this is an understudied subject. The creation of a reproducible experimental model has great potential to contribute to filling this gap in the literature. The development of an accessible method, standardizing variables such as the type of fracture, dose and direction of the radiation beam, sample processing, and its availability for imaging or histology studies are important to study this problem.

The ideal animal for experimental studies on long bone fractures is the rat (Rattus norvegicus).[6] It is an animal capable of reproducing the healing process of human bone tissue, with long bones of sufficient size to carry out studies based on a standardized experimental model. In our study, we used female Wistar animals, 3 months old. These have long bones of sufficient size to allow proper manipulation in the laboratory.

Table 1 Results and statistical analysis of data regarding radiographic classification

Radiographic Evaluation	Study	Control	*p-value*
Insufficient	10 (83.3%)	03 (25.0%)	0.012
Sufficient	02 (16.7%)	09 (75.0%)	



Fig. 5 Examples of radiographs of animals in each group. On the left, we have a typical radiograph of animals in the STUDY group. It is classified as type "0" – Insufficient. On the right, is an example of a typical image from the CONTROL group, classified as type "3" – Sufficient.

In our study, we observed differences in fracture healing when comparing the groups. Animals in the STUDY group had less efficient consolidation than those in the CONTROL group. As the only difference between them is the femoral exposure to ionizing radiation, this result suggests that the method is efficient for the experimental reproduction of the fracture that occurs in irradiated bone.

There are some alternatives to tissue exposure to ionizing radiation. Most publications use a specific device for hospital radiotherapy to perform it. In our model, we used a panoramic radiator with a Co60 source, with the radioactive beam directing through lead shields. In this way, we use the same radioactive isotope that most radiotherapy devices use. The effectiveness of this method was proven by the relevant difference in the healing of fractures in the STUDY and CONTROL groups, assessed in radiographic examinations.

Our results also support the effectiveness of the parameters used in the study. We highlight the exposure in a single dose and the radiation dose used. We used a dose of 18 Gy, in a single dose, at a depth of 1.5 cm. This was the same used by Nicholls et al.,[2] also with proven efficiency.

An important limitation of this experimental model is its difference in relation to the pathology that occurs in humans. Here, we present a way to study the healing of a fracture that occurs in a previously irradiated bone, which is different from a pathological fracture after radiotherapy. In humans, the fracture occurs due to mechanical failure, probably related to factors such as tissue necrosis and local inflammatory response, occurring after a long period of time.[1,7,8]

The methodology applied for fracture simulation is an important point of the present study. Other published models do not describe how the standardization of fractures was performed.[2,9,10] It seems relevant to us that the fractures have the same pattern. We achieved this standardization using a guillotine designed specifically for this purpose. All fractures obtained were transverse diaphyseal or short oblique, a fact that demonstrates the efficient standardization of

the fracture type. Therefore, we recommend using this method for standardizing the femoral fracture.

We performed surgical treatment of fractures by open reduction and intramedullary fixation with a 1.0mm thick Kirschner wire. In our experience, we observed that retrograde intramedullary fixation is efficient for fracture stabilization, promoting its consolidation. We used a time interval of 3 weeks between the fracture and the death of the animals. This time is enough for an initial consolidation of the fracture to occur. We believe that this is the optimal period to evaluate the results in rats.

After closing the surgical wound, we infiltrated 0.3 ml of saline solution into the fracture site. In studies designed to assess the effectiveness of any compound, they can be inserted into the fracture focus in the same way.

In the present study, we chose to assess the outcome based on digital radiographic exams. Other ways of evaluating the obtained samples are described.[3,11,12] The sample obtained can be decalcified and placed in formalin blocks for histological study, if this is the chosen option.

There are some options for the experimental study of fractures in irradiated bones. The use of a cobalt-60 source directed by lead shields to the point to be studied, with standardization of radiation dose, the method of producing the fracture, its fixation, and the way to administer the material to be studied are central points for the reduction of confounding factors. Here, we present an efficient and reproducible method for this purpose.

Conclusions

1. The irradiation method presented is an efficient alternative for the study of fractures in irradiated bones in rats.
2. The fracture standardization method proved to be efficient, producing diaphyseal, transverse or oblique fractures.

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

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Supracondylar Apophysis of the Humerus: Rare Cause of High Compression of the Median Nerve*

Apófise supracondilar do úmero: Causa rara de compressão alta do nervo mediano*

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Abstract

Supracondylar apophysis (SA) is a bony prominence that originates from the anteromedial aspect of the distal humerus with a lower projection and which, although usually asymptomatic, due to the relationship with adjacent structures can cause symptoms. We describe the case of a 42-year-old woman with pain complaints radiating from her elbow to her hand, with 6 months of evolution. On objective examination, the patient had a sensory deficit in the median nerve territory and decreased grip strength. Radiographs of the distal humerus were performed, in which a bone spike was visible, and magnetic resonance imaging showed thickening of the median nerve epineurium. Electromyography showed severe axonal demyelination of the median nerve proximal to the elbow. A median nerve compression caused by a SA was diagnosed. The patient underwent surgery and, 1 year after the operation, she had a complete clinical recovery. Supracondylar apophysis is a rare, but possible and treatable cause of high median nerve compression.

Keywords

- supracondylar apophysis
- median nerve
- compressive neuropathy
- median nerve compression

Resumo

A apófise supracondilar (ASC) é uma proeminência óssea que tem origem na face anteromedial do úmero distal com projeção inferior e que, apesar de habitualmente assintomática, pela relação com as estruturas adjacentes pode causar sintomatologia. Descrevemos o caso de uma mulher de 42 anos, com queixas álgicas irradiadas do cotovelo à mão, com 6 meses de evolução. Ao exame objetivo, a paciente apresentava um déficit sensorial no território do nervo mediano e diminuição da força de preensão. Foram realizadas radiografias do úmero distal nas quais era visível uma espícula óssea, e na ressonância magnética era evidente o espessamento do epineuro do nervo mediano. A eletromiografia apresentou uma desmielinização axonal grave do nervo

Palavras-chave

- apófise supracondilar
- nervo mediano
- neuropatia compressiva
- compressão do nervo mediano

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mediano proximal ao cotovelo. Foi diagnosticada uma compressão do nervo mediano por uma ASC. A paciente foi submetida à cirurgia e 1 ano pós-operatório apresentou recuperação clínica total. A ASC é uma causa rara, mas possível e tratável da compressão alta do nervo mediano.

Introduction

Supracondylar apophysis (SA) is an anatomical structure described by Knox in 1841. This bone prominence of variable size originates from the anteromedial face of the distal humerus, protrudes inferiorly and represents a vestigial remnant typical of climbing animals. The fibrous band known as the *Struthers* ligament, usually appears as a continuation of the SA and forms a foramen in which the median nerve and the brachial artery can be compressed in their path.[1] The prevalence of this anatomical structure varies widely in studies (0.7–2.5%); however, it is unanimous that it is rare and more marked in the Caucasian ethnicity and in females.[2]

Case Report

A 42-year-old Caucasian woman with no major medical history was observed in an Orthopedics consultation due to progressive pain complaints radiating from the elbow to the left hand, with 6 months of evolution. On objective examination, the patient had a sensory deficit in the median nerve territory and decreased grip strength. No palpable swelling in the left upper limb, no positive Tinel throughout the median nerve path, and no vascular changes. Then, she underwent imaging exams to study the symptoms presented, which revealed: on the radiographs of the distal humerus, a bone spike of inferior orientation (►**Fig. 1**), and magnetic resonance imaging showed a thickening of the epineurium of the median nerve suggestive of nerve compression. On electromyography, the patient had severe axonal demyelination of the median nerve proximal to the elbow. Therefore, a compression of the median nerve was diagnosed by a SA.

The patient underwent surgery to excise this structure through an anterior route of the distal humerus. Intraoperatively, compression of the median nerve was confirmed (►**Figs. 2** and **3**) and excision of the SA and *Struthers* ligament



Fig. 1 Radiographs (face and profile views) of the left elbow showing the supracondylar apophysis of the distal humerus.

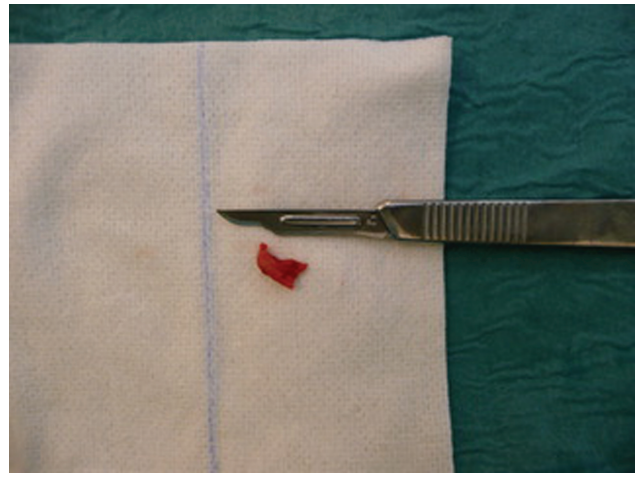


Fig. 3 Image of the supracondylar apophysis after excision.

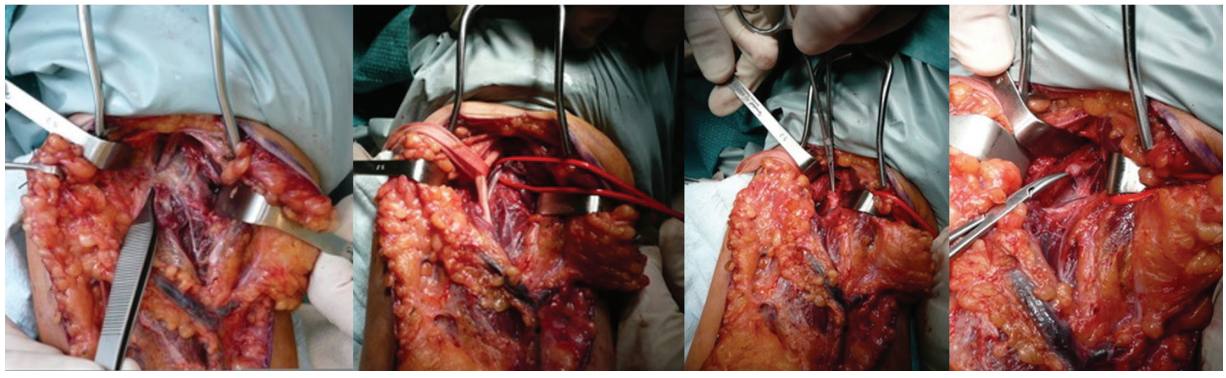


Fig. 2 Intraoperative images of the anterior plane dissection. Observation of several structures involved: median nerve, brachial artery, Struthers ligament, and supracondylar apophysis.

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was performed without complications. In the postoperative evaluation at 2 months, the patient had a significant improvement in neurological symptoms with gain in grip strength and decreased paresthesia. An electromyography was performed that showed an appreciable recovery of the left median nerve with normalization of the motor neurography. One year after the surgery, there was a complete regression of symptoms and strength recovery, comparable to the contralateral side.

Discussion

Supracondylar apophysis is an anatomical structure usually without clinical manifestations; however, in some cases, it can become symptomatic and manifest by swelling and/or symptoms of compression of the median nerve and brachial artery.[3] Soliere[4] reported, in 1929, the first case of clinical changes caused by the presence of a SA. This entity represents a diagnostic challenge, given the clinical presentation similar to the most common neuropathy of the upper limb—Carpal tunnel syndrome and also by the multiple possible sites of compression of the median nerve at the level of the elbow, which include: between the heads of the pronator teres, in the aponeurotic arch formed by the proximal insertion of the forearm flexor muscles, and in the *lacertus fibrosus*.[5] The possibility of treating heterotopic ossification or osteochondroma must also be part of the differential diagnoses, since this presents differentiating characteristics that pass through the orientation of the bone spike—not pointing towards the joint and continuing with the cortical humerus.[6]

Some clinical cases of neurovascular compression associated with this structure are described in the literature: Aydinlioglu et al.[7] described a case of bilateral compression of the median nerve by the SA; May-Miller et al.[8] reported a very rare case of compression of the cubital nerve, and there are also reports of fracture of this structure.[9]

In the clinical suspicion of neuropathy caused by the SA, imaging exams combined with electromyography are diagnostic, as in the clinical case we describe. The treatment recommended in symptomatic patients is surgical and consists of excision of the SA and of the *Struthers* ligament, when the latter is present, thus allowing confirmation of the decompression of the involved structures. As described in the literature and verified in the clinical case presently described, this treatment option is associated with good functional results in the short and long term.[10]

In conclusion, SA is a rare, but possible and treatable, cause of high median nerve compression.

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Conflict of Interests
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Open Fracture of the Femoral Neck in an Adult: Case Report and Surgical Solution*

Fratura exposta do colo do fêmur em adulto: Relato de caso e solução cirúrgica

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Abstract

Intracapsular proximal femoral fracture is a frequent injury in elderly patients, often associated with low-energy trauma and reduced bone mass. In young patient, it is uncommon, usually caused by high-energy trauma and accompanied by damage to the adjacent soft tissues. However, reports of open intracapsular proximal femoral fracture due to indirect trauma are rare in the orthopedic literature. In the present article, we describe a case of this injury in a 35-year-old man involved in a car accident. The proximal femur was exposed at the gluteal region due to a mechanism similar to dislocation of the posterior hip. We describe the initial treatment and subsequent management until achieving a definitive solution using total hip arthroplasty and muscle transfer to reconstruct the abductor mechanism of the hip. At 10 months of follow-up, the patient presented good functional outcome, with gradual recovery of the abductive strength and a Harris Hip Score of 91 points. In addition, a radiographic study showed that the cemented total prosthesis was well-positioned. This therapeutic strategy (total hip arthroplasty with muscle transfer to reconstruct the abductor musculature) was successful to treat an intracapsular proximal femoral fracture with bone exposure.

Keywords
- fractures, open
- femur neck
- adult
- aged

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Resumo

A fratura intracapsular do fêmur proximal é uma lesão frequente no paciente idoso, e em geral está associada a trauma de baixa energia e redução da massa óssea. No jovem, esta lesão é pouco frequente, decorre de trauma de alta energia, e resulta em dano das partes moles adjacentes. Contudo, o relato de fratura intracapsular do fêmur proximal com exposição óssea por trauma indireto é raro na literatura ortopédica. Neste relato, esta lesão foi diagnosticada em um homem de 35 anos, vítima de acidente automobilístico. Mediante um mecanismo semelhante ao da luxação posterior do quadril, o segmento proximal do fêmur determinou exposição óssea através da região glútea. Foram descritos o tratamento inicial e os tratamentos subsequentes até a solução definitiva por artroplastia total do quadril associada a transposição muscular para reconstrução do mecanismo abdutor do quadril. Após 10 meses de seguimento, o paciente apresentava boa recuperação funcional, com retorno gradual da força abdutora, Harris Hip Score de 91 pontos, com estudo radiográfico revelando prótese total cimentada bem posicionada. A estratégia terapêutica utilizada neste paciente (artroplastia total do quadril com transferência muscular para a reconstrução da musculatura abdutora) foi uma solução eficiente para tratar a fratura intracapsular do fêmur proximal com exposição óssea.

Palavras-chave

- fraturas expostas
- colo do fêmur
- adulto
- idoso

Introduction

Femoral neck fractures in patients younger than 50 years of age account for less than 5% of all hip fractures. These fractures result from high-energy trauma, and damage the soft tissues.[1] The pattern of the fracture pattern, the comminution in the focus of the fracture, and the degree of deviation of the fragments are associated with surgical complications, including lack of consolidation, osteosynthesis failure, and femoral head avascular necrosis.[2] When associated with a major trauma resulting in bone exposure and extensive injury to the soft tissue of the hip, this fracture becomes unique and difficult to solve.

Case Report

A Caucasian, single, 35-year-old male patient was involved in a car accident, and sustained typical trauma due to impact on the dashboard, resulting in a comminuted fracture at the left femoral neck with proximal migration of the diaphyseal segment, extensive injury at the gluteal musculature, and bone exposure. At the initial clinical evaluation, the patient was conscious, breathing normally, with no chest or abdominal complaints, and no signs of hemodynamic instability. Upon the physical examination, he reported severe hip pain and bleeding from a wound at the left gluteal region. The clinical examination also revealed pain and functional impairment at the ipsilateral knee, with joint instability suggesting a potential injury to the posterior cruciate ligament. A conventional radiographic study showed a comminuted, deviated fracture of the left femoral neck. Wound inspection revealed bone fragments, confirming it as an open femoral neck fracture (►**Fig. 1**). At the operating room, the fracture was mechanically cleaned with a thorough wound rinse. The fracture was aligned under traction, and the wound was closed in planes. Antibiotic therapy with intravenous cefazolin and tetanus prophylaxis were started. Five days after the initial trauma, a new surgical procedure was performed through an anterolateral approach to determine the potential of direct reduction and osteosynthesis. The surgical

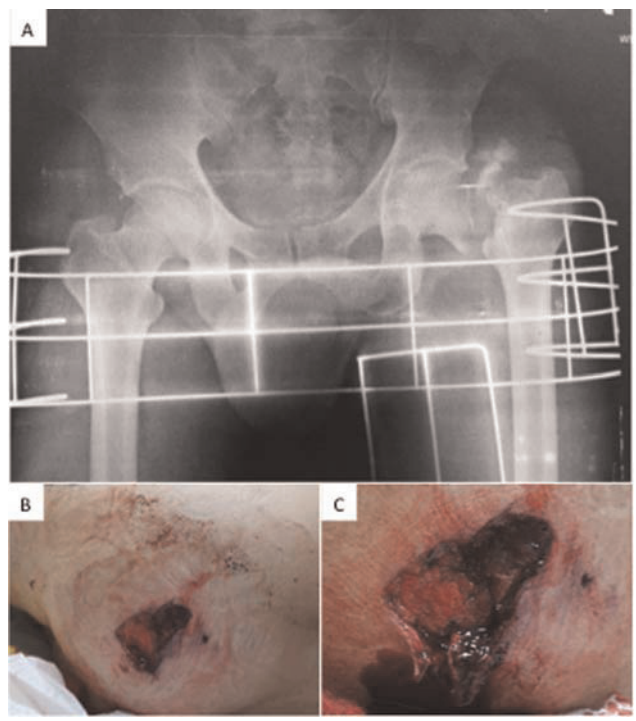


Fig. 1 Clinical and radiographic evaluation in the initial care provided to the patient: (**A**) panoramic anteroposterior radiograph of the pelvis showing a comminuted fracture at the left femoral neck with significant cephalic migration; (**B**) wound at the left gluteal region; (**C**) extensive muscle injury with bleeding and bone splinters confirming the diagnosis of open femoral neck fracture.

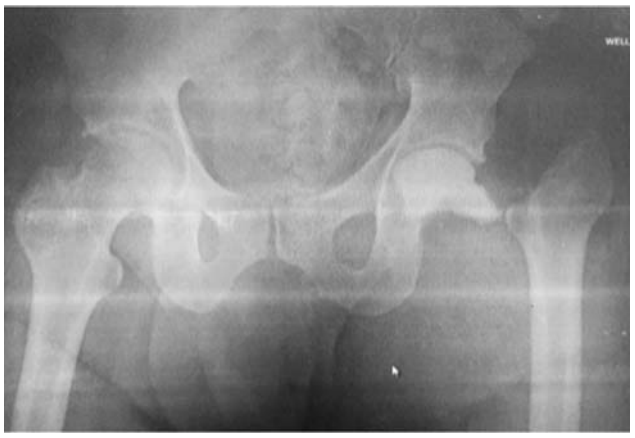


Fig. 2 Panoramic anteroposterior radiograph of the pelvis after the resection of the femoral head and placement of a non-articulated spacer.

finding was devastating, with a severe injury characterized by cephalic femoral devascularization and complete disinsertion of the iliopsoas, gluteus minimus, gluteus medius and external rotator muscles, as well as a circumferential capsulolabral lesion of the hip joint. We opted for a resection of the cephalic segment and placed a non-articulated bone cement spacer with antibiotics (vancomycin) to wait for the subsequent planning of a total hip arthroplasty (►**Fig. 2**). Eight weeks later, with negative culture tests, normal erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) levels, the third procedure was performed. Through a posterolateral approach, the spacer was removed, and a cemented total hip arthroplasty was performed. Next, the maximum gluteus muscle was transferred to restore the hip abductor mechanism according to the technique described by Whiteside[3] in 2012 (►**Fig. 3**). This technique is based on two gluteus maximus muscle flaps: the lower flap was sutured to the anterior capsule and the anterior border of the greater trochanter to emulate the function of the gluteus minimus, whereas the upper flap crossed the lower flap and was fixed at the lateral region of the greater trochanter to act as the gluteus medius (►**Fig. 4**). The patient evolved uneventfully until discharge. Partial loading with support was allowed for 3 months, and physical therapy was instituted for functional recovery. The patient evolved well, with gradual recovery of the abductive strength and negative Trendelenburg signal. Ten months after surgery, he presented a Harris Hip Score of 91 points, and a conventional radiography showed that the cemented total prosthesis was well-positioned (►**Fig. 5**).

Discussion

A query on the main available databases (Medline PubMed, LILACS, Scielo, Cochrane library) revealed no reports of a similar injury. There are some case reports of open anterior dislocation of the hip in adult patients,[4–6] and a single description of an open posterior dislocation in an adult who was run over on a public road.[7] Here, the trauma mechanism was knee impact on the car dashboard, which usually results only in posterior dislocation or fracture-dislocation of the hip through the posterior wall of the acetabulum, which is the most vulnerable. We believe that,

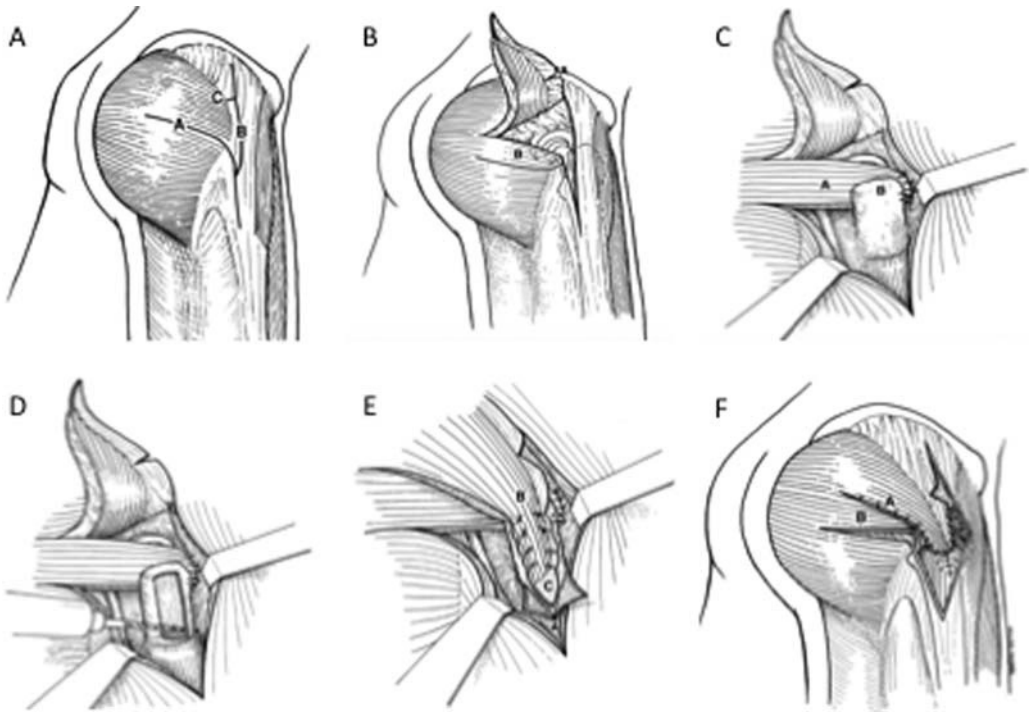


Fig. 3 Schematic representation of the maximum gluteus transfer technique for the restauration of the hip abductor mechanism: (**A**) planning of the maximum gluteus muscle flaps; (**B**) lifting of the upper flap; (**C**) fixation of the lower flap at the anterior part of the femoral neck; (**D**) preparation of the trochanter to receive the upper flap; (**E**) fixation of the upper flap; (**F**) final aspect of muscle the transfer. Adapted from Whiteside.[3]

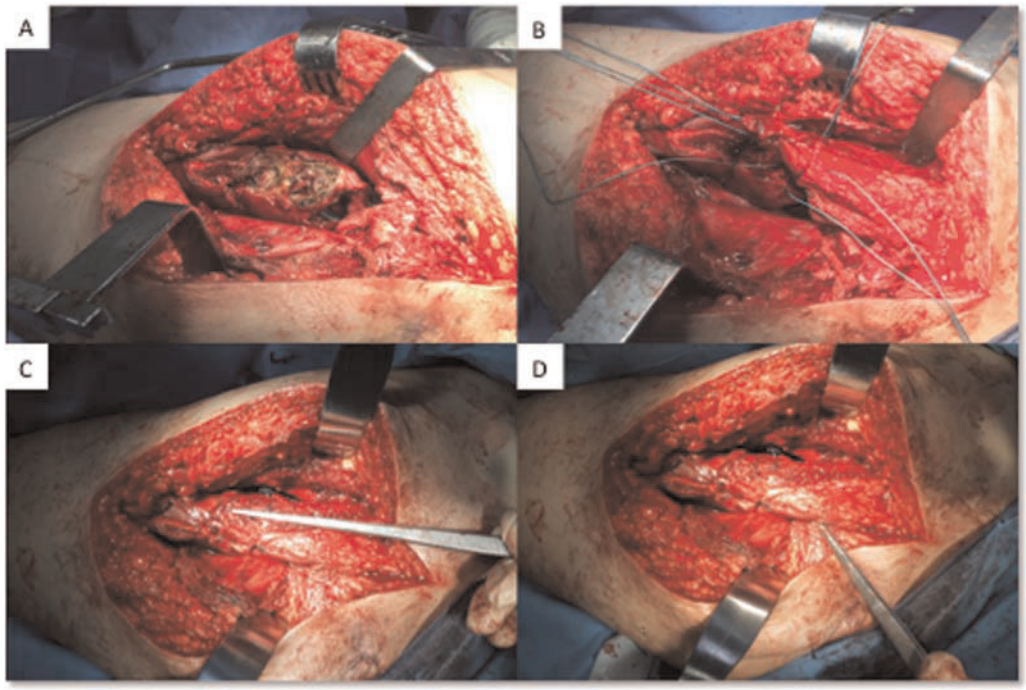


Fig. 4 Surgical image of the transfer of the gluteus maximus muscle to restore the abductor mechanism of the hip: (**A**) femoral preparation; (**B**) preparation of two flaps with preserved gluteus maximus muscle fibers; (**C**) upper flap crossing the first flap and fixation at the lateral region of the greater trochanter to function as the gluteus medius muscle; (**D**) lower flap transferred to the upper part of the femoral neck, under the tip of the greater trochanter, and sutured at the anterior capsule and at the anterior edge of the greater trochanter, to function as the gluteus minimus muscle.

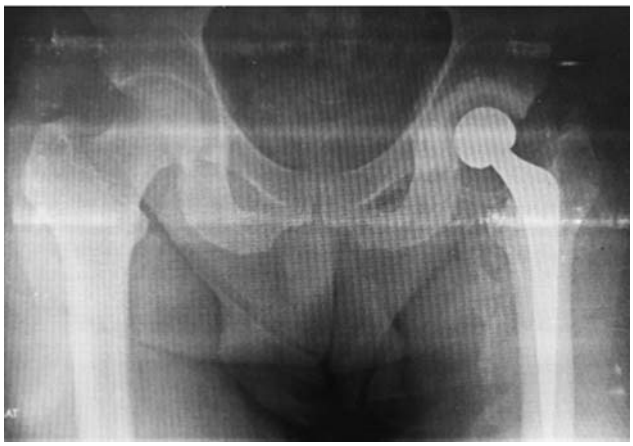


Fig. 5 Panoramic anteroposterior radiograph of the pelvis 10 months after surgery. Note the well-positioned cemented total prosthesis at the left hip.

at the time of trauma, the patient's hip was probably abducted, with the femoral head completely contained by the acetabular roof. Thus, the shear force vector caused the neck fracture, and the persistence of the impact energy resulted in upper migration of the proximal femur, with extensive soft tissue injury and bone exposure through the gluteal muscles. This mechanism is the same that causes femoral head fracture, which is often associated with posterior dislocation of the hip.[8] The ipsilateral knee ligament injury is also explained by this typical mechanism of knee trauma on a car dashboard during collision.

The blood supply to the femoral head is fragile and easily damaged by a deviated intracapsular fracture. The medial femoral circumflex artery supplies 82% of the femoral head and 67% of the femoral neck. The lateral femoral circumflex artery contributes to 18% and 33% respectively to the femoral head and neck vascularization. Both vessels branch off into delicate retinacular arteries spreading through the femoral neck surface up to the femoral head.[9] In our case, this vascular system was damaged due to disinsertion of the trochanteric musculature.

The therapeutic option consisting of reduction and osteosynthesis was ruled out due to the comminuted fracture focus and the risk of femoral head avascular necrosis. Thus, a total hip arthroplasty was indicated because of the biological risk of aseptic femoral head necrosis and the biomechanical risk related to the very high failure rate of an osteosynthesis at a fracture with a vertical line and posterior comminution of the femoral neck.[2] Another important aspect was the loss of the hip abductor musculature, resulting in a significant walk impairment and a potential predisposition to dislocation of the hip prosthesis. The Whiteside[3] technique enabled the stabilization of the prosthesis and minimized the walking deficit. Considering the favorable evolution of the patient, the muscle transfer described for revision of the hip prosthesis in case of loss of abductor musculature[10] was successful to treat this type of injury. Total hip arthroplasty associated with muscle transfer for the reconstruction of the abductor musculature was an efficient solution to treat open femoral neck fractures.

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Conflict of Interests
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Recurrent Anterior Shoulder Dislocation After Trauma with Coracoid Apophysis Fracture – A Rare Association*

Luxação anterior recorrente do ombro após traumatismo com fratura apófise coracoide – Uma associação rara

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Abstract

Anterior dislocations represent about 96% of total shoulder dislocations, with recurrence/instability being more common in young patients. Injury of other shoulder structures is frequent, namely bony Bankart lesion. However, the association with coracoid apophysis fracture is very rare.

The present article describes the clinical case of a 67-year-old man who presented to the emergency department with complaints of persistent omalgia, with acute episodes, beginning after a fall from his own height. The patient also presented history of shoulder trauma 3 months earlier, which was evaluated at another hospital. Shoulder anterior dislocation was observed radiographically, and the computed tomography (CT) confirmed bone erosion of the anteroinferior part of the glenoid (bone loss of about 50% of the anteroposterior diameter in the lower region of the glenoid), with almost complete resorption of the bony Bankart lesion (apparent in later analysis of the radiography of the initial traumatic episode). Connectedly, a transverse fracture of the coracoid apophysis (type II in the Ogawa classification) was diagnosed. The patient was submitted to surgical treatment, with anterior bone stop confection using the remnant of the fractured fragment of the coracoid supplemented by tricortical autologous iliac graft, fixed with cannulated screws (according to the Bristow-Latarjet and Eden-Hybinett techniques).

In the postoperative follow-up, a good functional result was observed, with no new episodes of dislocation and no significant pain complaints.

Keywords

- shoulder dislocation
- shoulder fractures
- coracoid process

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A rare association of shoulder lesions is described, and the challenge of their treatment is highlighted, given the late diagnosis, as in the case presented.

Resumo

As luxações anteriores representam cerca de 96% do total de luxações do ombro, sendo a recidiva/instabilidade mais comum em pacientes jovens. A lesão de outras estruturas do ombro é frequente, nomeadamente a lesão óssea de Bankart. Contudo, a associação com a fratura da apófise coracoide é muito rara.

Este artigo descreve o caso clínico de um homem de 67 anos que recorreu ao serviço de urgência com queixas de omalgia persistente, com episódios de agudização, iniciados após queda da própria altura. O paciente apresentava ainda histórico de trauma do ombro 3 meses antes, avaliado em outro hospital. A luxação anterior do ombro foi constatada radiograficamente, e a tomografia computorizada (TC) do ombro confirmou erosão óssea da vertente anteroinferior da glenoide (perda óssea de cerca de 50% do diâmetro anteroposterior na região inferior da glenoide), com reabsorção quase completa de lesão óssea de Bankart (aparente em análise a posteriori da radiografia do episódio traumático inicial). Associadamente, foi diagnosticada uma fratura transversa da apófise coracoide (tipo II da classificação de Ogawa). O paciente foi submetido ao tratamento cirúrgico, com confecção do batente ósseo anterior utilizando remanescente do fragmento fraturado do coracoide suplementado por enxerto autólogo tricortical do ilíaco, fixados com parafusos canulados (de acordo com as técnicas de Bristow-Latarjet e Eden-Hybinett).

No seguimento pós-operatório, foi observado um bom resultado funcional, sem novos episódios de luxação e sem queixas álgicas significativas.

Descreve-se uma associação rara de lesões do ombro, e salienta-se o desafio do tratamento das mesmas dado o seu diagnóstico tardio, como no caso apresentado.

Palavras-chave

- luxação do ombro
- fraturas do ombro
- processo coracoide

Introduction

Anterior dislocations represent about 96% of total shoulder dislocations. Dislocation recurrence is very common in young patients and may occur in up to 80% of cases.[1] However, in patients over 40 years of age, recurrence occurs in only about 10% of patinets.[2] In cases of recurrent dislocation, injury of the stabilizing structures of the glenohumeral joint (static and/or dynamic) occurs, and the lesion of the anteroinferior *labrum* of the glenoid with bone component (Bony Bankart lesion) is a well-known association.[3] Surgical treatment of this type of lesion varies from Bankart reinsertion to the creation of anterior bone increases using coracoid apophysis, autologous or heterologous graft.[4]

Coracoid apophysis fractures are uncommon and difficult to diagnose, constituting about 3 to 13% of shoulder blade fractures, which, in turn, represent less than 1% of total fractures.[5]

Most of the described coracoid fractures occur following seizures, and their association with episodes of anterior shoulder dislocation is extremely rare; as such, there are very few reports about the treatment performed.

The present study describes the case of a patient with recurrent dislocation/shoulder instability resulting from a Bony Bankart lesion and coracoid apophysis fracture, diagnosed late, and its implications on the treatment performed.

Clinical Case

The case describes a 67-year-old male patient with no relevant pathological history, namely epilepsy.

The patient was evaluated by the authors in the emergency department (ED) for acute persistent right shoulder pain, with multiple similar previous episodes of pain worsening. The onset of shoulder pain was 2 months before presentation to the authors, following fall from his own height with trauma of the upper limb in abduction and extension; at that time, the patient was evaluated at another institution. No other traumatic episodes followed.

He presented with the upper limb suspended in an antalgic position in slight external rotation. With positive hanger sign.

Anterior shoulder dislocation was verified radiologically on the date of the evaluation by the authors (►**Fig. 1**), and reduction maneuver was performed.

Objectively with great shoulder instability, anterior apprehension test and load and shift test positive. No neurological deficits.

The computed tomography (CT) of the shoulder showed significant bone erosion of the anteroinferior part of the glenoid, with bone loss of about 50% of the anteroposterior diameter in the lower region of the glenoid (►**Fig. 2**) and infracentimetric focal depression in the posteroexternal aspect of the humeral head (Hill-Sachs lesion).

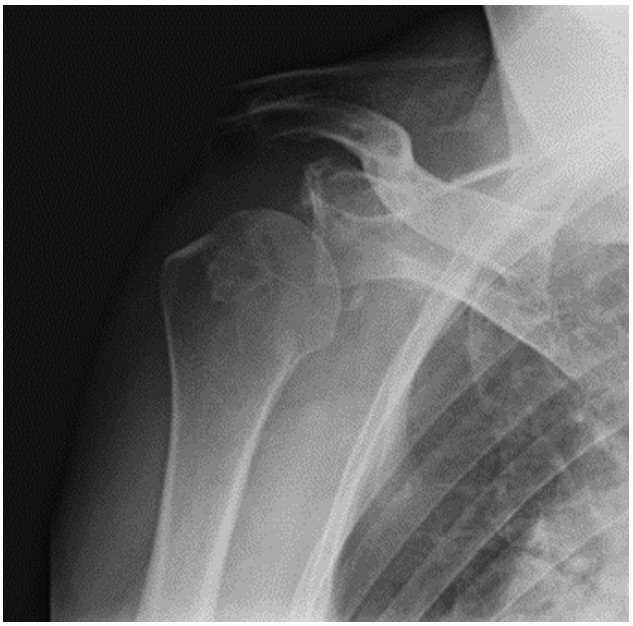


Fig. 1 Anterior shoulder dislocation (radiography of the ER episode used in the evaluation by the authors).



Fig. 3 Intraoperative image of the coracoid fragment fixation and iliac tricortical graft to the anteroinferior part of the glenoid.

In a later analysis of the radiography of the initial traumatic episode (previously evaluated at another institution), a fragment of bony Bankart lesion was observed; however, without anterior dislocation of the shoulder (by probable spontaneous reduction). In the CT performed by the authors, almost complete bone resorption of the bony Bankart fragment could be observed (►**Fig. 2**).

Connectedly, a transverse fracture of the coracoid apophysis (type II in the Ogawa classification) was diagnosed, with partial resorption of the fragment.

Given the instability with recurrent episodes of dislocation and severe pain, surgical treatment was proposed. A deltopectoral approach was performed to explore the glenohumeral joint, removal of loose bodies and confirmed a small coracoid fragment attached to the conjoint tendon.

An anterior bone block was made using coracoid fragment (fixed with cannulated screw on the anteroinferior edge of the glenoid – at 5 o'clock), supplemented by osteosynthesis of tricortical graft harvested from ipsilateral iliac (with 2.5cm x 3cm) with 2 screws in the inferior 2/3 of the glenoid (►**Figs. 3** and **4**).

No complications were reported in the postoperative period. The patient completed 4 weeks of immobilization and subsequent physiatric treatment.

In the postoperative follow-up, a good functional result was observed, with no new episodes of dislocation and no significant pain complaints. The Disabilities of the Arm, Shoulder and Hand (DASH) score before the surgery was 51.6 and 1 year after surgery it was 18.3.

One year after surgery, range of motion with limitation of 2 vertebrae of internal rotation, capable of 20° of external rotation and active anterior elevation of 100°. The anterior and posterior apprehension, load and shift and groove tests were negative.

Radiographically, we could verify bone block consolidation in the glenoid, maintaining adequate positioning of the

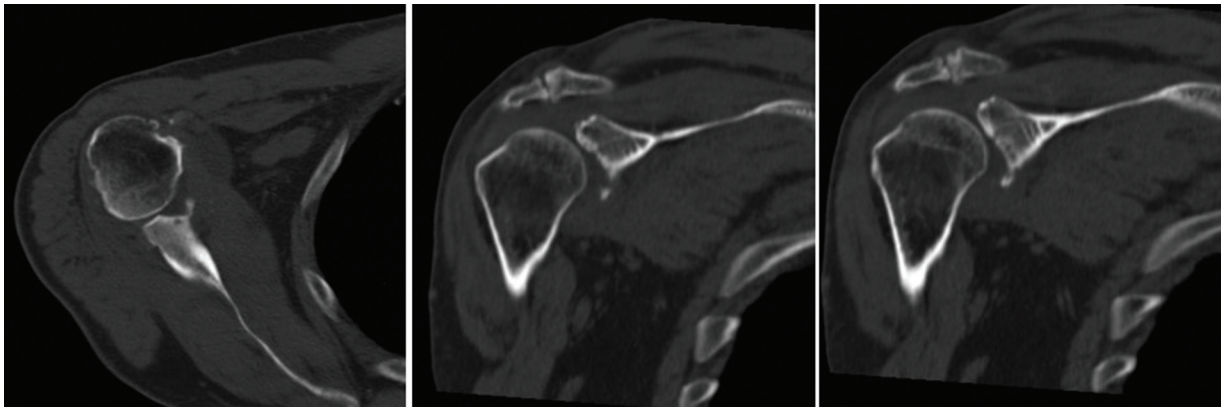


Fig. 2 Computed tomography images - Bony Bankart lesion of about 50% of the anteroinferior part of the glenoid with bone fragmentation.



Fig. 4 Shoulder radiography after surgery.

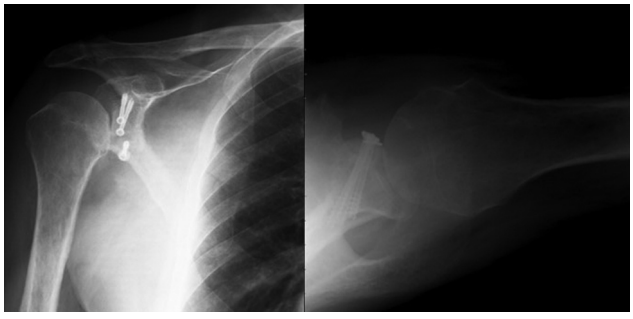


Fig. 5 Shoulder radiography 1 year after surgery.

canulate screws. There were slight degenerative changes of the glenohumeral joint, especially in the lower part (Grade I of the Samilson and Prieto classification) (►**Fig. 5**).

Discussion

In the case herein described, there are several factors that hinder the creation of shoulder stability:

1. Extensive bone destruction of the glenoid (about 50% of the anteroposterior diameter in the lower part of the glenoid) by bony Bankart lesion and progression of erosion by repeated episodes of dislocation are well documented as factors of increased instability and difficulty in treatment.[6]
2. The Bankart bone fragment was unfit for osteosynthesis, due to its resorption and fragmentation from the initial traumatic episode to diagnosis.
3. The coracoid fracture, with resorption of a substantial part of the bone fragment, made the creation of bone block with the coracoid insufficient to create stability in the shoulder of this patient.

In this context, the authors chose to combine the techniques of Bristow-Latarjet and Eden-Hybinett, already described. Thus, glenohumeral stability was obtained by the association of the bone block effect and increased glenoid joint surface created by the iliac tricortical graft fragment,[7] with the mechanical stabilizing effect of the coracoid apophysis and also an important dynamic stabilizer of the conjoint tendon.[8]

Osseocartilaginous lesions resulting from previous recurrent dislocations and not perfectly anatomical congruence of the glenoid after surgery lead to progressive degenerative changes, especially in the humeral head. This complication is more common in Eden-Hybinett procedures compared to Bristow-Latarjet technique alone.[9] In this case, the degree of osteoarthrosis 1 year after surgery is coincident with that described in the literature, grades I and II in the Samilson and Prieto classification, however with variable follow-up periods, making comparison difficult.[6]

The stability achieved in the patient described is corroborated by the low recurrence rate of dislocation after surgical treatment with anterior bone augmentation. The reported incidence is up to about 4.9% (4 out of 102 patients, all associated with traumatic episodes or seizures, after Latarjet surgery).[6,10] No description was found in the literature of the recurrence rate with the association of the procedures described.

This case report presents an unusual association of fractures, emphasizing the importance of a high rate of initial clinical suspicion and detailed radiological observation for the diagnosis of all lesions present.

In addition, there is an association of surgical techniques, whose therapeutic success, although well documented when used isolated, deserves further study when used together to corroborate the good results obtained in this case and may be a procedure to be considered in similar future cases.

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

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Deep Vein Thrombosis after a Supracondylar Fracture of the Humerus in a Child – A Rare Complication*

Trombose venosa profunda após uma fratura supracondilar do úmero em uma criança – Uma complicação rara

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Abstract

Deep vein thrombosis in the upper extremities is uncommon, especially in the pediatric population and in the trauma setting. The diagnosis is challenging, due to its rarity, requiring a high degree of suspicion.

We describe a rare case of humeral vein thrombosis after a displaced supracondylar fracture of the humerus in a 7-year-old girl. The risk factors for thromboembolism and sequelae are also discussed.

The early detection and treatment are mandatory to prevent poor outcomes, such as fatal thromboembolism.

Keywords

- deep vein thrombosis
- humeral fractures
- thrombosis
- venous thromboembolism
- child

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Resumo

Trombose venosa profunda nas extremidades superiores é incomum, especialmente na população pediátrica e no ambiente do trauma. O diagnóstico é desafiador, devido a sua raridade, exigindo alto grau de suspeita.

Descrevemos um caso raro de trombose venosa úmera após uma fratura supracondilar deslocada do úmero em uma menina de 7 anos. Os fatores de risco para tromboembolismo e sequelas também são discutidos.

A detecção e o tratamento precoces são obrigatórios para evitar desfechos ruins, como tromboembolismo fatal.

Palavras-chave

- trombose venosa profunda
- fraturas do úmero
- trombose
- tromboembolia venosa
- criança

Introduction

Humeral supracondylar fractures represent one third of all pediatric limb fractures in children under 7 years old, and are a cause of significant morbidity in the pediatric population.[1,2]

The complications most frequently encountered in this setting include neurovascular injuries, compartment syndrome, malunion, and functional impairment.[1,2]

Nerve and vascular injuries can be iatrogenic, or they may occur after a traumatic event. Vascular compromise can be caused by vessel rupture, kinking, compression, spasm, or intimal lesion, and the incidence increases according to the degree of fracture dislocation.[3]

The overall incidence of vascular complications associated with supracondylar fractures ranges from 3,2 to 14,3%, but may be as high as 20% in Gartland type III fractures.[3,4] Upon inspection, ecchymosis in the antecubital fossa with skin and brachialis tethering are warning signs of neurovascular damage.[4] Although the incidence and management of arterial injuries in supracondylar fractures is well established in the literature, little has been said about vein compromise.

Venous thromboembolism (VTE) in children is rare, ranging from 0.01% to 0.2% of pediatric hospitalizations; higher rates are observed in specific groups, including those with central venous catheters (CVC), malignancies, obesity and those submitted to major surgeries.[5,6]

In pediatric trauma patients, the risk of developing VTE is uncertain. The severity of the injury, increasing age, anemia, external fixation, obesity, length of hospital stay, postoperative complications, spinal cord injury and the presence of a CVC are well known risk factors in this population.[6–8] Some anatomical locations are also more prone to thrombotic events, that is, trauma to the head, the spine or major vessels, as well as pelvic and lower limb fractures.[8]

We report a case of humeral vein thrombosis after a supracondylar fracture in a child, given its rarity and difficult diagnosis, considering its potential complications.

Case Report

A 7-year-old girl was transferred to our emergency department after a fall with an outstretched arm which resulted in a supracondylar fracture of the left humerus, Gartland type III (►**Fig. 1**). She had been previously immobilized with a posterior splint at an outside hospital.

Upon presentation, she complained of pain and had a cold and reddish forearm, with a peripheral oxygen saturation of 89% to 90% and weak palpable radial and ulnar pulses (►**Fig. 2**).

After splint removal, the pain subsided, she had a weak radial pulse, normal capillary refill, and the hand oximetry reached 98%. On an emergency basis, the patient underwent a smooth manipulation with closed reduction and pinning with 2 divergent lateral Kirschner wires and immobilization in a posterior splint at 120° of flexion (►**Fig. 3**). Six hours postoperatively, the child had a pain-free and warm upper extremity, a peripheral oxygen saturation of 100%, and palpable distal pulses.



Fig. 1 Radiograph of the supracondylar humerus fracture (Gartland type III).



Fig. 2 Ecchymosis in the antecubital fossa.



Fig. 3 Closed reduction and fixation with two percutaneous Kirschner wires.



Fig. 4 Edema and blistering of the skin 48 hours postoperatively.



Fig. 5 Range of motion at three months of follow-up.

At 48 hours following surgery, there was persistent pain and progressive tender edema with skin blistering (►**Fig. 4**). The peripheral pulses were normal, and there was no pain exacerbation, with passive mobilization of the fingers. After excluding compartment syndrome, a venous duplex ultrasonography was performed, which revealed deep venous thrombosis (DVT) of the humeral vein.

Treatment with 20 mg of subcutaneous low-molecular-weight heparin was initiated and maintained for 3 months. One week after surgery, the child was pain-free, with edema improvement, and was discharged from the hospital. At 3 months of follow-up, the fracture had healed healed, and the elbow had full range of motion (0° to 120°), without additional skin or vascular complications (►**Figs. 5** and **6**). There were no embolic events. The studies conducted were negative for thrombophilia.

Discussion

The management of supracondylar fractures of the humerus can be demanding. Early complications include damage to neurovascular or muscular structures and compartment syndrome.[9] Neurological injuries, most frequently in the form of neuropraxia, are common (~20%), affecting mostly the median nerve and its anterior interosseous branch.[3,9] The most disastrous injuries are vascular, for, when left untreated, they can lead to neurologic deficits, muscle stiffness or Volkmann ischemic contractures.[9] Hardware-related complications and malunion sequelae are usually later events.[9]

According to the literature, pediatric trauma patients have a prevalence of VTE of 0.3 to 0.8 for every 1,000 trauma discharges.[7] In addition, emergent or urgent surgeries are more likely to result in VTE than elective procedures.[6]



Fig. 6 Intact skin and full extension at three months of follow-up.

For the diagnosis, clinical suspicion is needed and a detailed vascular examination is crucial, with assessment of pulses, temperature of the limb, capillary return and pulse oximetry.[3] The use of intraoperative or postoperative ultrasound is also helpful to assess the patency of the vessels.[4] In some cases, pulse oximetry waveform can be used to determine the need for vascular exploration.[10]

The sequelae of VTE, namely postthrombotic syndrome, death, and the risk of recurrence have not been fully investigated in children.[5] The morbidity of DVT depends on the location and and severity of the injury, inducing mainly pain and swelling when in the extremities.[5]

In children, VTE is associated with increased mortality, particularly among the younger patients, and it varies from 1% to 8%.[5,6] Guzman et al.[7] searched for an association between VTE and mortality in children, and they concluded that patients with upper-limb fractures and VTE had the highest overall mortality rate (6.4%). This increased mortality is thought to be due to a delay in diagnosis and treatment (owing to a lower index of suspicion) and/or because of the anatomical proximity of the upper-extremity veins to the right-sided chambers of the heart.[7]

The rationale to identify the groups at risk of developing VTE among children is to prevent death secondary to pulmonary embolism.[7] Currently, there is no consensus for thromboprophylaxis in the pediatric field, nor risk-stratification for VTE.[5,6]

Given the rare incidence of VTE in this age group, delays in diagnosis are frequent. In the case herein reported, the edema, skin coloration and blistering were crucial to raise suspicion. So far, there are many studies focusing on arterial and nervous complications, but none about venous thromboembolism in this setting.

The aim of the present case report is to raise attention to a rare vascular complication of a humeral supracondylar fracture. To our knowledge, the present is the first report of this complication.

All orthopedic surgeons must be aware of the existence of upper-extremity DVT to make an early diagnosis.

We, therefore, recommend a detailed neurovascular examination before and after surgery, and, if the clinical suspicion is high, an evaluation with Doppler sonography.

Ethics Statement

The present study was performed in compliance with the World Medical Association's Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects.

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Conflict of Interests

The authors have no conflict of interests to declare.

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Intramuscular Hemangioma: A Rare Cause of Omalgia*

Hemangioma intramuscular: Uma causa rara de Omalgia*

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Abstract

Intramuscular hemangiomas (IHs) are benign soft-tissue tumors that represent less than 1% of all hemangiomas. This clinical entity is rarely considered as a differential diagnosis in cases of musculoskeletal pain. A healthy 38-year-old woman presented to our office with complaint of left omalgia, with 8 months of evolution, limiting her daily activities. She reported the appearance of tumefaction in the previous 4 months. She was medicated with analgesic and antiinflammatory drugs with no clinical improvement. The objective examination showed limitation of left shoulder abduction (0–90°). The patient underwent a magnetic resonance imaging (MRI), in which a well-circumscribed nodular formation was detected in the deltoid muscle. Then, she underwent a biopsy, which confirmed the diagnosis of hemangioma. The patient was referred for sclerotherapy. Intramuscular hemangiomas are usually observed in young patients. The gold-standard examination for diagnosis is MRI, which often forestalls the need for a biopsy. In many cases, IHs are asymptomatic and tend to involute over time. Despite the low frequency of this clinical entity, it is important to place it as a diagnostic hypothesis in cases of chronic pain of the limbs in young patients with poor therapeutic response to antiinflammatory drugs and analgesia.

Keywords

- intramuscular hemangioma
- muscles
- muscular diseases
- occupational health
- omalgia

Resumo

Os hemangiomas intramusculares (HIs) são tumores benignos de tecidos moles que representam menos de 1% de todos os hemangiomas. Esta entidade clínica raramente é considerada como diagnóstico diferencial nos casos de dor musculoesquelética.

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Uma paciente do sexo feminino, de 38 anos de idade, saudável, se apresentou ao nosso consultório com queixa de omalgia esquerda, com 8 meses de evolução, que limitava suas atividades diárias. Ela relatou o aparecimento de tumefação 4 meses antes da consulta. A paciente estava medicada com analgésico e antiinflamatório sem melhoria clínica. Ao exame objetivo, ela apresentava limitação da abdução do ombro esquerdo (0–90°). A paciente foi submetida a uma ressonância nuclear magnética (RNM) na qual foi detectada uma formação nodular bem circunscrita no músculo deltoide,. Em seguida, foi realizada uma biópsia que confirmou o diagnóstico de hemangioma. A paciente foi então encaminhada para a realização de escleroterapia. Os HIs normalmente são observados em pacientes jovens. O exame padrão-ouro para o diagnóstico é a RNM, que muitas vezes torna a realização de biópsia desnecessária. Em muitos casos, os HIs são assintomáticos e tendem a involuir com o tempo. Apesar da baixa frequência desta entidade clínica, é importante colocá-la como hipótese de diagnóstico em casos de dor crônica dos membros em pacientes jovens com má resposta terapêutica a antiinflamatórios e analgesia.

Palavras-chave
- hemangioma intramuscular
- músculos
- doenças musculares
- saúde ocupacional
- omalgia

Introduction

Hemangiomas are a variant of benign soft-tissue tumors that are characterized by abnormal proliferations of vascular tissues; intramuscular hemangiomas (IHs) are rare (< 1% of all hemangiomas) and are mostly congenital, usually found at younger ages (90% before 30 years of age), and, in many cases, they tend to involute spontaneously over time.[1–3] Intramuscular hemangiomas are rarely considered as a differential diagnosis of musculoskeletal pain. They are usually associated with chronic pain with the appearance of an associated tumefaction, tend to aggravate the symptomatology with efforts and may, in some cases, limit daily activities.[4–6]

Case description

A 38-year-old woman who worked as an administrative employee in a tertiary hospital, with no relevant personal history, presented to our office with a complaint of pain in the anterior side of the left shoulder, with 8 months of evolution, which was limiting her daily activities, namely at the work and sports levels. She also reported the appearance of symptoms in the 4 months prior to the consultation. She was medicated with analgesic and antiinflammatory drugs with no clinical improvement. The patient associated the symptoms with poor postures as well as repetitive movements with the upper limb performed in her professional activity. The objective examination showed limitation of the left upper limb (LUL) movements, namely shoulder abduction (0–90°), with pain on local palpation. She performed a magnetic resonance imaging (MRI) in which a relatively well circumscribed, heterogeneous nodular formation was detected in the deltoide muscle, , measuring 16 × 16 mm in the axial plane and 45 mm of larger axis in the coronal plane (►**Figs. 1** and **2**). After discussing the case with the radiology service due to the absence of specific characteristics in complementary imaging exams (combination of vascular lesions with non-vascular elements, such as adipose tissue), we opted to perform histological characterization through biopsy. It demonstrated fibro-adipose, musculoskeletal tissues and vascular neoplasia fragment, thus confirming the diagnosis of hemangioma. The patient was referred to an intervention radiology consultation, where sclerotherapy was proposed (►**Fig. 3**). One month after performing

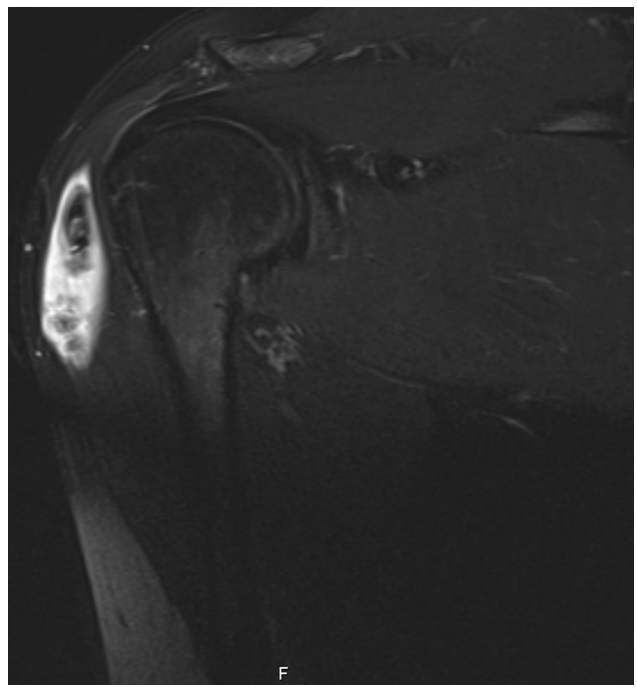


Fig. 1 Magnetic resonance imaging of intramuscular hemangioma of the deltoid.

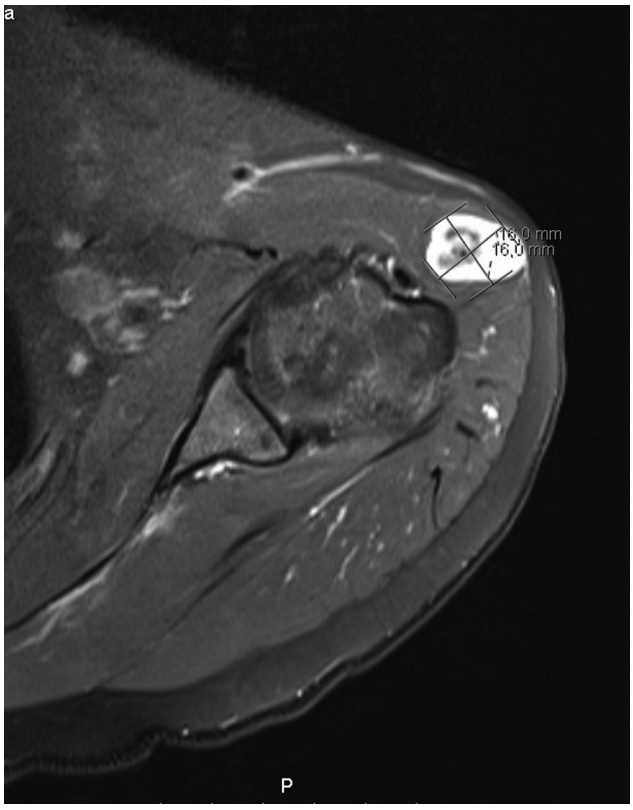


Fig. 2 Magnetic resonance imaging of intramuscular hemangioma of the deltoid.



Fig. 3 Sclerotherapy technique for the treatment of intramuscular hemangioma.

sclerotherapy, the patient reported an improvement in symptomatology, namely, of the joint amplitudes of the left shoulder (0–150°) and decreased limitations in daily activities.

Discussion

Intramuscular hemangiomas are usually observed at young ages (before 30 years) and are almost always associated with palpable tumefaction. Despite being a rare entity, it is something to take into account as a differential diagnosis in cases of musculoskeletal pain, especially in the upper and lower limbs, and at young ages.[4–6] The gold-standard examination for diagnosis is MRI, but ultrasound is something that can be useful in an initial diagnosis. Aspiration biopsy by thick needle should be performed in cases in which the diagnosis cannot be confirmed by imaging.[7] Pain, as well as limitation of day-to-day activities, is one of the main factors influencing the mode of treatment. The use of antiinflammatory drugs and analgesics as well as physiotherapy are modes of treatment commonly used in mild cases.[8] It should be considered that excessive efforts with the limb may aggravate the symptomology due to vasodilation. The treatment options for IHs can range from conservative treatment, given the possibility of spontaneous regression over time, to surgical treatment, in cases of persistent and very disabling pain, aesthetic deformities, neurovascular compression, effects of local compression causing skin necrosis, or suspected malignancy. Sclerotherapy is an alternative form of treatment, when there is poor response to conservative treatment and absence of surgical criteria. This intravascular procedure through the use of sclerosing agents that cause vascular thrombosis and endothelial damage, leading to endofibrosis and vascular obliteration, allow in many cases a complete regression of these tumors.[1,3,9,10] Another form of treatment consists in combining surgery with embolization 2 to 3 days before the surgical procedure, which is used in more complex, infiltrative and recurrent lesions.[5]

Despite the low frequency of this clinical entity, it is important to place it as a diagnostic hypothesis in cases of chronic pain and limitation of limbs movements of in young patients with poor therapeutic response to antiinflammatory drugs and analgesia.

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Conflict of Interests

The authors declare that there is no conflict of interests.

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Supplementary material such as applications, images and sound clips, can be published with your article to enhance it. Submitted supplementary items are published exactly as they are received (Excel or PowerPoint files will appear as such online). Please submit your material together with the article and supply a concise, descriptive caption for each supplementary file. If you wish to make changes to supplementary material during any stage of the process, please make sure to provide an updated file. Do not annotate any corrections on a previous version. Please switch off the 'Track Changes' option in Microsoft Office files as these will appear in the published version.

DIGITAL ARTWORK PREPARATION

General Guidelines

- It is best to use Adobe Photoshop to create and save images, and Adobe Illustrator for line art and labels.
- Do not submit art created in Microsoft Excel, Word, or PowerPoint. These files cannot be used by the typesetter.
- Save each figure in a separate file.
- Do not compress files.
- All black-and-white and color artwork should be at a resolution of 300 dpi (dots per inch) in TIFF format. Line art should be 1,200 dpi in EPS or TIFF format. Contact the Production Editor at Thieme if you are unsure of the final size.
- It is preferable for figures to be cropped to their final size (approximately 3½ inches for a single column and up to 7 inches for a double column), or larger, and in the correct orientation. If art is submitted smaller and then has to be enlarged, its resolution (dpi) and clarity will decrease.

  Note: Lower resolutions (less than 300 dpi) and JPEG format (.jpg extension) for grayscale and color artwork are strongly discouraged due to the poor quality they yield in printing, which requires 300 dpi resolution for sharp, clear, detailed images. JPEG format, by definition, is a lower resolution (compressed) format designed for quick upload on computer screens.

Black-and-White Art

- Black-and-white artwork can be halftone (or grayscale) photographs, radiographs, drawings, line art, graphs, and flowcharts. Thieme will only accept digital artwork.
- If possible, do not send color art for conversion to black-and-white. Do the conversion yourself so that you can check the results and confirm in advance that no critical details are lost or obscured by the change to black-and-white.
- For best results, line art should be black on a white background. Lines and type should be clean and evenly dark. Avoid screens or cross-hatching, as they can darken or be uneven in printing and lead to unacceptable printing quality.

Color Art

- All color artwork should be saved in CMYK, not RGB.

Art Labels

- Arrows, asterisks, and arrowheads (or other markers) should be white in dark or black areas and black in light or white areas, and large in size. If not, these highlighting marks may become difficult to see when figures are reduced in size during the typesetting process.
- Use 1-point (or thicker) rules and leader lines.
- Capitalize the first word of each label and all proper nouns. Consider using all capitals if you need a higher level of labels.
- Where there are alternate terms or spellings for a named structure, use the most common one and make sure it is consistent with what is used in the text.
- Avoid using multiple fonts and font sizes for the labels; use only one or two sizes of a serif font.

SUBMISSION PROCEDURE

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- Consult the checklist on the first page of this document to ensure that you are ready to submit your manuscript.
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- Log In to the submission system and find your article, which will be marked for revision.
- The best way to make revisions to your manuscript is by enabling the Track Changes mode in Microsoft Word, which will automatically highlight and mark up revised text. Please submit both a marked up copy and a clean copy of your revised manuscript to the submission system.
- Your original files will still be available after you upload your revised manuscript, so you should delete any redundant files before completing the submission.
- You will also be provided space in which to respond to the reviewers' and editors' comments. Please be as specific as possible in your response.

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