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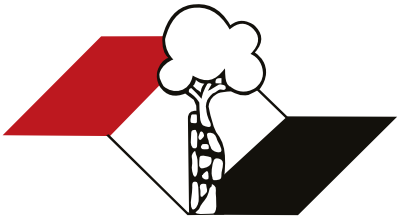

ISSN 1413-7852

# Acta Ortopédica Brasileira


Volume 33 – Number 1 – Year 2025

ISSN 1413-7852

# Acta Ortopédica Brasileira

Department of Orthopedics and Traumatology, Faculdade de Medicina da Universidade de São Paulo (DOT/FMUSP), São Paulo, SP, Brazil

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## Levels of Evidence for Primary Research Question[a]

(This chart was adapted from material published by the Centre for Evidence-Based Medicine, Oxford, UK. For more information, please visit www.cebm.net.)

**Types of study**

| Level | Therapeutic Studies Investigating the Results of Treatment | Prognostic Studies – Investigating the Effect of a Patient Characteristic on the Outcome of Disease | Diagnostic Studies – Investigating a Diagnostic Test | Economic and Decision Analyses – Developing an Economic or Decision Model |
|---|---|---|---|---|
| I | High quality randomized trial with statistically significant difference or no statistically significant difference but narrow confidence intervals | High quality prospective study[d] (all patients were enrolled at the same point in their disease with ≥80% of enrolled patients) | Testing of previously developed diagnostic criteria on consecutive patients (with universally applied reference ''gold'' standard) | Sensible costs and alternatives; values obtained from many studies; with multiway sensitivity analyses |
| | Systematic review[b] of Level RCTs (and study results were homogenous[c]) | Systematic review[b] of Level I studies | Systematic review[b] of Level I studies | Systematic review[b] of Level I studies |
| II | Lesser quality RCT (eg, < 80% followup, no blinding, or improper randomization) | Retrospective[f] study | Development of diagnostic criteria on consecutive patients (with universally applied reference ''gold'' standard) | Sensible costs and alternatives; values obtained from limited studies; with multiway sensitivity analyses |
| | Prospective[d] comparative study[e] | Untreated controls from an RCT | Systematic review[b] of Level II studies | Systematic review[b] of Level II studies |
| | Systematic review[b] of Level II studies or Level I studies with inconsis tent results | Lesser quality prospective study (eg, patients enrolled at different points in their disease or <80% followup) | | |
| | | Systematic review[b] of Level II studies | | |
| III | Case control study[g] | Case control study[g] | Study of non consecutive patients; without consistently applied reference ''gold'' standard | Analyses based on limited alternatives and costs; and poor estimates |
| | Retrospective[f] comparative study[e] | | Systematic review[b] of Level III studies | Systematic review[b] of Level III studies |
| | Systematic review[b] of Level III studies | | Case-control study | |
| | | | Poor reference standard | |
| IV | Case series[h] | Case series | | Analyses with no sensitivity analyses |
| V | Expert opinion | Expert opinion | Expert opinion | Expert opinion |

[a] A complete assessment of quality of individual studies requires critical appraisal of all aspects of the study design.
[b] A combination of results from two or more prior studies.
[c] Studies provided consistent results.
[d] Study was started before the first patient enrolled.
[e] Patients treated one way (eg, cemented hip arthroplasty) compared with a group of patients treated in another way (eg, uncemented hip arthroplasty) at the same institution.
[f] The study was started after the first patient enrolled.
[g] Patients identified for the study based on their outcome, called "cases" eg, failed total arthroplasty, are compared with patients who did not have outcome, called ''controls'' eg, successful total hip arthroplasty.
[h] Patients treated one way with no comparison group of patients treated in another way.

# SUMMARY

VOLUME 33 – Nº 1 – 2025

## Original Article

DOI: http://dx.doi.org/10.1590/1413-785220253301e285432



# PROTOCOLO DIGITAL PARA PROJETO CONCEITUAL E VALIDAÇÃO DE UMA ÓRTESE TORNOZELO-PÉ

# DIGITAL PROTOCOL FOR CONCEPTUAL DESIGN AND VALIDATION OF AN ANKLE-FOOT ORTHOSES

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## ABSTRACT

Objective: This original article aimed to develop a digital protocol for the conceptual design and validation of Ankle-Foot Orthoses (AFO) using 3D mapping technologies. Methods: A scanned model of the ankle-foot complex of a 12-year-old child with a drop foot was utilized, along with a generic AFO model from a Computer-Aided Design environment. Autodesk Meshmixer and Fusion software were employed for conceptual design and static load analysis. Results: The static load analysis using the Von Mises failure criterion on the AFO model with ABS material demonstrated structural integrity under critical loading conditions. The digital protocol facilitated the design of a functional and patient-specific AFO orthosis. Conclusions: The study successfully established a digital workflow for AFO design and validation, showcasing the potential of 3D technologies in creating customized orthoses for lower limb rehabilitation. ***Level of Evidence IV; Descriptive Study.***

**Keywords:** Orthoses; Foot; Equipment Design; Computer-Aided Design.

## *RESUMO*

*Objetivo: Este estudo teve como objetivo desenvolver um protocolo digital para o projeto conceitual e validação de Órteses de Tornozelo-Pé (AFO) utilizando tecnologias de mapeamento 3D. Métodos: Um modelo digital do complexo tornozelo-pé de uma criança de 12 anos com pé caído foi utilizado, juntamente com um modelo genérico de AFO de um ambiente de Projeto Auxiliado por Computador. Os softwares Autodesk Meshmixer e Fusion foram empregados para o projeto conceitual e análise de carga estática. Resultados: A análise de carga estática utilizando o critério de falha de Von Mises no modelo de AFO com material ABS demonstrou integridade estrutural sob condições críticas de carga. O protocolo digital facilitou o projeto de uma órtese AFO funcional e específica para o paciente. Conclusões: O estudo estabeleceu com sucesso um fluxo de trabalho digital para o projeto e validação de AFOs, destacando o potencial das tecnologias 3D na criação de órteses personalizadas para reabilitação dos membros inferiores.* ***Nível de Evidência IV; Estudo Descritivo.***

***Descritores:*** *Órteses; Pé; Desenho de Equipamento; Desenho Assistido por Computador.*

**Citation:** Araújo Júnior R, Fucs PMMB. Protocolo digital para projeto conceitual e validação de uma órtese tornozelo-pé. Acta Ortop Bras. [online]. 2025;33(1):Page 1 of 5. Available from URL: http://www.scielo.br/aob.

## INTRODUCTION

The ankle joint is crucial for human support and locomotion, divided into stance and swing phases.[1] Disorders in this region can lead to difficulties in daily activities and biomechanical compensations, affecting other areas of the body.[2] Neuropathic injuries can result in deformities, gait alterations, increased energy expenditure, and limitations in daily activities, impacting quality of life. Foot drop syndrome is an example, characterized by deficiency in leg dorsiflexion, leading to abnormal gait and steppage posture.[3]

The treatment of ankle and foot musculoskeletal disorders aims to reduce symptoms, improve mechanics, and restore participation in activities.[4] Common therapeutic modalities include the use of orthoses, physiotherapy, nerve stimulation, and, in some cases, surgery.[3] Ankle-Foot Orthoses (AFOs) play a significant role in the treatment of neurological or traumatic injuries, aiding in ankle stabilization, prevention of deformities, and alignment control, contributing to improved gait and balance.[5] Over decades, researchers have dedicated efforts to the development of innovative AFOs to promote lower limb rehabilitation.

Custom ankle and foot orthoses simplify the manufacturing process by using patient limb scanning to generate a digital model.[6] Additive Manufacturing (AM) emerges as a promising technology for producing highly customized orthoses, allowing for better fit and enhanced functionality.[7] Integrating Assistive Technology (AT) with AM aims to develop customized products that combine functionality, attractiveness, and reduced production times, aiming to facilitate the

All authors declare no potential conflict of interest related to this article.

***The study was conducted at Universidade Estadual da Paraíba (UEPB), Núcleo de Tecnologias Estratégicas em Saúde (NUTES), Laboratório de Tecnologias 3D, Campina Grande, PB, Brazil.***

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Article received on 04/09/2024, approved on 06/13/2024.

daily lives of individuals with specific needs.[8] Recent studies highlight the advantages of manufacturing customized orthoses using 3D technologies for patients with deformities.[9,10] Customizing orthoses according to individual patient needs promotes better adherence and contributes to rehabilitation progress. However, the lack of detailed information on the design and materials of orthoses in studies involving AT is a gap in the literature, compromising the validity of results[11] and support for healthcare professionals dedicated to the development and application of these technologies.[12]

In parallel, the integration of three-dimensional technology-based workflows in orthopedics and prosthetic medicine offers several advantages. One of them is the ability to perform 3D scans in specific regions and transmit the resulting files to other clinics, facilitating the design and manufacture of orthopedic or prosthetic devices in different locations.[13,14] The use of portable devices for 3D scanning expands access to these technologies in various medical facilities.[7] Additionally, the ease of storage and access to digital files allows for tracking patient progress and consultation of previous designs, facilitating the creation of creative and unique models.[15] The ability to adjust the alignment of foot and leg segments separately enables more precise modifications during modeling, as well as allowing for objective quantification of alignment, surpassing conventional methods of visual inspection used in orthopedic device manufacturing.[16] Therefore, this research aims to propose a digital protocol for the conceptual design of an AFO orthosis and its validation through static load analysis using 3D technologies, aiming to fill this gap in scientific study and improve clinical practices.

## MATERIALS E METHODS

### Ankle-foot joint model

For the development of the digital protocol for the conceptual design of the AFO orthosis, a scanned model of the ankle-foot complex (AFC) of a child estimated to be 12 years old, whose disabling condition was drop-foot, was used. This model was provided in partnership with the 3D Technologies Laboratory (LT3D) of the Health Technology Center (NUTES), at the State University of Paraíba (UEPB), and is shown in Figure 1a. The model was obtained after project approval by the Research Ethics Committee in Brazil, with favorable results for its execution (CAAE 21347419.0.0000.5187). The process followed the guidelines of Resolution No. 466/2012, which regulates research involving human subjects, using an informed consent form.

In addition, a generic open-source model of an AFO orthosis developed in a Computer-Aided Design (CAD) environment was also used, obtained from the Ultimaker Thingiverse library. This serves as a reference for the external and internal surfaces of the orthosis, as shown in Figure 1b.

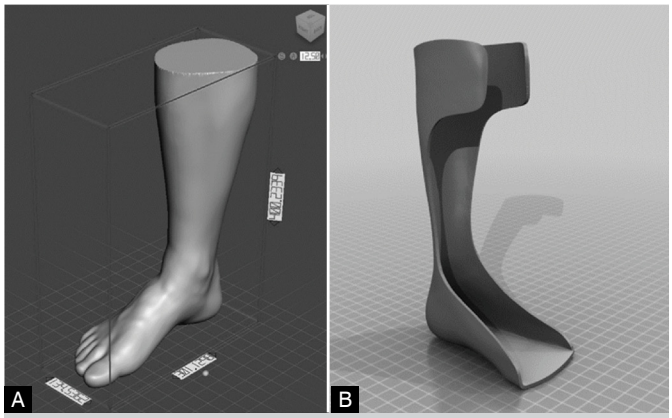


**Figure 1.** Reference models used: A) Scanned CTP and B) Standard AFO.

### Conceptual design of the afo model

To develop all the steps related to the conceptual design of the AFO orthosis, from the CTP and AFO models presented earlier, Autodesk Meshmixer 3.5 and Autodesk Fusion software (version 2024) were used. The former was specifically used to perform any mesh correction operations and to convert the model from mesh to a solid model, while the latter was used to carry out the CAD development process of the orthosis itself. It is worth noting that this conversion enables other analyses beyond conceptual design and manufacturing, such as static, modal, impact stress analysis, as well as topological optimization, among other CAE alternatives.[17]

### Validation of the orthesis by static load analysis

For the computational simulation of the new AFO orthosis model, aiming to analyse the interaction between the user's weight and its reaction on the component, stress and strain analysis using the Von Mises failure criterion is employed. ABS was chosen as the material for this model, as it is a viable option for future manufacturing by AM due to its compatible characteristics for the said application.[18] The mechanical properties of ABS used in the static analysis of the AFO were defined using standard ASTM sample results.[19] Autodesk Fusion software was used for this purpose, which offers static analysis capabilities in its CAE (Computer-Aided Engineering) simulation environment. With the obtained results, it is necessary to verify if they meet the convergence criterion, determined based on a safety coefficient and the maximum stress in the model.

For the validation of the designed AFO orthosis model, a static analysis was applied to preliminarily ensure its structural integrity in the face of loads applied in the most critical scenarios of the gait phases, allowing the design to conceive a functional, durable orthosis that meets the patient's requirements, considering the geometric and material characteristics employed in the model, without expending resources on defective models post-fabrication.[20] Due to the impossibility of measuring the weight of the patient whose CTP was used in this research, the average value for age and gender of a Brazilian child within the characteristics already presented was used. This allowed for the quantitative establishment of the maximum forces to which the AFO orthosis will be subjected, especially considering the critical cases of stresses applied to the model, which would occur during the midstance phase characterized by the maximum body weight supported on the planted foot in an almost static position and supported on the forefoot.[21]

## RESULTS

### Afo 3d modeling process

The conceptual design of the AFO orthosis, which involved the 3D modelling process of the customized AFO for the scanned CTP model, consisted of a sequence of steps, as shown in Figure 2.

From the steps shown in Figure 2, it can be observed that step 1 displays the initial model of the standard AFO orthosis, with dimensions adjusted to those of the scanned CTP model, for the preliminary parameterization of the new AFO model. In turn, step 2 shows the active selection tool in Meshmixer, with a highlighted area of the orthosis, which is a possible sketch of the new orthosis model, indicating the beginning of the customization process of the design. The continuation of the selection process, in step 3, shows the consequence of smoothing the selected area in step 2, as refining the mesh of the scanned model makes the sketch too coarse. In step 4, the interface for smoothing edges applied to the selected area is observed, which was used to smooth the transitions and edges of the selection, improving the adaptation of the orthosis to the user and smoothing the layer deposition process during the AM process of the designed AFO. Additionally, step 5 indicates an



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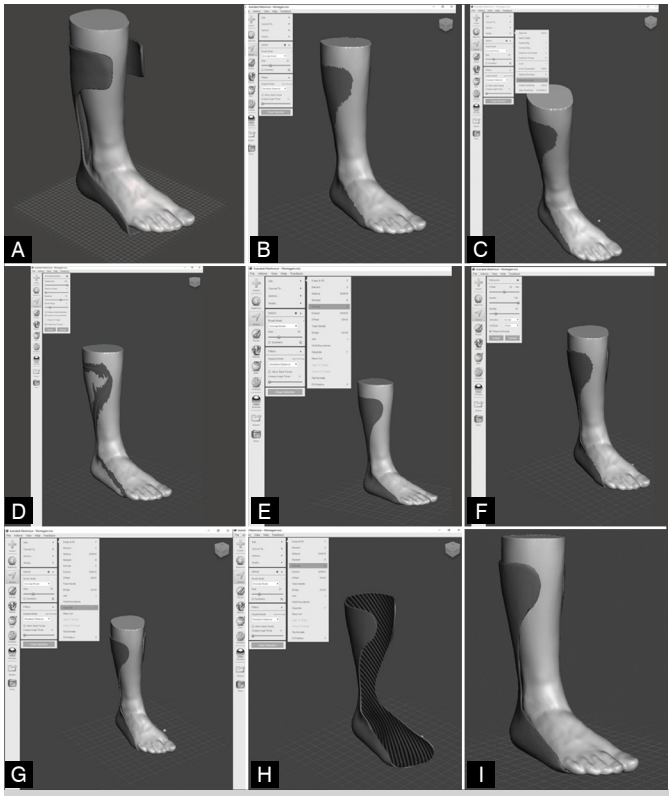


**Figure 2.** Steps of 3D modeling of the AFO orthosis.

extrusion operation of the selected area, which properly generates the physical shape of the AFO orthosis for the area outside the boundaries of the scanned model. Step 6 shows that the extrusion was performed on the selected area, as indicated by the overlay of a new geometry over the original area, with a defined thickness. Step 7 consists of essentially separating the previously extruded region from the original CTP model, creating a new model in the software environment that refers only to the AFO orthosis. In step 8, the separated AFO model is analysed individually, so the scanned CTP model is removed from the environment, and to repair the internal surface of the AFO, the external surface is selected and then extruded in the normal direction, to constitute the internal surface of the CAD model of the AFO. Finally, step 9 presents the finalized model after the previous operations. The modified area appears integrated with the rest of the model, indicating the end of the customized design process.

### Static load analysis of the afo model

Similarly to the AFO orthosis modelling process, its validation involved studying static stresses in the model, assessing critical static loading conditions during the use of the custom orthosis by the patient referenced by the scanned CTP model. This study involves following certain procedures, as depicted in Figure 3.
From the procedures shown in Figure 3, it is highlighted that step 1 refers to preparation and material, in which the AFO model was imported in stl format into Fusion, and the material is defined according to the part in question. In this case, ABS plastic was assigned as the material for the model, determining the physical properties to be considered in the analysis. In step 2, concerning boundary conditions, constraints are applied to the model to simulate how the orthosis will be fixed or where it will be in contact with the skin or other surfaces. In this case, the regions of the AFO in contact with the calf and the longitudinal medial arch. In step 3, regarding the application of static loading, the location and intensity of the loads to be applied are defined, such as gravitational force or some specific force to simulate body weight or pressure exerted during gait. Steps 4 and 5 subdivide the static analysis procedure with two types of statically defined loading. Finally, in step 6, a mesh is created for the model, involving dividing the model into small finite elements to be used in the calculation of the static load analysis.
When performing the analysis outlined by the previous steps, the CAE software calculates how the orthosis will respond to the applied loads, and following this simulation, the stress distribution for the AFO model was obtained according to the imposed loading and boundary conditions, as shown in Figure 4.
After verifying the convergence of the CAD model of the AFO from static loading analysis, it was concluded that the AFO design was validated and could be forwarded for manufacturing. At the end of the design phases addressed in this study, the digital protocol for the design and validation of an AFO presented in Figure 5 is proposed.

## DISCUSSION

The objective of this study was to develop a digital protocol aimed at the conceptual design of an AFO-type orthosis, as well as its validation through static load analysis, with the aid of 3D

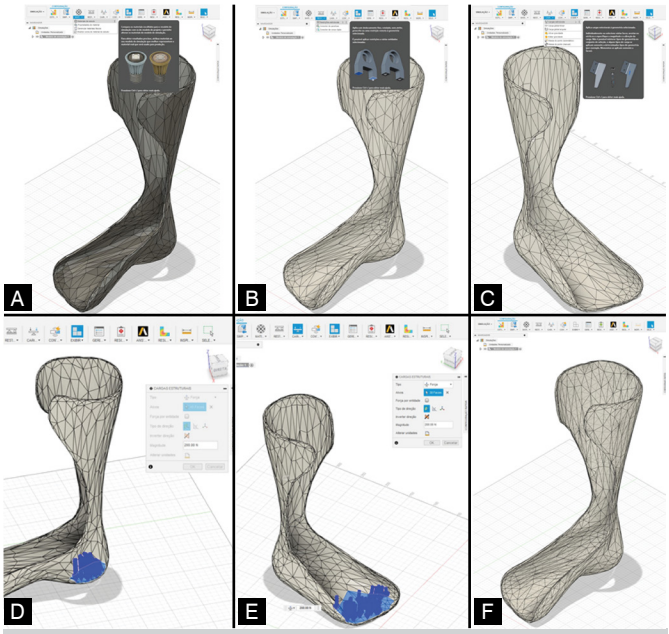


**Figure 3.** Steps for static load analysis of the AFO orthosis.

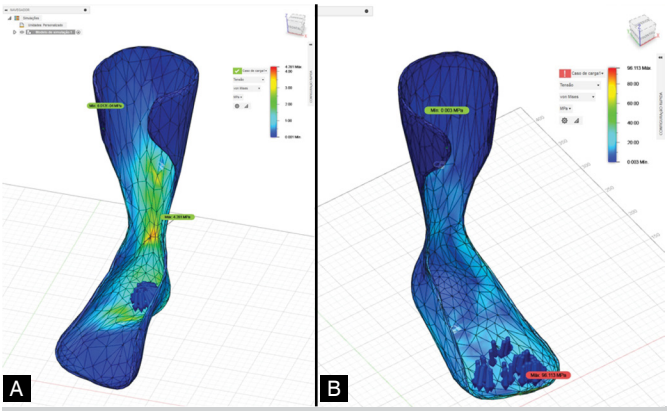


**Figure 4.** Stress distribution for the AFO model with ABS under loading conditions: A) on the heel and B) on the forefoot.

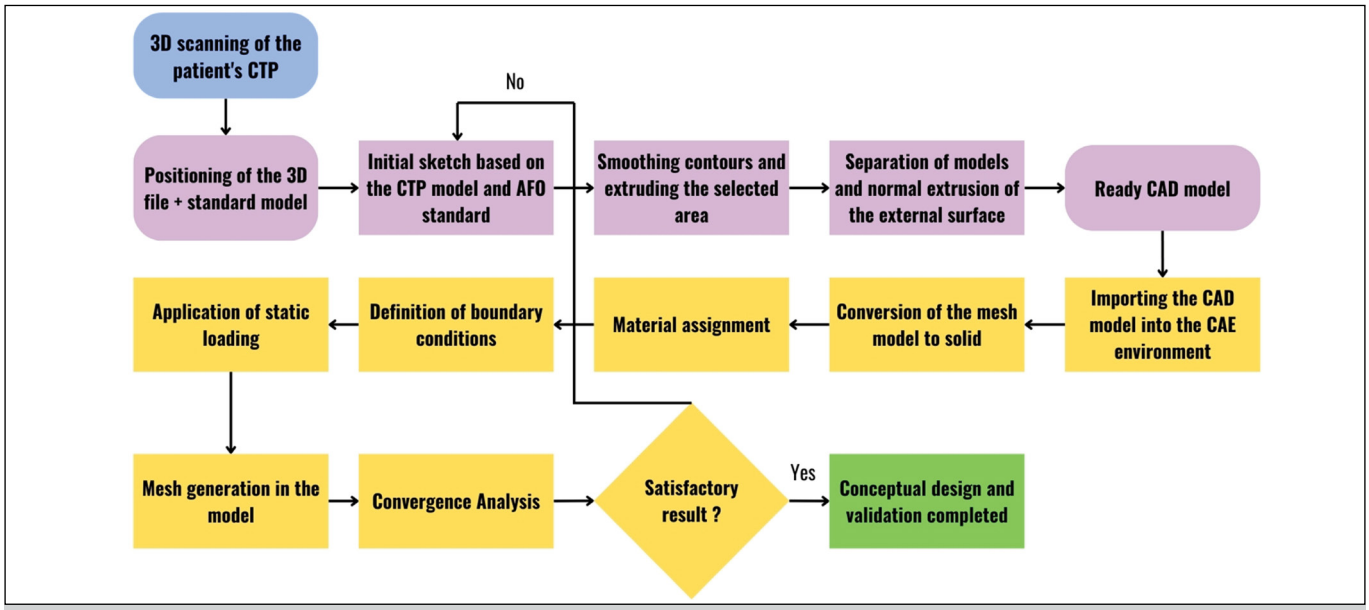


**Figure 5.** Digital mapping for modelling and validating an AFO model.

technologies. Creating a new model of customized AFO from a standardized parameterization model constitutes an approach to the research problem with good scientific acceptability in the O&P field given the design optimization processes, as it is reported that the design of custom or traditional AFOs is typically conducted from the scanned[22] or measured model using various techniques such as anthropometry,[10] considering that less experienced professionals may encounter difficulties in parameterizing AFO orthoses without some reference.[23] The proposed design, being devoid of straps or loops, reduces stress concentrators that may cause component rupture or breakage due to critical cases of static loading or fatigue, as also proposed by Banga et. al (2018).[20]

With regard to validation in CAE environment, other authors have also shown and discussed the loadings used for static analyses,[24] including considering case studies in children[19] and applying loading conditions similar to those of the present study. Considering also the stress distribution in the model with the different types of loading, knowing the mechanical properties of the material assigned in this study (ABS plastic, with 38.45 MPa for the yield strength and 43.8 MPa for the ultimate tensile strength), the results were consistent with other researchers who addressed FEA validation for AFO design, especially when considering appropriate boundary conditions. For the present study, the satisfactory result obtained by the CAD model of the AFO is evidenced, as the maximum stress values presented by the static analysis, in Figure 4, show that the assigned material is able to withstand the imposed loading conditions without exceeding the design limit.

## CONCLUSIONS

The study successfully developed a digital protocol for the conceptual design and validation of AFO-type orthoses using 3D technologies. Through static load analysis, the structural integrity of the customized AFO model was ensured, meeting the patient's requirements. This innovative approach showcases the potential of digital mapping and 3D technologies in designing functional and durable orthoses tailored to individual needs, advancing the field of lower limb rehabilitation.

**AUTHOR'S CONTRIBUTION:** Each author made significant individual contributions to the development of this manuscript. RAJ: intellectual concept of the article, design procedures, and writing of the work; PMMBF: intellectual concept of the article and review of the article.

## REFERENCES

1. Fukui T, Ueda Y, Kamijo F. Ankle, knee, and hip joint contribution to body support during gait. J Phys Ther Sci. 2016;28(10):2834-7. doi: 10.1589/jpts.28.2834.
2. Mohan DM, Khandoker AH, Wasti SA, Alali SIII, Jelinek HF, Khalaf K. Assessment Methods of Post-stroke Gait: A Scoping Review of Technology-Driven Approaches to Gait Characterization and Analysis. Front Neurol. 2021;12:650024. doi: 10.3389/fneur.2021.650024.
3. Kalra P, Belokar R, Kumar R. Improvement of Human Gait in Foot Deformities Patients by 3D Printed Ankle–Foot Orthosis. In: Singh S, Prakash C, Singh R (eds). 3D Printing in Biomedical Engineering. Materials Horizons: From Nature to Nanomaterials. Singapore: Springer; 2020. p. 269-88. doi: 10.1007/978-981-15-5424-7_13.
4. Rao S, Riskowski JL, Hannan MT. Musculoskeletal conditions of the foot and ankle: Assessments and treatment options. Best Pract Res Clin Rheumatol. 2012;26(3):345-68. doi: 10.1016/j.berh.2012.05.009.
5. Zhou C, Yang Z, Li K, Ye X. Research and Development of Ankle–Foot Orthoses: A Review. Sensors. 2022;22(17):6596. doi: 10.3390/s22176596.
6. Cho J-E, Seo K-J, Ha S, Kim H. Effects of community ambulation training with 3D-printed ankle–foot orthosis on gait and functional improvements: a case series of three stroke survivors. Front Neurol. 2023;14. doi: 10.3389/fneur.2023.1138807.
7. Hovorka CF. Leveraging Digital Workflows To Transition The Orthotics And Prosthetics Profession Toward A Client-Centric And Values-Based Care Model. Can Prosthetics Orthot J. 2024;6(2):42221. doi: 10.33137/cpoj.v6i2.42221.
8. Lozano AB, Álvarez SH, Isaza CV, Montealegre-Rubio W. Analysis and Advances in Additive Manufacturing as a New Technology to Make Polymer Injection Molds for World-Class Production Systems. Polymers (Basel). 2022;14(9):1646. doi: 10.3390/polym14091646.
9. Mohamaddan S, Ishak NZ, Aizuddin AM, Yamamoto S, Dawal SZM, Safawi EB, et al. Design and analysis of ankle foot orthosis for disabled children. J Adv Manuf Technol. 2018;12(1 Special Issue 2):247-58.
10. Banga HK, Kalra P, Belokar RM, Kumar R. Customized design and additive manufacturing of kids' ankle foot orthosis. Rapid Prototyp J. 2020;26(10):1677-85. doi: 10.1108/RPJ-07-2019-0194

11. Eddison N, Mulholland M, Chockalingam N. Do research papers provide enough information on design and material used in ankle foot orthoses for children with cerebral palsy? A systematic review. J Child Orthop. 2017;11(4):263-71. doi: 10.1302/1863-2548.11.160256.
12. Wang C, Zhu P, Lu YH, Shoji T. Effect of heat treatment temperature on microstructure and tensile properties of austenitic stainless 316L using wire and arc additive manufacturing. Mater Sci Eng A. 2022;832:142446. doi: 10.1016/j.msea.2021.142446.
13. Ball A. Quantifying Lower Limb Sagittal Plane Alignment Based on 3D Scans: Method Validation and Implementation to Compare Conventional and Digital AFO Shape Capture Processes [thesis Master of Applied Science in Biomedical Engineering]. Toronto: University of Toronto; 2023.
14. Sawacha Z, Guiotto A, Santini D, Bertoncello E. Development of a methodology for the design and 3D printing of plantar foot orthosis from gait analysis data. Gait Posture. 2022;97(Suppl 1):S168-9. doi: 10.1016/j.gaitpost.2022.07.110.
15. Lutfallah S. Path from Paper to Paperless at Abana O&P [thesis]. Louisiana State University; 2017. Available from: https://repository.lsu.edu/honors_etd/888.
16. Opitz M, Fröhlingsdorf P. The Digital O&P Workshop. Can Prosthetics Orthot J. 2021;4(2):36349. doi: 10.33137/cpoj.v4i2.36349.
17. Nosov NV, Zyabochkina AP. Designing the Structure of and a Fabrication Process for a Corrective Insole in CAD/CAE/CAM Systems. IOP Conf Ser Mater Sci Eng. 2020;709:022105. doi: 10.1088/1757-899X/709/2/022105.
18. Ferraresi C, De Benedictis C, Bono L, Del Gaudio F, Ferrara L, Masiello F, et al. A methodology for the customization of hinged ankle-foot orthoses based on in vivo helical axis calculation with 3D printed rigid shells. Proc Inst Mech Eng Part H J Eng Med. 2021;235(4):367-77. doi: 10.1177/0954411920981543.
19. Raj R, Dixit AR, Łukaszewski K, Wichniarek R, Rybarczyk J, Kuczko W, et al. Numerical and Experimental Mechanical Analysis of Additively Manufactured Ankle-Foot Orthoses. Materials (Basel). 2022;15(17):6130. doi: 10.3390/ma15176130.
20. Banga HK, Belokar RM, Kalra P, Kumar R. Fabrication and stress analysis of ankle foot orthosis with additive manufacturing. Rapid Prototyp J. 2018;24(2):301-12. doi: 10.1108/RPJ-08-2016-0125.
21. Neumann DA, Kelly ER, Kiefer CL, Martens K, Grosz CM. Kinesiology of the Musculoskeletal System: Foundations for Rehabilitation. Elsevier; 2017.
22. Wang JZ, Lillia J, Farhan M, Bi L, Kim J, Burns J, et al. Digital mapping of a manual fabrication method for paediatric ankle–foot orthoses. Sci Rep. 2021;11(1):19068. doi: 10.1038/s41598-021-98786-z.
23. Wojciechowski E, Chang AY, Balassone D, Ford J, Cheng TL, Little D, et al. Feasibility of designing, manufacturing and delivering 3D printed ankle-foot orthoses: A systematic review. J Foot Ankle Res. 2019;12:11. doi: 10.1186/s13047-019-0321-6.
24. Faustini MC, Neptune RR, Crawford RH, Stanhope SJ. Manufacture of Passive Dynamic Ankle–Foot Orthoses Using Selective Laser Sintering. IEEE Trans Biomed Eng. 2008;55(2):784-90. doi: 10.1109/TBME.2007.912638.

DOI: http://dx.doi.org/10.1590/1413-785220253301e287060



# MICRO-FRAGMENTED ADIPOSE TISSUE IN THE KNEE OSTEOARTHRITIS UNDER LOCAL ANESTHESIA

# TECIDO ADIPOSO MICROFRAGMENTADO EM JOELHO OSTEOARTRÍTICO COM ANESTESIA LOCAL

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## ABSTRACT

Objective: To assess the feasibility of the entire micro fragmented adipose tissue knee injection procedure under local anesthesia. From the subcutaneous harvesting and microfragmentation process to the intrarticular knee injection. Methods: A patient with bilateral knee osteoarthritis underwent adipose tissue harvesting and bilateral intra-articular micro fragmented adipose tissue knee injection under local anesthesia. Patient-related outcomes were collected before the procedure, 12 months, and 24 months follow-up. Womac, Koos, and VAS were recorded. Results: The visual analog scale, KOOS questionnaire, and WOMAC score all improved in the 12- and 24-month follow-ups. Conclusion: Adipose tissue harvesting and micro fragmented adipose tissue knee injection are procedures that can be performed under local anesthesia and have good patient report outcomes. ***Level of Evidence IV; Therapeutic Study.***

**Keywords**: Osteoarthritis, Knee; Subcutaneous Fat; Knee Joint.

## *RESUMO*

*Objetivo: Avaliar a possibilidade da realização do procedimento de injeção intra-articular de tecido adiposo microfragmentado sob anestesia local. Desde a coleta subcutânea até o processo de microfragmentação e injeção intra articular. Métodos: Um paciente com gonartrose bilateral que foi submetido a retida de tecido adiposo e injeção intra articular nos joelhos de tecido adiposo microfragmentado sob anestesia local. Desfechos relacionados ao paciente foram coletados antes do procedimento, no seguimento após 12 e 24 meses. Womac, Koos, and VAS foram avaliados. Resultados: Escala visual de dor, questionário KOOS e WOMAC todos mostraram melhora nas visitas de seguimento aos 12 e aos 24 meses. Conclusão: Coleta de tecido adiposo e injeção de tecido adiposo microfragmentado no joelho é um procedimento que pode ser realizado sob anestesia local com bons resultados reportados pelo paciente.* ***Nível de Evidência IV; Estudo Terapêutico.***

***Descritores:*** *Osteoartrite do Joelho; Gordura Subcutânea; Articulação do Joelho.*

**Citation:** Varone BB, Fuller H, Perini D, Leal DP, Gobbi RG, Demange MK. Micro-fragmented adipose tissue in the knee osteoarthritis under local anesthesia. Acta Ortop Bras. [online]. 2025;33(1):Page 1 of 4. Available from URL: http://www.scielo.br/aob.

## INTRODUCTION

Knee osteoarthritis (KOA) is one of the most prevalent joint diseases,[1] affecting more than 13% of men and 10% of women over 60 years of age.[2] The prevalence is expected to increase with the advancing age of the population and the prevalence of obesity.

The treatment for KOAs ranges from conservative treatment with physiotherapy and muscle strengthening to a surgical approach with total knee arthroplasty. Recently, biological and regenerative therapies have begun to provide new perspectives within orthopedics. These therapies can expand the non-surgical or minimally invasive options available as a treatment for patients with early OA.[3] The orthobiologicals are found naturally in the human body. The most studied orthobiologicals currently are: platelet-rich plasma (PRP), hyaluronic acid(HA), microfragmented adipose tissue (mFAT) and bone marrow aspirate concentrate (BMAC).

The use of mFAT in the context of knee osteoarthritis has been studied due to the large availability of tissue and easily accessible tissue for harvesting. Encouraging results in mild to moderate cases in a 3-year follow-up,[4] and even in severe KOA a the short-term significant improvement (1-year follow-up) in the KOOS and WOMAC scales.[5] Performing this procedure on an outpatient basis under local anesthesia has been increasingly encouraged, once more patients would benefit from the increased availability of this therapy. Until the present moment, the vast majority of mFAT collection procedures have been performed under general anesthesia without major complications.[6]

## OBJECTIVES

Several studies have shown the beneficial effects of intrarticular injection of mFAT for degenerative conditions, especially for knee osteoarthritis.

All authors declare no potential conflict of interest related to this article.

***The study was conducted at Universidade de São Paulo, Hospital das Clínicas, Institute of Orthopedics and Traumatology, School of Medicine.***
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Article received on 05/27/2024, approved on 08/14/2024.

Harvesting adipose tissue from the low abdominal area can appear challenging for orthopedics surgeons. Studies show that a small volume of adipose tissue is necessary to prepare micro fragmented adipose tissue (mFAT) for an articular injection.
Therefore, the objective of this study is to report a 24-month follow-up case of mFAT infiltration performed just under local anesthesia.

## METHODS

This protocol case was done preliminarily to access the feasibility of harvesting adipose tissue, microfragment the subcutaneous tissue with a one-stage device Lipogems® and injected the mFAT intra-articularly in both knee all in an ambulatory setting. The study was approved in the ethics committee number 5.259.237. The patient signed an informed term of consent.

### Patient demographics

Our pilot patient is a 56 year old female who states that has bilateral pain for over 6 years. She failed initial non-operative treatment with physical therapy, analgesics and anti-inflammatory medications. She is otherwise healthy, her BMI is 26,5kg/m$^2$.
According to Kellgreen Lawrence classification, right knee was considered grade 3 and left knee was considered grade 4.

### Patient set up

The patient underwent a bilateral knee injection. Adipose tissue was collected under sterile conditions in a surgical center under local anesthesia, without sedation. The attire included a hat, gloves, private clothing, and face masks. The participant was positioned in the supine position on a surgical table. In all patients, an intravenous access was obtained for the administration of cefazolin 2g as antibiotic prophylaxis, sodium dipyrone 1g and dimenhydrate 50mg.

### Local anesthesia

Figure 1. Patient positioning, portal placement.
Adipose tissue (AT) harvest site was performed in the lower abdomen. The portals were marked above the inguinal line, on each side of the abdome.
The skin anesthesia of 1ml of 2% lidocaine was applied in the portal location. After the anesthetic latency time, a small incision of approximately 4 mm was made with an 11-blade scalpel on each side of the abdomen. For harvesting the adipose tissue, a two staged intumescent technique was performed.
The technique for anesthetic infiltration consists of inserting the cannula through the portal made in the skin to disperse the solution throughout the area of capture of subcutaneous adipose tissue.

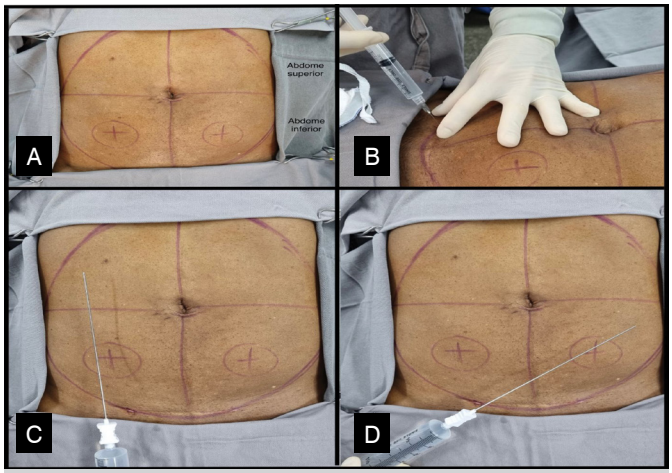



**Figure 1.** Patient positioning, portal placement.

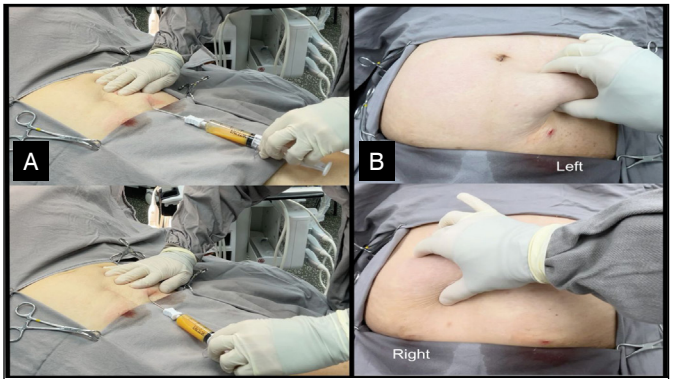
First, subcutaneous adipose tissue was infiltrated through a 19G cannula provided by the Lipogems® kit.
The injected solution was composed of 20 ml of 2% lidocaine, 20 ml of 0.5% bupivacaine, 1 ml of 1mg/ml adrenaline and 250 ml of 0.9% saline. Totaling a volume of 291ml. We used 120ml of this solution in each hemi-abdome, the remaining 51 ml was reserved to be used in case we needed more anesthesia during the harvesting.
Since the procedure was performed with no sedation, some details are important: A 20ml syringe was used to diffuse the solution in a low-flow and low-pressure way. The subcutaneous tissue intumescence was carried out slowly to avoid discomfort to the patient.
The capture region must be homogeneously infused so that tissue harvesting does not cause discomfort.
Based on the latency of lidocaine, we standardize a 5-minute wait before proceeding with the adipose tissue harvesting. After the waiting period, the adipose tissue harvesting was performed with the 13G cannula provided in the Lipogems® kit.

### Adipose tissue harvesting

A vaclock syringe was connected to the cannula, this syringe is specially designed to keep adequate pressure in the system for an optimal fat tissue harvest.
Adipose tissue was harvested in a homogeneous way, avoiding repetitive harvesting next to the portal, which can lead to cosmetic problems. Pinching the abdomen to evaluate the amount of remaining subcutaneous tissue in each area is a reliable way to avoid any cosmetic changes.
We planned to harvest 120ml of adipose tissue which would lead to approximately 20ml of mFAT. Our goal was to inject 10ml of mFAT on each knee.
After the procedure, skin portals were closed with Nylon 5.0 sutures, and Adipose tissue was processed using Lipogems®, a single-use and disposable kit.
Figure 2. Adipose tissue harvesting

### Adipose tissue processing

Adipose tissue was processed using Lipogems®, a single-use and disposable kit that through mild mechanical forces, washing, and reduction filters eliminates oil from ruptured adipocytes and red blood cells present in the adipose tissue aspirate.
For this patient, 120 ml subcutaneous tissue was inserted into the system, which was prefilled with saline. After that, mechanical dissociation was obtained by gently shaking the system. Stainless steel marbles inside provide additional mechanical fragmentation. Oil residues and blood components are washed out by gravity counter-flow of saline solution, this procedure is repeated until the solution in the divide appears clear and the lipoaspirate is yellow.




A - Fan-shaped harvesting; B - Evaluation of subcutaneous tissue; Right side before harvesting, left site after harvesting.

**Figure 2.** Adipose tissue harvesting.

Microfragmented adipose tissue migrates to the top of the device. Finally, the device is turned upside down by 180 degrees, with the fat tissue product now facing a narrower size reduction filter. MFAT is then removed from the device and reserved in 10-ml syringes.
Figure 3. MFAT processing

### Ultrasound-guided intra-articular infiltration

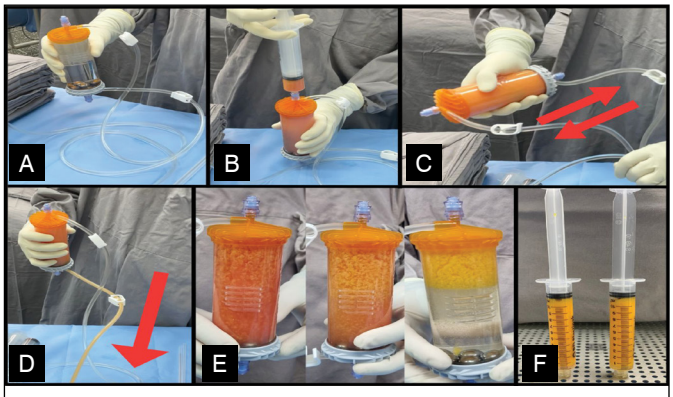
With the patient in the supine position, the knees were prepared with 2% degerming chlorhexidine gluconate, then cleaned with an alcoholic chlorhexidine solution, in addition to placing sterile drapes. The area was anesthetized with a 1ml anesthetic button and deep tissues were anesthetized with an additional 1ml of 2% lidocaine. A 16G Jelco needle was inserted into the suprapatellar bursa under the guidance of a Logiq E GE Healthcare® ultrasound device and a 12MHz linear probe to ensure that the infiltration of the product was articular. If there was a joint effusion, the excess fluid was drained. The microfragmented fat tissue was then infiltrated. The orthopedic surgeon who performed the joint infiltration has experience in the area, and the use of ultrasound during infiltration increases the precision and degree of certainty that the product was delivered to the joint cavity.
Figure 4. US guided injection

### Post-operative care

The patient was admitted and discharged on the same day. The participant was instructed to remove all dressings 24 hours after the procedure. Stitches were removed on a seven-day follow-up. Patients was instructed to avoid physical activities or more intense efforts for one week. The home prescription consisted of dipyrone sodium in cases of mild pain and tramadol in cases of more intense pain. Hirudoid® (mucopolysaccharide polysulfate) was recommended in its topical gel form to minimize bruising. Furthermore, cryotherapy was indicated to control pain, edema, and bruising.

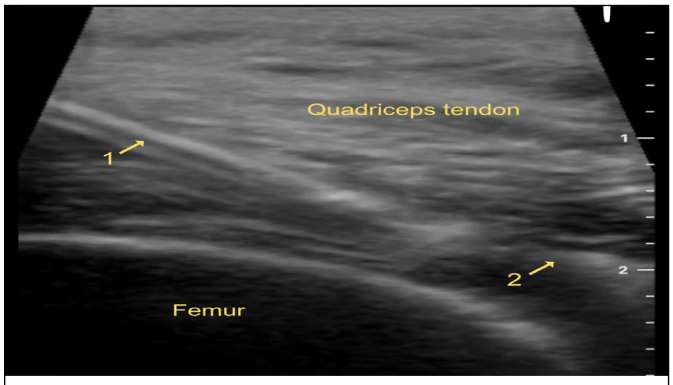
### Outcomes

Patient-reported outcomes (WOMAC, VAS, and KOOS) were accessed at the baseline and in the 12 and 24-month follow-ups. The patient was evaluated within seven days of the procedure to evaluate adverse effects due to adipose tissue harvesting and the bilateral knee injection. The patient was instructed to report any discomfort or pain to the medical team.




A - The system is filled with saline; B - harvested adipose tissue is inserted; C - micro-fragmentation due to gentle mechanical forces; D - fat is washed and rinsed; E - changes in the aspect after the washing procedure; F - final product.

**Figure 3.** Adipose tissue micro-fragmentation procedure.




1 - 16 G needle; 2 - microfragmented adipose tissue.

**Figure 4.** US guided injection.

## RESULTS

During all those 24 months of the follow-up period, there were no complications regarding the harvest site and injected knees. It was observed at the 7-day follow-up, as expected, mild abdominal ecchymosis and knee discomfort that resolved within 15 days from the surgery. No important cosmetic changes were identified during the 24 months.
All three parameters showed an improvement on both the first and second follow-up appointments (Table 1). The WOMAC score[7] questionnaires before the procedure was 83, on the 12-month follow up it was 24, and on the 24 month follow up 30. Changes in values greater than 10 are above minimal clinically important difference (MCID)[8] and changes greater than 25 are above substantial clinical benefit.[9] The baseline VAS score was 8, after 12 months VAS was 1, and on the 24-month follow up 3 points. KOOS questionnaire was 38% at the baseline, 54% at 12 months, and 50% at 24 months follow-up, both greater than MCID when compared to baseline score.[10]

**Table 1.** Results at baseline, 12 month follow up and 24 month follow up.

| | Womac score (0-96) | VAS | KOOS |
|---|---|---|---|
| Preop | 83 | 8 | 38% |
| 12 months | 24 | 1 | 54% |
| 24 months | 30 | 3 | 50% |

## CONCLUSION

Most studies had evaluated the feasibility of harvesting adipose tissue for obtaining mFAT associated with other procedures such as osteotomy,[4] knee arthroscopy,[6] or meniscus tears.[11] Therefore, in these cases, the harvesting is usually performed with the patient under sedation. Knee osteoarthritis is an extremely prevalent disease, and mFAT has recently shown its beneficial effect in this disease.[5,12,13] Evaluating the safety and feasibility of this procedure in an ambulatory setting is essential to make mFAT treatment available to more patients. In this case report, we showed that, with adequate technique, it is possible to perform this procedure under local anesthesia in patients with knee osteoarthritis. We also report important symptomatic and quality of life improvements in the patient, shown in her patient-reported outcomes improvements. Those results encourage further studies using this setting in controlled protocols with a larger number of patients.

**AUTHOR'S CONTRIBUTION:** Each author made significant individual contributions to the development of this manuscript. VBB: writing and performing surgeries; FH: data analysis and writing; PD: writing and patient follow-up; LDP: writing and organizing the manuscript; GRG: review of the article; DMK: intellectual concept of the article.

## REFERENCES


1. Felson DT, Lawrence RC, Dieppe PA, Hirsch R, Helmick CG, Jordan JM, et al. Osteoarthritis: New Insights. Part 1: The Disease and Its Risk Factors. Ann Intern Med. 2000;133(8):635-46.
2. Yelin E, Weinstein S, King T. The burden of musculoskeletal diseases in the United States. Semin Arthritis Rheum. 2016;46(3):259-60.
3. DeChellis DM, Cortazzo MH. Regenerative medicine in the field of pain medicine: Prolotherapy, platelet-rich plasma therapy, and stem cell therapy—Theory and evidence. Tech Reg Anesth Pain Manag. 2011;15(2):74-80.
4. Russo A, Condello V, Madonna V, Guerriero M, Zorzi C. Autologous and micro--fragmented adipose tissue for the treatment of diffuse degenerative knee osteoarthritis. J Exp Orthop. 2017;4:33.
5. Hudetz D, Borić I, Rod E, Jeleč Ž, Kunovac B, Kunovac B, Vrdoljak T, et al. Early results of intra-articular micro-fragmented lipoaspirate treatment in patients with late stages knee osteoarthritis: a prospective study. Croat Med J. 2019;60(3):227-36.
6. Ulivi M, Meroni V, Viganò M, Colombini A, Lombardo MDM, Lombardo MDM, et al. Micro-fragmented adipose tissue (mFAT) associated with arthroscopic debridement provides functional improvement in knee osteoarthritis: a randomized controlled trial. Knee Surg Sports Traumatol Arthrosc. 2023;31(8):3079-90.
7. Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt L. Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. J Rheumatol. 1988;15(12):1833-40.
8. Clement ND, Bardgett M, Weir D, Holland J, Gerrand C, Deehan DJ. What is the Minimum Clinically Important Difference for the WOMAC Index After TKA?. Clin Orthop Relat Res. 2018;476(10):2005-14.
9. Kim MS, Koh IJ, Choi KY, Sung YG, Oark DC, Lee HJ, et al. The Minimal Clinically Important Difference (MCID) for the WOMAC and Factors Related to Achievement of the MCID After Medial Opening Wedge High Tibial Osteotomy for Knee Osteoarthritis. Am J Sports Med. 2021;49(9):2406-15.
10. Lyman S, Lee YY, McLawhorn AS, Islam W, MacLean CH. What Are the Minimal and Substantial Improvements in the HOOS and KOOS and JR Versions After Total Joint Replacement?. Clin Orthop Relat Res. 2018;476(12):2432-41.
11. Malanga GA, Chirichella PS, Hogaboom NS, Capella T. Clinical evaluation of micro-fragmented adipose tissue as a treatment option for patients with meniscus tears with osteoarthritis: a prospective pilot study. Int Orthop. 2020;45(2):473-80.
12. Onorato F, Rucci M, Alessio-Mazzola M, Bistolfi A, Castagnoli C, Formica M, et al. Autologous microfragmented adipose tissue treatment of knee osteoarthritis demonstrates effectiveness in 68% of patients at 4-year follow-up. Arch Orthop Trauma Surg. 2024;144(9):3925-35.
13. Fan F, Grant RA, Whitehead JP, Yewlett A, F Lee PY. An observational study evaluating the efficacy of microfragmented adipose tissue in the treatment of osteoarthritis. Regen Med. 2023;18(2):113-21.


Source: Brazilian Institute of Geography and Statistics (IBGE), 2024.

DOI: http://dx.doi.org/10.1590/1413-785220253301e278744



# RETURN TO SPORTS FOLLOWING KNEE OSTEOTOMY IN COMPETITIVE ATHLETES – CASE SERIES

# RETORNO AO ESPORTE APÓS OSTEOTOMIA DO JOELHO EM ATLETAS EM NÍVEL COMPETITIVO – SÉRIE DE CASOS

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## ABSTRACT

Objectives: To analyze the return to the sport and the level of sports practice in a longitudinal cohort of athletes treated with osteotomy around the knee. Methods: Active athletes who underwent osteotomy or knee surgery to treat knee osteoarthritis were included, and their data was collected retrospectively. The primary outcomes were maximum physical activity level before and after the surgery (Tegner score), time to return to maximum activities and reoperation. Results: Twenty athletes with a mean age of 33 years at the time of surgery (standard deviation 8.9 (SD)) and with a mean follow-up of 9.8 years (SD 4) were included. The mean maximum Tegner score achieved before surgery was 8.6 (SD 1.4). Nineteen patients returned to sports (95%), and 13 returned to the same prior level (65%). The median time to return to the maximum level was 13 months (mean 17.9, SD 12.4). The mean maximum postoperative Tegner score was 7.5 (SD 2.0), slightly lower than the maximum achieved before surgery (mean difference:1.1, CI:0.2-1.9, P=0.026). Conclusion: The results of this study suggest that, after osteotomies around the knee, athletes present a high rate of return to sports activities, with most returning at the same level as before the surgery. ***Level of Evidence IV; Case series.***

**Keywords**: Knee; Osteotomy; Sports; Athletes; Return to Sport.

## *RESUMO*

*Objetivos: Analisar o retorno ao esporte e o nível de prática esportiva em uma coorte longitudinal de atletas tratados com osteotomia ao redor do joelho. Métodos: Foram incluídos atletas ativos submetidos à cirurgia de osteotomia ao redor do joelho para tratamento de osteoartrite do joelho e seus dados foram coletados retrospectivamente. Os desfechos primários foram nível máximo de atividade física antes e depois da cirurgia (escore de Tegner), tempo para retorno às atividades máximas e reoperação. Resultados: Foram incluídos 20 atletas com idade média de 33 anos no momento da cirurgia (desvio padrão 8,9 (DP)) e com seguimento médio de 9,8 anos (DP 4). A média do escore máximo de Tegner alcançado antes da cirurgia foi de 8,6 (DP 1,4). Dezenove pacientes retornaram à prática esportiva (95%) e 13 retornaram ao mesmo nível anterior (65%). O tempo mediano para retornar ao nível máximo foi de 13 meses (média 17,9, DP 12,4). A média do escore máximo de Tegner pós-operatório foi de 7,5 (DP 2,0), ligeiramente inferior ao máximo alcançado antes da cirurgia (diferença média: 1,1, IC: 0,2-1,9, P = 0,026). Conclusão: Os resultados deste estudo sugerem que, após osteotomias ao redor do joelho, os atletas apresentam alto índice de retorno às atividades esportivas, sendo que a maioria retorna no mesmo nível de antes da cirurgia.* ***Nível de Evidência IV; Serie de Casos.***

***Descritores:*** *Joelho; Osteotomia; Esportes; Atletas; Volta ao Esporte.*

**Citation:** Meirelles D, Bitar AC, D'Elia C, Garofo G, Terrível A, Castropil W. Return to sports following knee osteotomy in competitive athletes – Case series. Acta Ortop Bras. [online]. 2025;33(1):Page 1 of 4. Available from URL: http://www.scielo.br/aob.

## INTRODUCTION

Osteoarthritis (OA) of the knee is often observed in high-demand athletes. OA patients often suffer from pain, limitations on activities, and worsening quality of life.[1] Initially, the treatment is conservative, through behavioral measures, such as weight loss, and pharmacological ones aimed at reducing disease progression and improving limb function.[2]

While total arthroplasty of the knee is reserved for elderly and less active patients with OA, osteotomies around the knee are indicated for young, active individuals, who still fully exercise their physical capacity.[3] Treatment in these patients, in addition to aiming to relieve pain, is focused on returning to sports activities and slowing down the progression of the disease. According to the literature, the candidates for osteotomy around the knee are patients under 60 years of age, with unicompartmental OA, without ligament instability, and with a good range of knee motion.[4,5] Other procedures associated with osteotomy can be performed, such as meniscal transplant, cartilage repair procedures, or even ligament reconstruction.[1,6]

In recent years, the improvement in surgical techniques, the fixation materials available, and the increase in evidence in the literature have led to better postoperative results in terms of function and

All authors declare no potential conflict of interest related to this article.

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Article received on 09/20/2023, approved on 08/14/2024.

pain, and to the longevity of the procedure. Survival rates for high tibial osteotomy at five and ten years are 87-99% and 66-84%, respectively,[7-9] and for distal femoral osteotomy are 75-90% at five years and 64-82% at ten years.[10-13]

Bonnin et al. concluded that only 56% of the patients submitted to osteotomy around the knee were able to return to the preoperative sports level and that 62% had limited activity due to the operated knee.[14] Although the literature about the results from osteotomies around the knee to treat OA is well established, few studies have considered a population of athletes who play highly demanding sports.[15,16]

The objective of the study was to analyze the time to return to the sport and the sports practice level of a longitudinal cohort of athletes who underwent osteotomy around the knee at a single center.

## MATERIALS AND METHODS

### Study design

This was a retrospective case series study, conducted at a single center, which included patients who underwent surgery between January 2000 and December 2014. This study was evaluated and approved by the Research Ethics Committee under the number 4.160.318. The authors declare that there is no conflict of interest that interferes with this study.

### Study population

Inclusion criteria: to have undergone osteotomy around the knee surgery for the treatment of osteoarthritis of the knee associated or not with ligament reconstructions (the other reconstruction procedures were not evaluated in this study and were not exclusion criteria) , to play sports at a competitive level and be in an active career stage.

Exclusion criteria: incomplete medical record data or inability to contact the participant for data collection. All the surgeries were performed by the senior surgeons at our institution. Cases treated with corrective osteotomies of femur and tibia (axial osteotomies) or Fulkerson osteotomy with or without ligament reconstruction, cartilage repair and/or meniscal procedures were included.

### Data collection and analysis

The following data were collected: sex, age at the time of surgery, maximum level of physical activity prior to surgery as measured by the Tegner score, type of surgery performed, return to sports, need to change sport after surgery, time to return to athletic activity (at least four times a week), time to return to activity at the maximum level achieved, maximum physical activity level (Tegner) after surgery, current physical activity level (Tegner) (maximum postoperative follow-up), reoperations, and an evaluation of expectations.[17] We also analyzed the results according to type of osteotomy.

An evaluator who did not participate in the surgeries collected and analyzed the data. Initially, a thorough search of the medical records was conducted. Missing data were completed directly by the participants using a digital questionnaire. Analysis was conducted with qualitative and quantitative descriptions of the data. The Wilcoxon signed rank test was used to compare the pre- and postoperative maximum activity levels. An analysis by subgroup was performed for the different types of osteotomy: axial osteotomies (tibial and femoral) and Fulkerson osteotomies. The level of significance adopted was 95% and the tests were performed using SPSS software.

## RESULTS

Of the 26 initially eligible individuals found in the search of the medical records of our institution, we were able to include 20 athletes in this study (77% retention) with an average of ten years of postoperative follow-up. The baseline data are shown in Table 1.

Among the surgical procedures of the 20 included patients, 14 were axial osteotomies (ten opening wedge high tibial valgus, one femoral extension, and three opening wedge distal femoral varus) and six were Fulkerson anterior tibial tubercle osteotomies.

After surgery, 19 patients returned to sports (95% of cases), 13 of whom returned to the same previous level (65%). Four individuals changed sports after surgery (20%). The median postoperative time for return to athletic activities (at least four times a week) was nine months (mean 11.7, SD 9.0) and the median postoperative time for return to the maximum level was 13 months (mean 7.9, SD 12.4).

The mean maximum postoperative Tegner score was 7.5 (SD 2.0) and was slightly lower than the mean of the maximum scores that had been achieved during the sports career prior to surgery (mean of differences: 1.1, CI 0.2-1.9, $P=0.026$), Table 2.

The patients were able to maintain this maximum level following surgery for an average survival time of 5.1 years (SD 3.7). At the final clinical follow-up of ten years, the individuals reported a mean Tegner score of 6.2 (SD 1.8) (Table 1). Three patients (15%) underwent reoperations for removal of synthesis material related to the osteotomies performed (after two, 18 and 24 months).

Even though the patient sample was small, we observed a better return to maximum level in the patients submitted to Fulkerson osteotomies than in the patients who underwent axial osteotomies, but with greater need for removal of the synthesis implant, but given the sample (n = 6) of Fulkerson osteotomy, we cannot consider this as a tendency, but only a random finding that must be proven with a greater subject number.

## DISCUSSION

Studies in the population that practiced recreational activities and sports have shown that young, active patients submitted to knee osteotomy were able to return to sports activities in a similar level as before surgery.[18-20] Bonnin et al. concluded that young, motivated patients are able to return to high demand sports activities, which corroborates our results, since we demonstrated a high rate of return to sports: 95% of the high demand athletes returned to sports, with 65% achieving their preoperative sports level.[14]

We also chose to compare the maximum preoperative and postoperative performance levels of the athletes. The mean physical activity level achieved after surgery was very close to that achieved by the athletes before the need for treatment. De Carvalho et al.

**Table 1.** Demographic data.

| Patients | 20 |
|---|---|
| Females / Males | 6 (30%)/ 14 (70%) |
| Age (years) | 33 ± 9 (20-57) |
| Follow-up after osteotomy (years) | 10 ± 4 (5-20) |
| Maximum Tegner score preoperatively | 8.6 ± 1.4 (6-10) |

Data are shown as mean ± standard deviation (minimum - maximum) or as observed absolute values (percentage among total cases)

**Table 2.** Clinical outcomes.

| | Total (n=20) | Axial (n=14) | Fulkerson (n=6) | P value (Axial vs Fulkerson) |
|---|---|---|---|---|
| Tegner score preoperatively | 8.6 ± 1.4 | 8.6 ± 1,3 | 8.5 ± 1.6 | 0.891 |
| Tegner score postoperatively | 7.5 ± 2.0 | 7.4 ± 2.2 | 7.8 ± 1.6 | 0.854 |
| P value (pre vs postop) | 0.026* | 0.042* | 0.317 | - |
| Return to the preop level | 65% | 64% | 83% | 0.612 |
| Reoperation | 15% | 14% | 33% | 0.342 |

Data are shown as mean ± standard deviation (minimum - maximum) or as observed absolute values (percentage among total cases). Tegner scores shown represent the maximum level reached both pre and postoperatively. *Statistically significant ($P<0.05$)

identified a mean Tegner score of 3.0 (range 1-7) both before and after the surgical procedure.[21] Hoorntje et al. evaluated the Tegner score the same way that we approached it in the present study and arrived at a mean result of four, prior to symptoms, and of three, postoperatively.[22] We can see that, because the cohort analyzed in our study was composed of competitive-level athletes, we reached mean maximum Tegner score values of 7.5 following surgery, slightly lower than the maximum Tegner score that the athletes had achieved in their career at any time prior to surgery (mean of 8.6). Another important fact was that our sample was composed of high demand athletes, almost all of them at a competitive level, including Olympic athletes. We observed very high return to sports rates as compared to those reported to date in the literature. Hoorntje et al. obtained a postoperative rate of return to sports of 82%, but in a cohort without competitive-level athletes.[23] Kanto et al. studied 77 patients with Tegner scores ≥ 5 points before surgery and a mean age of 56.1 ± 11.6 years (range 26–79) and confirmed a 75.3% return rate to the same level in a mean time to return of 8.7 ± 2.7 months (range 6–14).[24]

Over the last decade, several studies have focused on demonstrating the rate of return to sports in patients submitted to knee osteotomy. Older studies reported a rate of return to sports following knee osteotomy below 50%.[25] With the improvement in surgical techniques for fixation in osteotomies, such as fixed angle plates, surgical outcomes have undergone an important evolution with a significant increase in patients who returned to sports after undergoing osteotomies around the knee.[20,25] The percentage of patients (95%) who returned to sports following the surgical procedure in our study, was higher than that found in two recent systematic literature reviews.[22,26] If we analyze studies in the literature that only considered return to high-impact activities, we find rates from 35 to 70%.[20,26,27]

Regarding the time to return to sports activities following the surgical procedure, Hoorntje et al. concluded that 75% of the patients who returned to sports did so after less than six months.[23] In another study, the same author reported that 71% of the patients returned to playing sports in less than six months, with 50% returning less than 15 weeks after distal femoral osteotomy.[28] Jacquet et al. reached a similar outcome in which the patients who underwent high tibial osteotomy returned to sports practice in an average of 4.9 months.[29] In our study, we had a longer time to return to sports, at nine months on average. Our hypothesis for this finding is that many of the patients did not undergo only osteotomy around the knee. Most of them had associated ligament or cartilage repair procedures, which increased the time to return. Studies of osteotomies around the knee associated with meniscal transplants had mean return to sports times of 16.9 months[30] and 9.7 months.[31]

If we consider only the patients who were submitted to anteromedialization osteotomy of the anterior tibial tubercle (ATT), 86% of this group returned to the same athletic level as before the onset of symptoms. This finding is in line with that published by Liu et al., who evaluated the return to sports after ATT osteotomy in a group of 48 patients, 83.3% of whom returned to playing sports.[30] However, the group was not composed of high-demand athletes. Finally, we also decided to conduct an analysis grouping the tibial and femoral osteotomies (axial osteotomies) and comparing their results with the Fulkerson osteotomy results. Even though the patient sample was small, we observed a better return to maximum level in the patients submitted to Fulkerson osteotomies than in the patients who underwent axial osteotomies, but with a greater need for removal of synthesis material. Neither showed a statistical difference. Because of the subjective limitation, it is possible that it could not be a tendency, but only a coincidence, which is necessary to be clarified in future studies with a greater number of subjects. Tjoumakaris et al. performed Fulkerson osteotomy and lateral retinacular release in athletes due to patellofemoral instability.[32] All 34 patients returned to sports practice and 17 had to have the osteotomy fixation screws removed after eight months.

It is well established in literature, the use of osteotomy for the axis correction in patients not only with osteoarthritis but also chondral lesions, in association with other procedures for chondral repair. In this study, we have chosen only patients with established osteoarthritis, given the difference of both diseases.[33,34]

The current study has some important limitations. First, the study is retrospective and subject to the inherent limitations of this design, with patients being asked questions about events that occurred, in some cases, many years before. In addition, the sample size is relatively small and thus, subgroup analyses, such as the comparison between the results of patients submitted to axial osteotomy and of patients submitted to ATT osteotomy, or between prognostic factors, end up having little statistical power. Another limitation of this study is that different osteotomy around the knee techniques were used by different surgeons, and we did not analyze the degrees of correction of the osteotomies, directly related to their success. Also, we did not analyze the use of other procedures combined to the osteotomies such as meniscus sutures, ligament reconstructions, which could have influenced the patient's final results.

## CONCLUSION

The study suggests that osteotomies around the knee may be valid treatments for athletes of competitive age who want to return to sports activities. These results also show that in some cases it is possible to return to practically the same sports level that was achieved by the athlete at their peak, prior to surgery. It should be emphasized that a thorough analysis of each case and the use of a pertinent surgical technique are essential for safe treatment and for greater chances of reaching the individual goal. Multicenter studies that cover a greater number of athletes may be able to identify the best prognostic factors in these clinical situations.

**AUTHOR'S CONTRIBUTION:** Each author made significant individual contributions to the development of this manuscript. DM: Data curation; Investigation; Methodology; Visualization; Roles/Writing - original draft; Writing - review & editing; ACB: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Supervision; Validation; Visualization; Roles/Writing - original draft; Writing - review & editing; CD: Conceptualization; Methodology; Writing - review & editing; GG: Conceptualization; Data curation; Methodology; Writing - review & editing; AT: Conceptualization; Data curation; Methodology; Writing - review & editing; WC: Conceptualization; Methodology; Supervision; Writing - review & editing.

## REFERENCES

1. Brouwer RW, Huizinga MR, Duivenvoorden T, van Raaij TM, Verhagen AP, Bierma-Zeinstra SM, et al. Osteotomy for treating knee osteoarthritis. Cochrane Database Syst Rev. 2014;2014(12):CD004019.
2. Fibel KH, Hillstrom HJ, Halpern BC. State-of-the-Art management of knee osteoarthritis. World J Clin Cases. 2015;3(2):89-101.
3. Kohn L, Sauerschnig M, Iskansar S, Lorenz S, Meidinger G, Imhoff AB, et al. Age does not influence the clinical outcome after high tibial osteotomy. Knee Surg Sports Traumatol Arthrosc. 2013;21(1):146-51.
4. Prodromos CC, Amendola A, Jakob RP. High tibial osteotomy: indications, techniques, and postoperative management. Instr Course Lect. 2015;64:555-65.

5. Khan M, Evaniew N, Bedi A, Ayeni OR, Bhandari M. Arthroscopic surgery for degenerative tears of the meniscus: A systematic review and meta-analysis. CMAJ. 2014;186(14):1057-64.
6. Savarese E, Bisicchia S, Romeo R, Amendola A. Role of high tibial osteotomy in chronic injuries of posterior cruciate ligament and posterolateral corner. J Orthop Traumatol. 2011;12(1):1-17.
7. Niinimäki TT, Eskelinen A, Mann BS, Junnila M, Ohtonen P, Leppilahti J. Survivorship of high tibial osteotomy in the treatment of osteoarthritis of the knee: Finnish registry-based study of 3195 knees. J Bone Joint Surg Br 2012;94(11):1517-21.
8. Bode G, von Heyden J, Pestka J, Schmal H, Salzmann G, Südkamp N, et al. Prospective 5-year survival rate data following open-wedge valgus high tibial osteotomy. Knee Surg Sports Traumatol Arthrosc. 2015;23(7):1949-55.
9. Efe T, Ahmed G, Heyse TJ, Boudriot U, Timmesfeld N, Fuchs-Winkelmann S, et al. Closing-wedge high tibial osteotomy: Survival and risk factor analysis at long-term follow up. BMC Musculoskelet Disord. 2011;12:46.
10. Saithna A, Kundra R, Getgood A, Spalding T. Opening wedge distal femoral varus osteotomy for lateral compartment osteoarthritis in the valgus knee. Knee. 2014;21(1):172-5.
11. Cameron JI, McCauley JC, Kermanshahi AY, Bugbee WD. Lateral Opening--wedge Distal Femoral Osteotomy: Pain Relief, Functional Improvement, and Survivorship at 5 Years. Clin Orthop Relat Res. 2015;473(6):2009-15.
12. Backstein D, Morag G, Hanna S, Safir O, Gross A. Long-Term Follow-Up of Distal Femoral Varus Osteotomy of the Knee. J Arthroplasty. 2007;22(4 Suppl 1):2-6.
13. Sternheim A, Garbedian S, Backstein D. Distal femoral varus osteotomy: Unloading the lateral compartment: Long-term follow-up of 45 medial closing wedge osteotomies. Orthopedics. 2011;34(9):e488-90.
14. Bonnin MP, Laurent JR, Zadegan F, Badet R, Pooler Archbold HA, Servien E. Can patients really participate in sport after high tibial osteotomy?. Knee Surg Sports Traumatol Arthrosc. 2013;21(1):64-73.
15. Uquillas C, Rossy W, Nathasingh CK, Strauss E, Jazrawi L, Gonzalez-Lomas G. Osteotomies about the knee: AAOS exhibit selection. J Bone Joint Surg Am. 2014;96(24):e199.
16. Gao L, Madry H, Chugaev DV, Denti M, Frolov A, Burtsev M, et al. Advances in modern osteotomies around the knee: Report on the Association of Sports Traumatology, Arthroscopy, Orthopaedic surgery, Rehabilitation (ASTAOR) Moscow International Osteotomy Congress 2017. J Exp Orthop. 2019;6:9.
17. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. Clin Orthop Relat Res. 1985;(198):43-9.
18. Holden D, James S, Larson R, Slocum D. Proximal Tibial Osteotomy in Patients Who Are Fifty Years Old or Less. A Long-term Follow-Up Study. J Bone Joint Surg Am. 1988;70(7):977-82.
19. Korovessis P, Katsoudas G, Salonikides P, Stamatakis M, Baikousis A. Medium- and long-term results of high tibial osteotomy for varus gonarthrosis in an agricultural population. Orthopedics. 1999;22(8):729-36.
20. Salzmann GM, Ahrens P, Naal FD, El-Azab H, Spang JT, Imhoff AB, et al. Sporting activity after high tibial osteotomy for the treatment of medial compartment knee osteoarthritis. Am J Sports Med. 2009;37(2):312-8.
21. de Carvalho LH, Temponi EF, Soares LFM, Gonçalves MBJ, Costa LP. Physical activity after distal femur osteotomy for the treatment of lateral compartment knee osteoarthritis. Knee Surg Sports Traumatol Arthrosc. 2014;22(7):1607-11.
22. Hoorntje A, Witjes S, Kuijer PPFM, Koenraadt KLM, van Geenen RCI, Daams JG, et al. High Rates of Return to Sports Activities and Work After Osteotomies Around the Knee: A Systematic Review and Meta-Analysis. Sports Med. 2017;47(11):2219-44.
23. Hoorntje A, Kuijer PPFM, van Ginneken BT, Koenraadt KLM, van Geenen RCI, Kerkhoffs GMMJ, et al. Prognostic Factors for Return to Sport After High Tibial Osteotomy: A Directed Acyclic Graph Approach. Am J Sports Med. 2019;47(8):1854-62.
24. Kanto R, Nakayama H, Iseki T, Onishi S, Ukon R, Kanto M, et al. Return to sports rate after opening wedge high tibial osteotomy in athletes. Knee Surg Sports Traumatol Arthrosc. 2021;29(2):381-8.
25. Lerat JL, Moyen B, Garin C, Mandrino A, Besse JL, Brunet-Guedj E. Anterior laxity and internal arthritis of the knee. Results of the reconstruction of the anterior cruciate ligament associated with tibial osteotomy. Rev Chir Orthop Reparatrice Appar Mot. 1993;79(5):365-74.
26. Ekhtiari S, Haldane CE, De Sa D, Simunovic N, Musahl V, Ayeni OR. Return to work and sport following high tibial osteotomy: A systematic review. J Bone Joint Surg Am. 2016;98(18):1568-77.
27. Johnstone SF, Tranovich MJ, Vyas D, Wright VJ. Unicompartmental arthritis in the aging athlete: Osteotomy and beyond. Curr Rev Musculoskelet Med. 2013;6(3):264-72.
28. Hoorntje A, van Ginneken BT, Kuijer PPFM, Koenraadt KLM, van Geenen RCI, Kerkhoffs GMMJ, et al. Eight respectively nine out of ten patients return to sport and work after distal femoral osteotomy. Knee Surg Sports Traumatol Arthrosc. 2019;27(7):2345-53.
29. Jacquet C, Gulagaci F, Schmidt A, Pendse A, Parratte S, Argenson JN, et al. Opening wedge high tibial osteotomy allows better outcomes than unicompartmental knee arthroplasty in patients expecting to return to impact sports. Knee Surg Sports Traumatol Arthrosc. 2020;28(12):3849-59.
30. Liu JN, Wu HH, Garcia GH, Kalbian IL, Strickland SM, Shubin Stein BE. Return to Sports After Tibial Tubercle Osteotomy for Patellofemoral Pain and Osteoarthritis. Arthrosc. 2018;34(4):1022-9.
31. Liu JN, Agarwalla A, Garcia GH, Christian DR, Gowd AK, Yanke AB, et al. Return to Sport and Work After High Tibial Osteotomy With Concomitant Medial Meniscal Allograft Transplant. Arthrosc. 2019;35(11):3090-6.
32. Tjoumakaris FP, Forsythe B, Bradley JP. Patellofemoral instability in athletes: Treatment via modified fulkerson osteotomy and lateral release. Am J Sports Med. 2010;38(5):992-9.
33. Dhillon J, Kraeutler MJ, Fasulo SM, Belk JW, Scillia AJ, McCulloch PC. Isolated Osteotomy Versus Combined Osteotomy and Cartilage Repair for Osteoarthritis or Focal Chondral Defects of the Medial Compartment of the Knee Joint: A Systematic Review. Orthop J Sports Med. 2023;11(5):23259671231162030.
34. Ghasemi SA, Kolesnick E, Murray BC, Leiby BE, Bartolozzi AR, Zaslav KR. High tibial osteotomy combined with cartilage restoration: A systematic review of clinical outcomes and prognostic factors. J Clin Orthop Trauma. 2024;50:102360.

DOI: http://dx.doi.org/10.1590/1413-785220253301e282483



# DIAGNOSTIC COMPETENCE IN BONE TUMORS: INFLUENCE OF ONCO-ORTHOPEDIC TRAINING

# COMPETÊNCIA DIAGNÓSTICA EM TUMORES ÓSSEOS: INFLUÊNCIA DO TREINAMENTO ONCO-ORTOPÉDICO

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## ABSTRACT

Understanding the nature of musculoskeletal tumors is crucial for appropriate management and to secure a favorable prognosis. Orthopedists' ability to identify these pathologies early and accurately is paramount. There is a requirement to raise awareness within the orthopedic community regarding the necessity of referrals to orthopedic oncology specialists, as delays in initiating proper treatment can compromise patient prognosis. Objective: The objective was to assess the capability of non-specialist orthopedists in identifying bone lesions suggestive of tumors and thus classify them by employing a questionnaire with radiographs and comparison with specialists. We aim to gain an in-depth understanding of their diagnostic competence and provide insights into teaching the subject in orthopedic residency programs. Methods: The sample consisted of 90 participants who answered the questionnaire: 18 orthopedic oncology specialists, 58 non-specialist orthopedists, and 14 orthopedic residents. Results: Specialists achieved an average accuracy of 12.50 ± 1.07, while non-specialists scored 10.00 ± 0.60 ($p<0.001$). Among non-specialists, there was no statistical significance when comparing whether they underwent specialization internship during residency nor the duration of the year of such training. The period since graduation also indicated no differences. Conclusion: This study highlights the importance of referring patients with suspected tumors to specialized orthopedists. ***Level of Evidence V; Expert Opinion.***

**Keywords:** Internship and Residency; Education, Medical; Neoplasms; Bone and Bones; Diagnostic Errors; Delayed Diagnosis.

## *RESUMO*

*Compreender a natureza dos tumores musculoesqueléticos é crucial para a abordagem adequada e prognósticos favoráveis. A capacidade de identificação precoce e correta dessas patologias por ortopedistas é uma questão importante. Busca-se conscientizar a comunidade ortopédica sobre a necessidade de encaminhamentos para especialistas em oncologia ortopédica, uma vez que o atraso no início do tratamento adequado pode comprometer o prognóstico do paciente. Objetivo: O objetivo foi avaliar a capacidade de ortopedistas não especialistas em tumor musculoesquelético em identificar lesões ósseas sugestivas de tumores e classificá-las a partir de questionário com radiografias e da comparação com especialistas. Pretendemos obter uma visão aprofundada de sua competência diagnóstica, bem como traçar um panorama do ensino do tema nos serviços de residência médica. Métodos: A amostra consistiu em 90 participantes que responderam ao questionário eletrônico: 18 especialistas em onco-ortopedia, 58 ortopedistas não especialistas e 14 residentes em ortopedia. Resultados: Os especialistas tiveram média de acerto de 12,50 ± 1,07, enquanto os não especialistas, 10,00 ± 0,60 ($p<0,001$). Dentre os não especialistas, não houve significância estatística quando comparados se tiveram estágio na especialização durante a residência, nem quanto à duração do estágio ou em que ano da residência teve tal treinamento. O tempo de formado também não mostrou diferenças. Conclusão: O estudo aponta a importância de encaminhar pacientes com suspeita de tumores para ortopedistas especializados.* ***Nível de Evidência V; Opinião de Especialistas***

***Descritores:*** *Internato e Residência; Educação Médica; Neoplasias; Osso e Ossos; Erros de Diagnóstico; Diagnóstico Tardio.*

**Citation:** Daou JP, Giannotti CF, Garcia JG, Petrilli MT, Viola DCM, Garcia Filho RJ. Diagnostic competence in bone tumors: influence of onco-orthopedic training. Acta Ortop Bras. [online]. 2025;33(1):Page 1 of 5. Available from URL: http://www.scielo.br/aob.

## INTRODUCTION

Primary malignant bone and soft tissue tumors, whilst considered rare, approximate 1% of malignancies, which pose significant challenges to orthopedic practice. To better understand the nature of these lesions proves crucial in determining the appropriate therapeutic approach and as such, achieve a more favorable prognosis. However, the ability for early and accurate detection of these pathologies by non-specialist orthopedic practitioners in orthopedic oncology remains an issue that is deserving of further attention.[1-3]

All authors declare no potential conflict of interest related to this article.

***The study was conducted at Universidade Federal de São Paulo, Department of Orthopaedics and Traumatology, Discipline of Orthopaedic Oncology.***
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Article received on 01/21/2024, approved on 03/21/2024.

The inherent complexity in interpreting images of musculoskeletal tumors adds a layer of difficulty to the diagnostic approach. This challenge is particularly evident when considering the variety of tumors and pseudotumoral conditions that can emerge in radiological examinations which often present similar imaging characteristics. Within this context, radiography, being the initial exam, may not prove sufficient to accurately differentiate the nature of the lesions by a lesser trained individual. Failure to interpret imaging findings may indeed lead to inappropriate clinical management and treatment.[1,3,4]
The importance of this work transcends the mere assessment of the individual orthopedic competence. It aims to raise awareness among the orthopedic community as to the requirement for early referrals to orthopedic oncology specialists, as delays in initiating appropriate treatment, both for malignant and benign tumors, can significantly compromise patient prognosis.[5]
This article's principal objective is to evaluate the ability of orthopedists who are not recognized specialists in musculoskeletal tumors to identify bone lesions suggestive of tumors and classify their nature based on radiographs via the application of a questionnaire and comparison with specialists' responses. By assessing how these professionals approach the interpretation of imaging examinations and the classification of lesions as benign, malignant or aggressive benign, we set out to obtain an in-depth understanding of their diagnostic competence within this challenging context, and moreover, outline the landscape of teaching this subject in orthopedic residency programs.

## METHODS

This is a cross-sectional survey study approved by the Research Ethics Committee of the Universidade Federal de São Paulo (CEP-UNIFESP) and registered in Plataforma Brasil under the number 71176123.0.0000.5505/2023. The study was conducted at the Disciplina de Ortopedia Oncológica of the Departamento de Ortopedia e Traumatologia (DOT-UNIFESP).
The target population for this study consisted of orthopedic residents, orthopedic doctors specialized in oncology and orthopedic doctors without distinction based on subspecialization. Exclusion criteria were (A) refusal to participate in the study or (B) not in agreement with the content of the consent form.
The participants were requested to identify bone lesions suggestive of tumors and classify their nature based on radiographs via the application of a questionnaire. Due to the scarcity of similar studies within the Brazilian population - the restricted sample size, and the importance of evaluating the ability of orthopedists to identify potentially malignant lesions - a convenience sample was then selected.
The prepared questionnaire by researchers included sociodemographic data to characterize the sample and questions containing radiographic imagens and were required to indicate whether the radiographic images represented a tumor condition and to classify whether the lesion was malignant, benign, or aggressive benign (Figure 1).
The questionnaire was developed and reviewed within Google Forms. It was disseminated electronically on WhatsApp, in groups of orthopedists and residents via the following link: https://forms.gle/1akkWvtTBnoLgcrx8. The questionnaire was administered between November 2023 and January 2024. By agreeing to answer the questionnaire, the participant consented to participate in the study (Figure 2).
Quantitative variables were analyzed descriptively. Microsoft Excel software was applied for both descriptive and inferential analysis. Statistical analysis employed parametric tests using the software programs SPSS V26 (2019), Minitab 21.2 (2022), and Excel Office 2010, with a predetermined significance level of 5% ($p<0.05$) and an adjusted confidence interval (CI 95%).

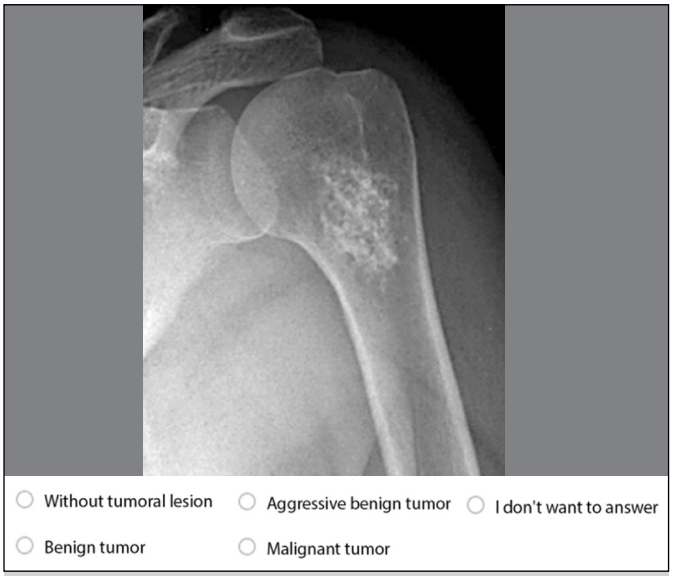


**Figure 1.** Example of a question to be answered by the participant in Google Forms.

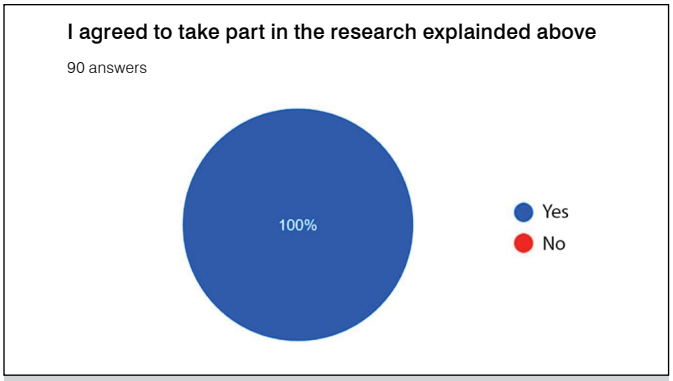


**Figure 2.** Proportion of participants who agreed to take part in the research and signed the Informed Consent Form.

## RESULTS

Our sample constituted 90 orthopedic surgeons, comprising 18 (20%) specialists in orthopedic oncology, 58 (64.4%) orthopedic oncology non-specialists, and 14 (15.6%) orthopedic resident physicians. Among the residents, there were five (5.6%) first-year residents (R1), five (5.6%) second-year residents (R2), and four (4.4%) third-year residents (R3) (Figure 3)."
Among the 90 research participants, 26 (28.9%) completed their orthopedic training more than 10 years ago, 20 (22.2%) between 5 and 10 years ago, 30 (33.3%) within the last 5 years, and 14 (15.6%) were still residents at the time of the survey (Figure 4).
As for training in orthopedic oncology, 55 (61.1%) participants underwent a specialty rotation at the main institution of their residency program, 17 (18.9%) at affiliated institutions of their primary center, 17 (18.9%) did not have this rotation in their training curriculum, and one (1.1%) participant did not respond to the question (Figure 5).
Of the 72 participants who underwent training in orthopedic oncology via the residency program, 51 (71%) completed this rotation for a period of 3 months or more, 16 (22%) for 1 to 2 months, and 5 (7%) for up to 1 month.
These 72 participants completed their internships as follows: 39 (54%) in only one year of residency, and 33 (46%) undertook the internship more than once throughout their term of residency (Figure 7A). Of these 33 participants, 26 (79%) underwent orthopedic

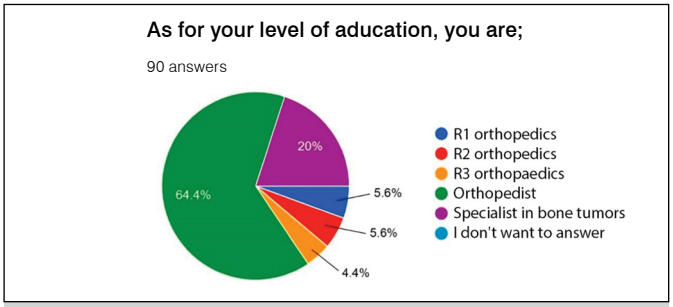


**Figure 3.** Characterization of the sample regarding the participants' level of education (R1 = first year resident; R2 = second year resident; R3 = third year resident).

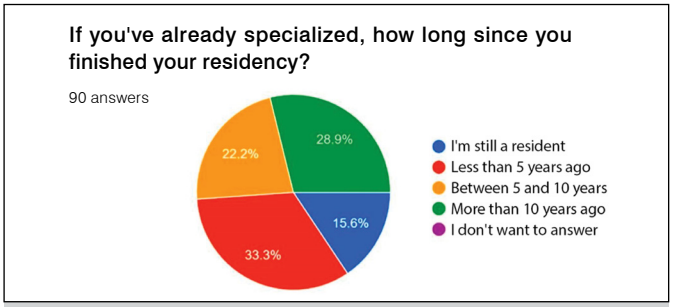


**Figure 4.** Characterization of the sample based on the completion time of orthopedic residency.

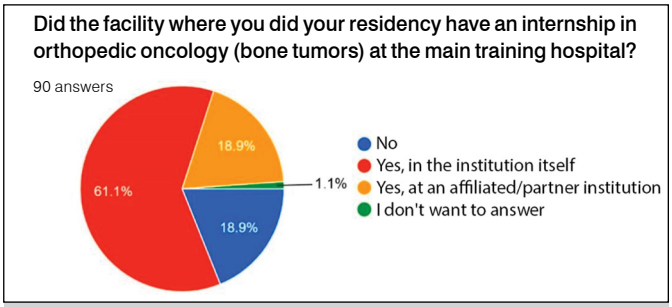


**Figure 5.** Proportion of participants who completed an internship in orthopedic oncology at the main hospital of their training.

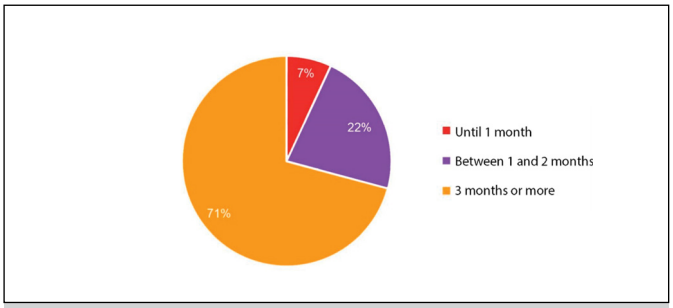


**Figure 6.** Characterization of the sample based on the duration of the orthopedic oncology rotation during residency.

oncology training in all three years of residency, two (6%) had training in the first two years of residency, one (3%) underwent the internship in the first and third years of residency, and four (12%) in the last two years of residency. Among the 39 participants who completed the internship only once during their term of residency, two (5%) did so only in the first year, seven (18%) only in the second year, and 30 (77%) only in the third year of residency (Figure 7B).

Participants were presented with a clinical case of a 12-year-old child with suspected bone tumor and asked what course of action they would take. 64 (71.1%) participants would elect to refer to the specialized service without further tests; 17 (18.9%) would request tests before referring to the specialized service, six (6.7%) would perform a biopsy before referring to the specialized center, one (1.1%) would not do any of the alternatives proposed in the question and two (2.2%) did not wish to respond (Figure 8).

In relation to the identification of tumors, specialists recorded an average of 12.50 ± 1.07 correct answers, while non-specialists registered an average of 10.00 ± 0.60 questions ($p<0.001$) (Table 1).

When comparing the results of questionnaires answered by non-specialists in relation to the time of completion of their orthopedic residency training, we found no statistically significant difference between the mean scores (Table 2).

There was no statistical significance among non-specialists when compared to duration of the internship during residency, as evidenced in Table 3.

When comparing whether non-specialists undertook an internship in oncologic orthopedics at the main institution, at a partner institution, or those who did not undergo internship, no significant statistical differences were observed, as shown in Table 4.

In relation to the time as to when participants underwent training in oncologic orthopedics, we divided the analysis into two parts: we

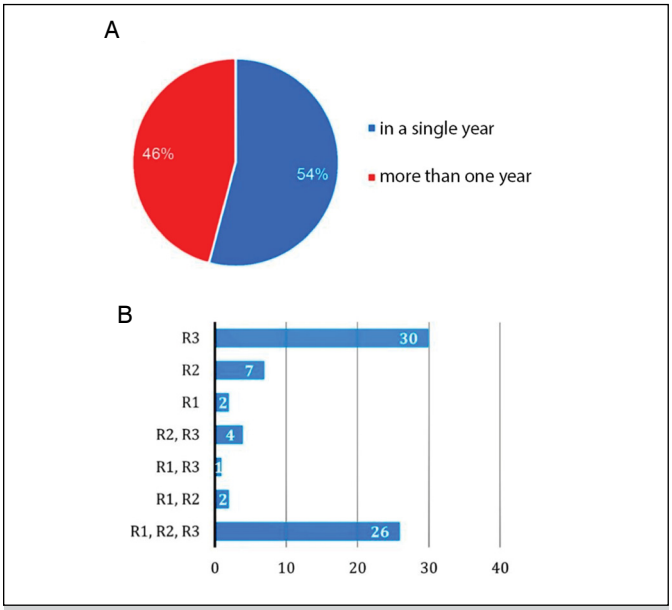


**Figure 7.** Participants who underwent the orthopedic oncology rotation multiple times. B. Distribution of the rotation during the residency years (R1 = first year resident; R2 = second year resident; R3 = third year resident).

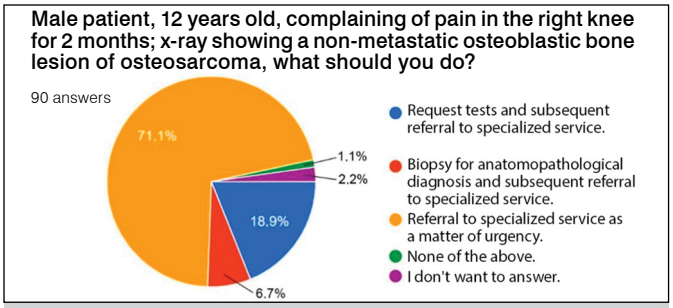


**Figure 8.** Participants' responses regarding the approach to the presented clinical case.

**Table 1.** Comparison of mean accuracy between specialists and non-specialists in musculoskeletal tumors.

| | Specialist | Non-Specialist |
|---|---|---|
| Mean | 12.50 | 10.00 |
| Median | 13 | 10 |
| Standard Deviation | 2.31 | 2.58 |
| CV | 18% | 26% |
| Min | 7 | 6 |
| Max | 17 | 17 |
| N | 18 | 72 |
| CI | 1.07 | 0.60 |
| P-value | <0.001 | |

**Table 2.** Comparison of mean accuracy among non-specialists in musculoskeletal tumors in relation to the time since completion of their orthopedic residency training.

| | Resident | Less than 5 years | 5-10 years | More than 10 years |
|---|---|---|---|---|
| Mean | 9.43 | 10.36 | 8.93 | 10.93 |
| Median | 9 | 10 | 8 | 11 |
| Standard Deviation | 2.85 | 1.97 | 2.34 | 3.26 |
| CV | 30% | 19% | 26% | 30% |
| Min | 6 | 7 | 6 | 6 |
| Max | 16 | 14 | 13 | 17 |
| N | 14 | 28 | 15 | 15 |
| CI | 1.49 | 0.73 | 1.19 | 1.65 |
| P-value | 0.124 | | | |

**Table 3.** Comparison of mean accuracy among non-specialists in musculoskeletal tumors in relation to the duration of the internship during residency.

| | Until 1 month | 1 to 2 months | 3 months or more |
|---|---|---|---|
| Mean | 10.75 | 8.50 | 10.46 |
| Median | 10 | 8 | 10 |
| Standard Deviation | 2.36 | 2.50 | 2.57 |
| CV | 22% | 29% | 25% |
| Min | 9 | 6 | 6 |
| Max | 14 | 13 | 17 |
| N | 4 | 12 | 41 |
| CI | 2.32 | 1.42 | 0.79 |
| P-value | 0.063 | | |

**Table 4.** Comparison of mean accuracy among non-specialists, stratified by the presence in the curriculum of the residency program.

| | Não | Yes (Partnership) | Yes (Own) |
|---|---|---|---|
| Mean | 9.73 | 9.91 | 10.11 |
| Median | 9 | 10 | 10 |
| Standard Deviation | 2.46 | 2.55 | 2.68 |
| CV | 25% | 26% | 26% |
| Min | 6 | 6 | 6 |
| Max | 14 | 14 | 17 |
| N | 15 | 11 | 46 |
| CI | 1.25 | 1.51 | 0.77 |
| P-value | 0.883 | | |

first identified the last year they had contact with the subject and secondly, the number of years during residency in which internship was completed. None of the analyses yielded significant statistical results (Table 5).

## DISCUSSION

This study comprehensively assessed the ability of non-specialist orthopedists in oncologic orthopedics to identify bone lesions suggestive of tumors and classify their nature based on radiographs by employing a questionnaire. Non-specialist responses were compared with those of specialists, which prompted statistical differences in just how these images were evaluated. Moreover, the study aimed to outline the landscape of teaching on this topic in orthopedic residency programs, given the scarcity of literature on the subject. Freeman T et al (2019) noted that out of the 11,773 articles published in the top 15 orthopedic journals in 2015, only 51 addressed education-related topics. The analysis of impact of formal oncologic orthopedic internships during residency - *on the diagnosis of bone lesions* - only further highlights the importance of specific experience in the field. It is pertinent to note that the Sociedade Brasileira de Ortopedis e Traumatologia corroborates the Resolution No. 22 of April 8, 2019, from the Ministry of Education, orthopedic residents should acquire the necessary competency to evaluate and manage the treatment of tumor lesions by the end of the third year of residency. That said, the lack of formal internships in oncologic orthopedics in various Brazilian residency programs underscores a gap in training, which could potentially contribute to the non-identification of tumor lesions in emergency or outpatient situations. It is therefore essential for all orthopedists to possess at least a basic understanding of musculoskeletal system tumors. This approach is crucial to optimize the effective use of time and resources, thus aiming for appropriate therapeutics within each clinical case.[5-7] Undue delay in the diagnosis of bone tumors is problematic, given the potential decrease in the chances of successful treatment and increased morbidity after inadequate interventions. The two questions related to infections recorded the lowest accuracy rates, with one showing 1.1% correct responses, and the other, 5.5%. As infection is one of the principal differential diagnoses of bone tumors, it is crucial to highlight that in cases of diagnostic uncertainty, the most prudent approach is to refer the patient to a specialized oncologic service. This precaution aims to rule out the possibility of initiating treatment for infection when the underlying condition may, in reality, not be a tumor. Orthopedists should by right, be aware of the early referral of suspicious cases to specialists. For this reason, the referral question was established as the primary question guiding this study, which then revealed a rate of 71.1% favorable responses to the early referral approach, thus avoiding errors and diagnostic delays that can negatively influence the patient's clinical outcome.

The first step in following patient cases with suspected bone tumors is the indication for biopsy. It is crucial to distinguish lesions that do not require this procedure, as some tumors exhibit unequivocal characteristics of benignity, avoiding the need for a biopsy. Furthermore, in cases where biopsy results do not alter the

**Table 5.** Comparison of mean accuracy according to the years of internship.

| | | Mean | Median | Standard Deviation | CV | Min | Max | N | CI | P-value |
|---|---|---|---|---|---|---|---|---|---|---|
| Last year of contact with the subject | R1 | 6.50 | 6.5 | 0.71 | 11% | 6 | 7 | 2 | 0.98 | 0.129 |
| | R2 | 9.71 | 10 | 2.81 | 29% | 6 | 13 | 7 | 2.08 | |
| | R3 | 10.27 | 10 | 2.57 | 25% | 6 | 17 | 48 | 0.73 | |
| Number of years they had the internship | 1 year | 9.86 | 9 | 2.81 | 29% | 6 | 17 | 29 | 1.02 | 0.321 |
| | 2 years | 8.80 | 10 | 1.64 | 19% | 7 | 10 | 5 | 1.44 | |
| | 3 years | 10.61 | 11 | 2.52 | 24% | 6 | 16 | 23 | 1.03 | |

course of action, the performance of this procedure can be avoided. When biopsy is indicated, it is preferable that it be performed by a specialized team, guided by imaging exams to obtain tumor material in the best topographies and via the best access route for possible definitive surgery. Early diagnosis is crucial to maintaining the quality of life of patients, especially in the presence of metastases and skeletal events. In relation to soft tissue tumors, improper treatment results in compromised margins in 91% of patients and recurrence in at least 39%. It is essential to emphasize the importance of accurate diagnosis and appropriate treatment to optimize clinical outcomes and the patients quality of life.[8-11]

The limitations of this research include recognition that the extensive questionnaire, with 21 questions, may have potentially caused difficulties among participants; this, as well as the low number of orthopedists who responded to the questionnaire may have influenced the result. It was not assessed whether the orthopedist who answered the questions is associated with a teaching and resident training service, which could generate greater exposure to cases of musculoskeletal tumors. Additionally, it is important to note that radiography, despite being the exam of choice and in general, proving sufficient to form most diagnostic hypotheses, may indeed not be sufficient to identify a possible neoplastic lesion, especially in anatomically complex regions such as the pelvis. and spine. As such, MRI and CT scans can provide more detailed information. The choice to use solely radiographs in this study is due to their greater accessibility, as they are often the first point of approach to identifying injuries in an emergency care context.

Whilst this study highlights that radiography is not the most detailed of examination, it did prove sufficient for specialists in musculoskeletal tumors to identify, on average, more than half of the nature of the presented lesions (12,50 ± 1,07). Non-specialists however, did not achieve the same results (10,00 ± 0,60), which only emphasized the importance of prompt referral to specialized services.

Furthermore, the study indicated that the duration of time since completing orthopedic training, for the non-specialists in oncologic orthopedics, does not influence discriminatory capacity. This likely occurs due to the rarity of musculoskeletal tumors, which results in sporadic experience with these cases, thus the lack of generating diagnostic experience for the non-specialist.

No significant differences were identified between whether or not training in musculoskeletal tumors was conducted during the residency period. Despite the absence of differences in terms of duration of internship, a trend appeared in which participants with latter contact with the subject in the third year of residency scored more correct answers than those with last contact in their second and first years of residency, in that order. Participants who underwent specialization training in all three years also scored more correct answers. Within this context, various hypotheses could be considered: the annual completion of the specialist title exam by the Brazilian Society of Orthopedics, for which all residents of accredited services prepare, may contribute to uniformity in theoretical knowledge on the subject; or alternatively, questions may be raised in relation to the onco-orthopedic teaching offered in residency programs.

## CONCLUSION

When compared with recognized specialists, the ability of non-specialist orthopedists in identifying bone lesions suggestive of tumors and then classifying their nature based on radiographs proved to be statistically lower. However, various training modalities during medical residency for non-specialists, as well as time duration since completion of training, failed to unearth any significant statistical difference.

The results obtained can be directed as guidance for non-specialist orthopedists by emphasizing the importance of promptly referring patients with suspected musculoskeletal tumors to specialized orthopedists, and the requirement to more diligently evaluate the training of residents, as this can pose a direct influence on the outcomes of patient treatment and prognosis.

**AUTHOR'S CONTRIBUTION:** Each of the individual authors contributed significantly to the development of this article. JPD: article composition, review, the surveying of epidemiological data on the applied platform, statistical analysis; CFG, JGG: review, the surveying of epidemiological data on the applied platform, article composition; MTP, RJGF: review, the surveying of epidemiological data on the applied platform; DCMV: article review, article intellectual concept development, the surveying of epidemiological data on the applied platform.

## REFERENCES

1. Burke NG, Moran CJ, Hurson B, Dudeney S, O'Toole GC. Musculoskeletal oncology training during residency. J Orthop Surg (Hong Kong). 2011;19(3):350-3. doi: 10.1177/230949901101900318.
2. Rydholm A. Improving the management of soft tissue sarcoma. Diagnosis and treatment should be given in specialist centres. BMJ. 1998;317(7151):93-4. doi: 10.1136/bmj.317.7151.93.
3. Weber MA, Lalam R. Bone and Soft Tissue Tumors. Semin Musculoskelet Radiol. 2019;23(1):1-2. doi: 10.1055/s-0038-1676291.
4. Arkun R, Argin M. Pitfalls in MR imaging of musculoskeletal tumors. Semin Musculoskelet Radiol. 2014;18(1):63-78. doi: 10.1055/s-0034-1365836.
5. Saotome K. Bone and soft-tissue tumors in postgraduate education. J Orthop Sci. 2001;6(3):215-6. doi: 10.1007/s007760100036.
6. Brasil. Ministério da Educação/Secretaria de Educação Superior, Medida provisória nº 22, de 08 de abril de 2019. Diário Oficial da União: 11 de abril de 2019. Seção 1, p. 213.
7. Freeman T, Shelke N, Rajani R. Assessment of Orthopedic Educational Research in 2015 Publications. J Surg Educ. 2019;76(2):578-84. doi: 10.1016/j.jsurg.2018.08.015.
8. Meek RD, Mills MK, Hanrahan CJ, Beckett BR, Leake RL, Allen H, et al. Pearls and Pitfalls for Soft-Tissue and Bone Biopsies: A Cross-Institutional Review. Radiographics. 2020;40(1):266-90. doi: 10.1148/rg.2020190089.
9. Goedhart LM, Gerbers JG, Ploegmakers JJ, Jutte PC. Delay in Diagnosis and Its Effect on Clinical Outcome in High-grade Sarcoma of Bone: A Referral Oncological Centre Study. Orthop Surg. 2016;8(2):122-8. doi: 10.1111/os.12239.
10. Brodowicz T, Hadji P, Niepel D, Diel I. Early identification and intervention matters: A comprehensive review of current evidence and recommendations for the monitoring of bone health in patients with cancer. Cancer Treat Rev. 2017;61:23-34. doi: 10.1016/j.ctrv.2017.09.008.
11. Pretell-Mazzini J, Barton MD Jr, Conway SA, Temple HT. Unplanned excision of soft-tissue sarcomas: current concepts for management and prognosis. J Bone Joint Surg Am. 2015;97(7):597-603. doi: 10.2106/JBJS.N.00649.

DOI: http://dx.doi.org/10.1590/1413-785220253301e285342



# TREATMENT OF PATIENTS WITH GIANT CELL BONE TUMOR IN NORTHERN BRAZIL, IN 2020 AND 2021

# TRATAMENTO DE PACIENTES COM TUMOR ÓSSEO DE CÉLULAS GIGANTES NO NORTE DO BRASIL, EM 2020 E 2021

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## ABSTRACT

Objective: This study aimed to evaluate the profile of patients diagnosed with giant cell tumors treated at the Ophir Loyola Hospital. Method: An analytical study in the form of a retrospective cohort, conducted through a review of patient medical records and imaging exams of individuals treated at the hospital between January 1, 2020, and December 31, 2021. Result: A total of 19 patients were evaluated, with an average time of 10.5 months between diagnostic suspicion and the first consultation with the Orthopedic Oncology team. Conclusion: Among the patients studied, 73% were presented with advanced-stage disease, requiring aggressive surgical treatment with wide resection and replacement with an endoprosthesis. ***Level of Evidence II; Retrospective Prognostic Study.***

**Keywords:** Giant Cell Tumors; Cohort Studies; Bone Neoplasms.

## *RESUMO*

*Objetivo: Avaliar o perfil do paciente com diagnóstico de tumor de células gigantes atendidos no Hospital Ophir Loyola. Método: Estudo analítico em forma de coorte retrospectiva, realizado por revisão dos prontuários e exames de imagem dos pacientes atendidos no hospital no período de 1 de janeiro de 2020 a 31 de dezembro de 2021. Resultado: Foram avaliados 19 pacientes, com tempo médio de 10,5 meses entre a suspeita diagnóstica e a primeira consulta com a equipe da Oncologia Ortopédica. Conclusão: Dos pacientes estudados, 73% apresentavam-se em estágio avançado, necessitando tratamento cirúrgico agressivo com ressecção ampla e substituição por endoprótese.* ***Nível de Evidência II; Estudo Prognóstico de Caráter Retrospectivo.***

***Descritores:*** *Tumores de Células Gigantes; Estudos de Coortes; Neoplasias Ósseas.*

**Citation:** Couto Filho FB, Yonamine ES, Magno FG, Favacho-Silva AB, Brito CRA, Brito TRB. Treatment of patients with giant cell bone tumor in northern Brazil, in 2020 and 2021. Acta Ortop Bras. [online]. 2025;33(1):Page 1 of 6. Available from URL: http://www.scielo.br/aob.

## INTRODUCTION

Giant cell tumors (GCT) are rare, accounting for less than 10% of benign primary bone tumors. They have a higher prevalence after skeletal maturity, although they can also be found in patients with open growth plates. It is considered one of the most controversial and least predictable tumors in its behavior.[1,2]

They preferably affect long bones, although they have been reported in the spine, pelvis, patella, and sacrum. They are differentially diagnosed from aneurysmal bone cyst, chondroblastoma, and simple bone cyst.[3]

The main clinical symptoms are pain and swelling. Diagnoses can be suspected through a pathological fracture as the initial presentation. Imaging tests such as X-rays, often show the triad: epiphyseal, eccentric, and lytic lesions. The bone cortex may show thinning or local destruction. The transition zone is not well defined, but in less aggressive cases, there is sclerotic reaction. Invasion and destruction of the cortex with invasion of soft tissues are commonly observed. Sometimes there is no joint involvement due to the barrier formed by the subchondral bone.[4,5]

The interval between the first symptom and the definitive diagnosis is termed as "delay time". The period between the initial symptoms and the initial treatment can be divided into two main categories: patient delay, which is defined as the time between the initial symptoms and the first medical consultation, and professional delay, primarily caused by the physician, defined as the time between the first consultation and the initial treatment. The addition of these two delays is called the overall symptom interval.[6]

Diagnosis is made through biopsy, and treatment is surgical, which may involve intralesional resection with curettage, adjuvants and/or cavity filling with bone cement, auto or allograft; in more advanced cases,

All authors declare no potential conflict of interest related to this article.

***The study was conducted at Ophir Loyola Hospital.***
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Article received on 04/07/2024, approved on 06/13/2024.

wide resection with endoprosthesis replacement or even amputation may be performed.[2,7]
Since the morbidity of these patients is directly related to the time between diagnosis and treatment, it is important to understand the patient entry profile into the service and the outcomes of their treatment. Furthermore, there are no similar studies in the Amazon region.
To address the issues, this study aims to evaluate the profile of patients diagnosed with GCT treated at Hospital Ophir Loyola in the Years 2020 and 2021, demonstrating the time between diagnostic suspicion and the first consultation with the Orthopedic Oncology team, the characteristics of the lesion at the initial consultation and the proposed treatment.

## METHODOLOGY

This is an analytical study, in the form of a retrospective cohort, which will be conducted through the analysis of medical records and imaging studies of patients seen in the outpatient clinic from January 1, 2020, to December 31, 2021, at a quaternary hospital.
The study includes 19 patients diagnosed with GCT treated at the Orthopedic Oncology outpatient clinic from January 1, 2020, to December 31, 2021. The medical records of patients seen in the years 2022 and 2023 were not analyzed due to data unavailability at the service until the study was completed.
Patients with suspected diagnosis but who did not undergo biopsy were excluded from the study.
The research was conducted through medical record review and analysis of imaging studies.
The studied variables were divided into demographic and clinical. Demographic variables include age, sex, and place of origin. Clinical variables include the date of diagnostic suspicion, the date of the first consultation with the Orthopedic Oncology team, the date of diagnosis, the anatomical location of the tumor, the tumor stage, the presence of pulmonary metastasis, the presence of recurrence, date of pathological fracture (if applicable), type of surgery, type of cavity filling (if applicable), adjuvants used (if applicable), and the use and indication of denosumab.
First, the medical records of patients seen in the outpatient clinic with ICD-10 D16 were selected to screen for patients diagnosed with GCT. Then, date contained in the medical records and Imaging studies database were collected. A questionnaire was filled out for standardization purposes.
A descriptive analysis of the sample characterization was conducted, with frequencies, percentages, mean, standard deviation, median, interquartile range (p25%-p75%), presented in tables and/or graphs. Continuous quantitative variables, such as age (years) and duration of suspicion (months), were first subjected to the Shapiro-Wilk test to analyze their normal distribution.
For comparative analysis between the stage and recurrence groups, the Mann-Whitney test was Applied for continuous variables. The Fisher's Exact Test was used for comparative analysis between categorical variables.
All statistical analyses were performed using SPSS 20.0 software respecting a significance level of 5% ($p \leq 0.05$).
This research was approved by the Institutional Ethics Committee through the Plataforma Brazil, with identification number CAEE 7509023.6.0000.5550 (amendment no. 6.585.557). The administration of questionnaires and retrospective medical record collection were preceded by a Data Use Agreement to ensure the reliability of the collected information, and a request for Waiver of Informed Consent was submitted.

## RESULTS

The initial database included 137 patients. After reviewing the medical records, patients diagnosed with GCT through biopsy were selected. Thus, the final database consisted of 19 patients treated at the Orthopedic Oncology outpatient clinic in the years 2020 and 2021. The majority of patients were male (57.89%); with mean age of 37.32 (±13.47) years; residents of other regions of the state of Pará (47.37%), outside the Metropolitan region of Belém; with a mean patient delay time of 10.47 (±13.08) months; predominantly with lesions located in the distal femur region (47.37%), at Campanacci stage 3 (73.68%); without a history of pathological fracture (84.21%); undergoing mostly marginal/wide surgical type (73.68%) and without a history of recurrence (84.21%), as detailed in Table 1.
The most employed treatment among patients in this study was surgery with wide resection and replacement with unconventional endoprosthesis. Only 2 patients did not undergo treatment at the hospital due to loss to follow-up; for one male patient with GCT in the calcaneus, intralesional resection with cavity filing was requested, and for one female patient with GCT in the distal third of the femur, wide resection and replacement with unconventional endoprosthesis were requested, both patients did not attend for hospitalization.
Three patients experienced tumor recurrence after primary treatment. Two patients experienced recurrence about 2 years after surgery with wide resection and replacement with unconventional endoprosthesis, and they were managed with denosumab prescription. The third patient was diagnosed with tumor recurrence 6 months after surgical treatment, also with wide resection and unconventional endoprosthesis, denosumab was prescribed without significant improvement, progressing to transfemoral limb amputation.
Although not planned criteria, during the research, complications were noted in 4 patients undergoing surgical treatment. One patient initially treated with intralesional resection and osteosynthesis required endoprosthesis replacement due to significant worsening of knee osteoarthritis after initial surgical treatment. Two patients required surgery revision due to dislocation or loosening of components. And one patient progressed to transfemoral limb amputation due to surgical site infection.
None of the patients in this study were diagnosed with pulmonary metastasis.
When comparing demographic and clinical differences between the Campanacci stages groups, it was observed that patients in Stage 3 differed significantly (p-value: 0.002) from Stages 1 and 2 regarding the type of surgery performed. While in stages 1 and 2, the most used surgery type was intralesional or marginal (60%), in the stage 3, wide surgery stood out (92.9%). The other variables did not differ significantly, as detailed in Table 2.

## DISCUSSION

To better understand the profile of patients diagnosed with GCT seen at our service, we noted that the average time between diagnostic suspicion and consultation with the Orthopedic Oncology team was 10.5 months, with the tumor being in an advanced stage, necessitating extensive surgical treatment.
Among all patients seen in the service during the study period, those diagnosed with GCT presented a prevalence of approximately 14%. This is above the average described in the literature, but it is important to consider that the initial sample does not solely account for bone tumors.[8,9]
Despite epidemiological studies showing a slight predominance among females, most of our patients were male.[8-10]
The average range of most patients, the primary site of the tumor, and the presence of pathological fractures in our study are consistent with epidemiological studies. At diagnosis, most patients were between 20 and 39 years old, a finding similar to the literature.[11,12]
The most common primary sites were the distal third of the femur and the proximal third of the tibia, at 47% and 31%, respectively.
The knee is the most common primary site in the body, with the distal third of the femur being the main site, followed by the proximal

**Table 1.** Analysis of the demographic and clinical profile of patients diagnosed with giant cell tumor treated at a quaternary hospital in Northern Brazil, in the years 2020 and 2021.

| Variable | Frequency (n. 19) | Percentage (%) | CI95% |
|---|---|---|---|
| **Sex** | | | |
| Male | 11 | 57.89 | 36.8 - 78.9 |
| Female | 8 | 42.11 | 21.1 - 63.2 |
| **Age (years)** | | | |
| Mean ( sd) | 37.32 ( 13.47) | | 31.0 - 43.8 |
| Median (p25-75%) | 39.00 (24.00 - 45.50) | | 24.0 - 44.0 |
| **Age range** | | | |
| < 30 years | 6 | 31.58 | 10.5 - 52.6 |
| ≥ 30 years | 13 | 68.42 | 47.4 - 89.5 |
| **Location** | | | |
| Metropolitan region of Belém | 6 | 31.58 | 10.5 - 52.6 |
| Other regions of Pará | 9 | 47.37 | 26.3 - 68.4 |
| Other state | 4 | 21.05 | 5.3 - 42.1 |
| **Patient delay (months)** | | | |
| Mean ( sd) | 10.47 ( 13.08) | | 6.1 - 17.1 |
| Median (p25-75%) | 7.00 (4.00 - 12.00) | | 4.0 - 12.0 |
| **Patient delay ≥ 12 months** | | | |
| Yes | 6 | 31.58 | 10.5 - 52.6 |
| No | 13 | 68.42 | 47.4 - 89.5 |
| **Anatomic location** | | | |
| Proximal femur | 1 | 5.26 | 0.0 - 15.8 |
| Distal femur | 9 | 47.37 | 21.2 - 68.4 |
| Proximal tibia | 6 | 31.58 | 10.5 - 52.6 |
| Calcaneus | 1 | 5.26 | 0.0 - 15.8 |
| Hand bones | 2 | 10.53 | 0.0 - 26.3 |
| **Campanacci** | | | |
| Stage 1 | 2 | 10.53 | 0.0 - 26.3 |
| Stage 2 | 3 | 15.79 | 0.0 - 31.6 |
| Stage 3 | 14 | 73.68 | 52.5 - 89.5 |
| **Pathological fracture** | | | |
| Yes | 3 | 15.79 | 0.0 - 36.8 |
| No | 16 | 84.21 | 63.2 - 100.0 |
| **Surgery type** | | | |
| Wide resection | 14 | 73.68 | 52.5 - 89.5 |
| Marginal/Intralesional | 3 | 15.79 | 0.0 - 31.6 |
| Not performed | 2 | 10.53 | 0.0 - 26.3 |
| **Recurrence** | | | |
| Yes | 3 | 15.79 | 0.0 - 36.8 |
| No | 16 | 84.21 | 63.2 - 100.0 |
| **Denosumab use** | | | |
| Yes | 5 | 26.32 | 10.5 - 47.4 |
| No | 14 | 73.68 | 52.5 - 89.5 |
| **Pulmonary metastasis** | | | |
| Yes | 0 | 0.00 | 0.0 - 0.0 |
| No | 19 | 100.00 | 100.0 - 100.0 |

Sd: Standard deviation. P: Percentile. CI: confidence interval.

**Table 2.** Comparative analysis of the demographic and clinical profile of patients diagnosed with GCT in Stages 1/2 and Stage 3 treated at a quaternary hospital in Northern Brazil, in the years 2020 and 2021.

| Variable | Stage 1 e 2 (n. 5) | Stage 3 (n. 14) | p-value |
|---|---|---|---|
| **Sex** | | | |
| Male | 1(20.0%) | 10(71.4%) | 0.071[a] |
| Female | 4(80.0%) | 4(28.6%) | |
| **Age(years)** | | | |
| Mean( sd) | 38.6( 9.6) | 36.8( 14.9) | 0.830[b] |
| Median(p25-75%) | 39.0(39.0-43.0) | 36.5(24.0-47.0) | |
| **Agerange** | | | |
| <30years | 1(20.0%) | 5(35.7%) | 0.480[a] |
| ≥30years | 4(80.0%) | 9(64.9%) | |
| **Location** | | | |
| MetropolitanregionofBelém | 1(20.0%) | 5(35.7%) | 0.814[a] |
| OtherregionsofPará | 3(60.0%) | 6(42.9%) | |
| Otherstate | 1(20.0%) | 3(21.4%) | |
| **Patientdelay** | | | |
| Mean( sd) | 14.0( 25.7) | 9.2( 5.2) | 0.070[b] |
| Median(p25-75%) | 3.0(2.0-4.0) | 7.5(6.0-12.0) | |
| **Patientdelay≥12months** | | | |
| Yes | 1(20.0%) | 5(35.7%) | 0.631[a] |
| No | 4(80.0%) | 9(64.3%) | |
| **Anatomiclocation** | | | |
| Proximalfemur | 0(0.0%) | 1(7.1%) | 0.164[a] |
| Distalfemur | 3(60.0%) | 6(42.9%) | |
| Proximaltibia | 0(0.0%) | 6(42.9%) | |
| Calcaneus | 1(20.0%) | 0(0.0%) | |
| Handbones | 1(20.0%) | 1(7.1%) | |
| **Pathologicalfracture** | | | |
| Yes | 0(0.0%) | 3(21.4%) | 0.530[a] |
| No | 5(100.0%) | 11(78.6%) | |
| **Surgerytype** | | | |
| Wideresection | 1(20.0%) | 13(92.9%) | 0.002[a*] |
| Marginal/Intralesional | 3(60.0%) | 0(0.0%) | |
| Notperformed | 1(20.0%) | 1(7.1%) | |
| **Recurrence** | | | |
| Yes | 0(0.0%) | 3(21.4%) | 0.530[a] |
| No | 5(100.0%) | 11(78.6%) | |
| **Denosumabuse** | | | |
| Yes | 0(0.0%) | 5(35.7%) | 0.257[a] |
| No | 5(100.0%) | 9(64.3%) | |
| **Pulmonarymetastasis** | | | |
| Yes | 0(0.0%) | 0(0.0%) | 1.000[a] |
| No | 5(100.0%) | 14(100.0%) | |

Sd: Standard deviation. P: percentile a: Fisher's exact test. B: Mann-Whitney test. *. p-value < 0.05.

third of the tibia. When it affects, the distal third of the radius, the third most common site described in the literature, it usually exhibits more evident aggressive characteristics. Involvement of the sacrum is rare.[8,9]

Our service recorded the bones of the hand as the third most common site. The fact that 10% of tumors were in the hand differs from the epidemiology found in the literature. In 2021, a study demonstrated the low prevalence of giant cell tumors in the phalanges. In a study involving 2.400 patients, there were fewer than 50 cases, while another study showed only 1 case among 327 patients.[13]

Pathological fractures occurred in 3 patients, corresponding to 15% of the group. Most patients experience progressive pain, initially manifesting during activities but progressing to rest pain. It is not usually disabling, except in cases associated with pathological fractures which are evident in the initial examination of 10 to 30% of patients.[14]

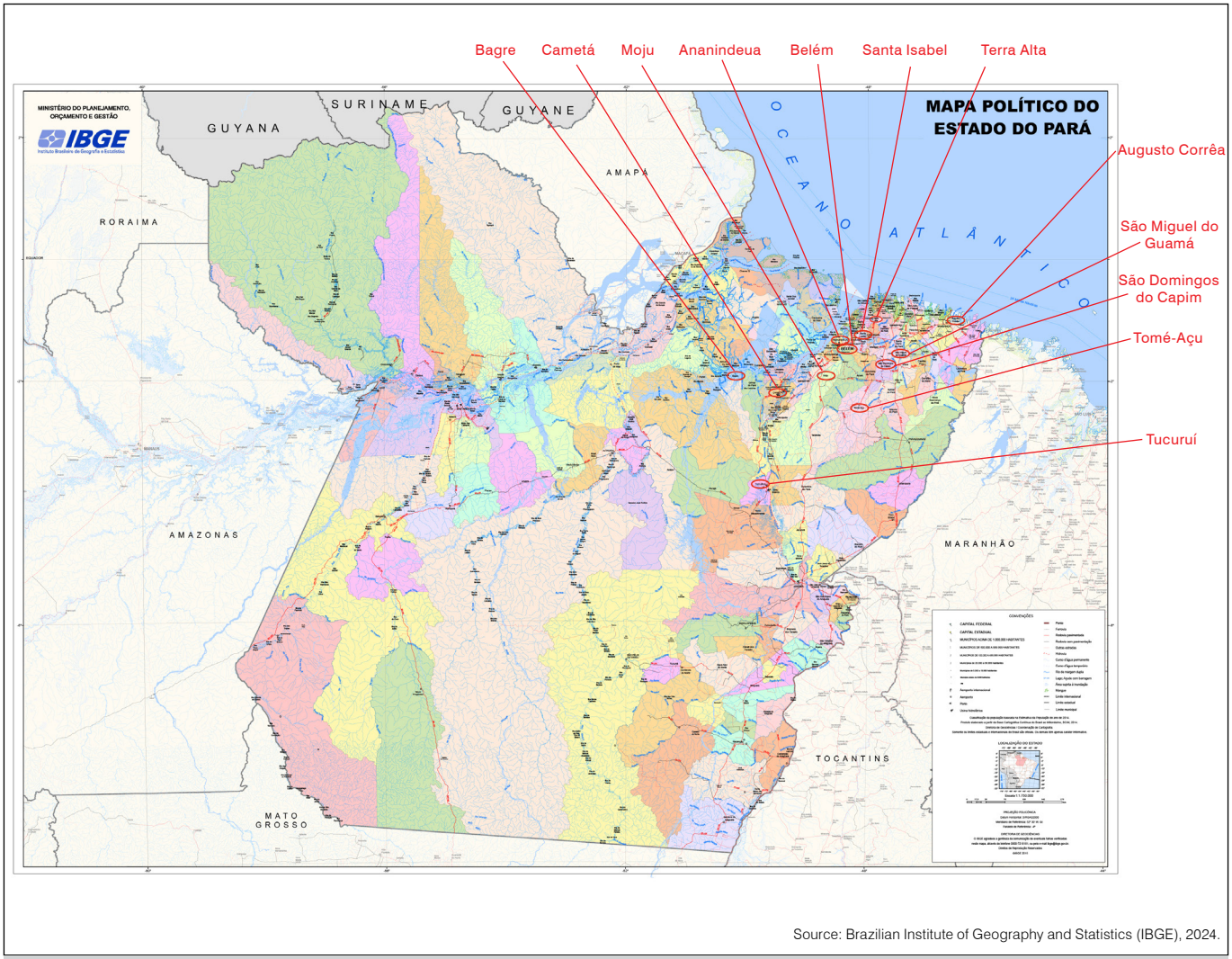
The average diagnosis delay time is considered high, which directly influences the increased likehood of diagnosis tumors at advanced stages.[15] The average patient delay time of 10.5 months may reflect the size of the state of Pará, the difficulties faced by the Public Health Service in identifying the need for specialized care early on and may also indicate difficulties in accessing health services for the more deprived population in remote areas. Additionally, there were patients from the state of Maranhão receiving treatment, showing that the complexity of health problems extends nationally (Figure 1 and 2).

Currently, in our service the increase in the Orthopedic Oncologist team in 2023, there is no longer a surgical procedure waiting list, as was the reality in the period of 2020 and 2021. There is now a window of only a few weeks between the indication for surgical treatment and the procedure. However, the main difficulty lies in the stage at which patients arrive for the initial consultation. Over 70% of patients presented at Campanacci stage 3, highlighting the diagnostic delay we face in the state and the direct relationship between Campanacci Stage 3 and the average time of 10.5 months for diagnosis.[15,16]

Due to this, the primary surgical treatment employed in these patients was wide resection with replacement with unconventional endoprosthesis, differing from much of the national and worldwide literature, which shows that most diagnosed patients are in Campanacci stage 2 and are managed with intralesional resection and cavity grafting.[17] Even with aggressive treatment, there was still a case requiring amputation due to recurrence, highlighting the importance of early diagnosis as a major modulator in the prognosis of these patients.

Studies over the last decade have already demonstrated the relationship between early diagnosis and the severity of the lesion, as well as the temporal relationship between symptom onset and tumor severity. Early diagnoses reduce morbidity related to both diagnosis and surgical treatment, in addition to bringing benefits to the public health system.[15]

Recurrences are defined on symptomatic evidence or changes in imaging studies. They are considered from three months after treatment, but can be detected within the first two years.[8] The rate of local recurrence can be influenced by diagnostic delay and the surgical technique employed. Campanacci 1 and 2 are treated with curettage and adjuvants. Isolated intralesional surgeries have a recurrence risk of 50%, decreasing to 30% with the use of local adjuvants. Campanacci 3 is generally treated with radical excision due to the high risk of recurrence, often requiring joint reconstruction with endoprosthesis. The risk of recurrence after this therapeutic modality is around 0-12%. The recurrence rate in our study was 15% with the need for denosumab treatment or limb amputation.[8,10,18]




Source: Brazilian Institute of Geography and Statistics (IBGE), 2024.

**Figure 1.** Political map of the state of Pará.

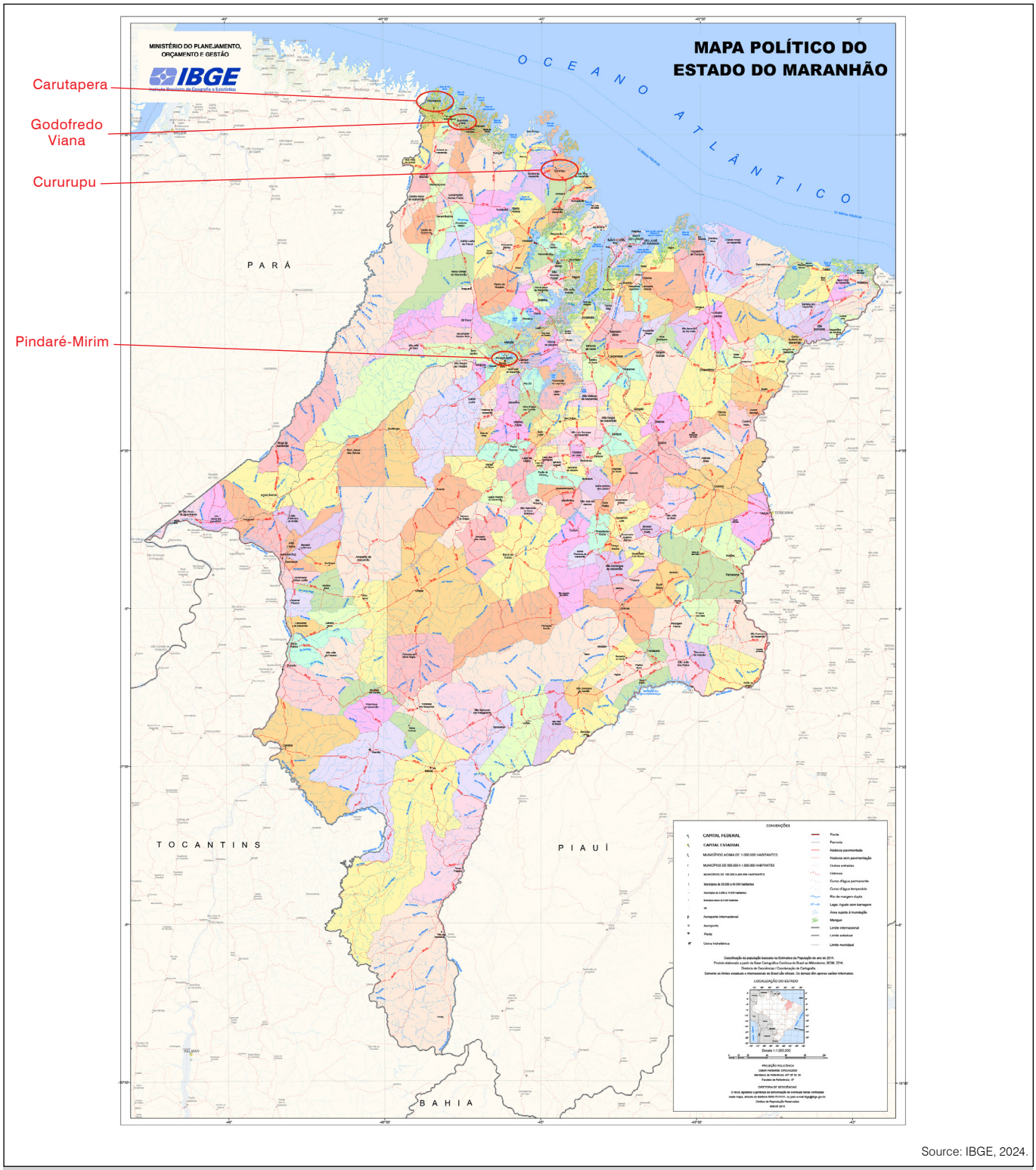



**Figure 2.** Political map of the state of Maranhão.

In our service, denosumab treatment was used before surgical approach in 2 patients. In another 3, was used after the diagnosis the tumor recurrence. The medication is a biological agent that prevents bone cell destruction by interrupting osteoclast maturation, as it prevents RANK activation by binding to RANK-L. It is indicated for use in cases where it is not possible to completely excise the tumor, which would increase the risk of recurrence, and in cases where surgery is contraindicated. [18,19] The use of medication does not cure the disease, but has a limb-preserving potential, preventing amputations, hemipelvectomy, neurological disorders, and reducing morbidity associated with surgical treatment.[19,20]

As mentioned earlier, several factors influence the diagnostic delay of oncology patients. The hospital serves as a reference for the entire

state, and the demographic and socioeconomic constraints in the state of Pará are significant and impact the reality of public health. We must also consider the knowledge of generalist physicians and clinical areas regarding bone tumors because often these professionals will provide initial care. Recognizing an aggressive tumor and knowing that referral to a specialized service is necessary directly impact the early treatment of these patients.

Our study showed an average time of 10.5 months between diagnostic suspicion and the first consultation with the Orthopedic Oncologist. At the time of diagnosis, 73% of patients presented with Giant Cell Tumor in an advanced stage, Campanacci grade 3, necessitating aggressive surgical treatment with wide resection and endoprosthesis replacement.


## ACKNOWLEDGMENTS

The authors would like to thank Hospital Ophir Loyola and its staff for all the assistance and support provide for the completion of this word.


**AUTHOR'S CONTRIBUTION:** Each author contributed individually and significantly to the development of this article. CFFB: critical revision of its intellectual content and final approval; YED: critical revision of its intellectual content and final approval; MFG: contribution to the conception of the word, critical revision of its intellectual content, and final approval; FSAB: contribution to conception, analysis, and interpretation of data for the work; drafting the work and critical revision of its intellectual content; BCRA: contribution to conception and analysis of the work, drafting the work; BTRB: contribution to conception and analysis of the work, drafting the work.

## REFERENCES


1. Viana EMBO, Batista KT, Carneiro Junior JL. Tumor de células gigantes do sacro inoperável: opções terapêuticas e controle da dor. Rev Bras Ortop. 2019;54(3):347-52.
2. Latorre MR, Albergo JI, Farfalli GL, Roitman PD, Plantalech L, Ayerza MA, et al. Denosumab como tratamiento neoadyuvante del tumor de células gigantes del hueso. Indicaciones, resultados y efectos adversos. Medicina (Buenos Aires). 2021;81(5):767-73.
3. Córdoba CH. Tumor de células gigantes en rótula manejado con patelectomía. Rev Artroscopia. 2022;29(03):124-30.
4. Alvarez-López A, Valdenbenito-Aceitón V, Soto-Carrasco SR, Fernández-Delgado M. Tumor de células gigantes malignizado: a propósito de un caso. Acta Méd Centro. 2023;17(2):332-9.
5. Acosta PL, Pérez RP, Torres PR. Tumor de células gigantes del fémur. Rev Cuba Reumatol. 2021;23(1):776-83.
6. Schnurr C, Pippan M, Stuetzer H, Delank KS, Michael JWP, Eysel P. Treatment delay of bone tumours, compilation of a sociodemographic risk profile: a retrospective study. BMC Cancer. 2008;8:22.
7. Quiñonez-Flores CM, Arzate-Quintana C, Carrasco-De la Fuente JL, Torres-Castro C. Tratamiento reconstructivo de bajo costo tras resección de tumor de células gigantes de radio distal. Acta Ortop Mex. 2023;36(3):190-4.
8. Oliveira Júnior RCL, Pereira MGS, Garcia PBL, Santos PA, Cavalcanti AS, Meohas W. Epidemiological study on giant cell tumor recurrence at the Brazilian National Institute of Traumatology and Orthopedics. Rev Bras Ortop (English Edition). 2016;51(4):459-65.
9. Jiang CY, Zhao L, Schuetza SM, Chugh R. Giant Cell Tumor of Bone: effect of longer dosing intervals of denosumab on tumor control and bone-related complications. Oncologist. 2022;27(7):595-9.
10. Aguiar LTA, Vasconcelos JBM, Ribeiro MB. Tratamento de pacientes com diagnóstico de tumor ósseo de células gigantes: Experiência de um hospital filantrópico no Piauí, Brasil. Rev Bras Ortop. 2022;57(5):802-6.
11. Kamal AF, Muhamad A. Outcomes of En bloc resection followed by reconstruction of giant cell tumor around knee and distal radius. A case series. Ann Med Surg (Lond). 2020;49:61-6.
12. Kumar S, Nandan B, Chauhan R, Dhawan M, Agrawal S, Rivi S. Coagulação por plasma de argônio como adjuvante à curetagem estendida em tumores de células gigantes do osso: um estudo de 50 casos. Rev Bras Ortop. 2022;58(2):211-21.
13. Goel A, Gupta A, Bhatia N, Goyal R, Mehndiratta A, Yadav A. Giant Cell Tumor of the Ring Finger Distal Phalanx. J Hand Surg Am. 2021;46(3):249-54.
14. Semino RP, Beltrán RL, Gutiérrez RH. Tumor de células gigantes en el extremo distal del radio / Giant Cell Tumor Of The Distal Radius. Rev Cuba Ortop Traumatol. 2022;36(1):e385.
15. Ferraz DFCD, Santos CAT, Costa VHF, Souza AMG, Lima PRG. Tumor de células gigantes: análise sobre importância do diagnóstico precoce e perfil epidemiológico. Rev Bras Ortop. 2016;51(1):58-62.
16. Becker RG, Galia CR, Pestilho JFCS, Antunes BP, Baptista AM, Guedes A. GIANT CELL TUMOR OF BONE: a multicenter epidemiological study in Brazil. Acta Ortop Bras. 2024;32(1):26-30.
17. Su YP, Chen WM, Chen TH. Giant-cell tumors of bone: an analysis of 87 cases. Int Orthop. 2004;28(4):239-43.
18. Mallick AB, Chawla SP. Giant Cell Tumor of Bone: an update. Curr Oncol Rep. 2021;23(5):51.
19. Montgomery C, Couch C, Emory CL, Nicholas R. Giant Cell Tumor of Bone: Review of Current Literature, Evaluation, and Treatment Options. J Knee Surg. 2018;32(4):331-6.
20. Bazán PL, Falco R, Borri AE, Medina M, Ciccioli NM, Danielle S. The use of denosumab in giant cell tumors in the sacrum. Coluna/Columna. 2020;19(2):151-3.

DOI: http://dx.doi.org/10.1590/1413-785220253301e289573



# GIANT CELL TUMOR OF THE DISTAL RADIUS: FACTORS ASSOCIATED WITH LOCAL RECURRENCE

# TUMOR DE CÉLULAS GIGANTES DO RÁDIO DISTAL: FATORES ASSOCIADOS À RECIDIVA LOCAL

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## ABSTRACT

Objectives: To assess patient and tumor characteristics and treatment outcomes, focusing on local recurrence rates based on treatment type. Methods: This is a retrospective review of cases of GCTB of the distal radius, identified from the databases of 74 patients in Brazilian institutions specializing in musculoskeletal tumor treatment. Data were collected from electronic and paper medical records by 18 centers between 1989 and 2021. Variables included demographic data, clinical presentation, treatment-related factors, and primary outcome (local recurrence rate). Results: Among the 74 patients in the study, the mean age at diagnosis was 32.6 years, with a slight female predominance. Pathological fractures on presentation were observed in 15.7% of patients, and pulmonary metastasis in 1.4%. Treatment approaches were divided equally between intralesional curettage and en bloc resection. The overall local recurrence rate was 25.7% and was higher in patients treated with intralesional curettage (35.1%) compared to resection (16.2%). Conclusions: The study confirms high recurrence risk with intralesional curettage, emphasizing the need for standardized protocols and improved surgical techniques to reduce recurrence rates and enhance outcomes for distal radius GCTB patients. ***Level of Evidence III; Retrospective Cohort Study.***

**Keywords:** Bone Neoplasms; Giant Cell Tumors; Giant Cell Tumor of Bone; Curettage; Denosumab; Recurrence.

## *RESUMO*

*Objetivos: Avaliar as características dos pacientes e dos tumores, e os resultados do tratamento, focando nas taxas de recorrência local baseadas no tipo de tratamento. Métodos: Relata-se uma revisão retrospectiva de casos de TCG do rádio distal, identificados a partir dos bancos de dados de 74 pacientes tratados em instituições brasileiras especializadas em tratamento de tumores musculoesqueléticos. Os dados foram coletados de registros médicos eletrônicos e físicos por 18 centros entre 1989 e 2021. As variáveis incluíram dados demográficos, apresentação clínica, fatores relacionados ao tratamento e desfecho primário (taxa de recorrência local). Resultados: Dos 74 pacientes incluídos no estudo, a idade média no diagnóstico foi de 32,6 anos, com uma leve predominância feminina. Fraturas patológicas na apresentação foram observadas em 15,7% dos pacientes, e metástase pulmonar em 1,4%. As abordagens de tratamento foram divididas igualmente entre curetagem intralesional e ressecção em bloco. A taxa geral de recorrência local foi de 25,7%, sendo maior em pacientes tratados com curetagem (35,1%) em comparação com a ressecção (16,2%). Conclusões: O estudo confirma o alto risco de recidiva com uso da curetagem, enfatizando a necessidade de protocolos padronizados e técnicas cirúrgicas aprimoradas para reduzir as taxas de recorrência e melhorar os resultados para pacientes com TCG do rádio distal.* ***Nível de Evidência III; Estudo de Coorte retrospectivo.***

***Descritores:*** *Neoplasias Ósseas; Tumores de Células Gigantes; Tumor de Células Gigantes do Osso; Curetagem; Denosumab; Recidiva.*

**Citation:** Rabuske WBS, Ghert M, Antunes BP, Galia CR, Pestilho JFCS, Silveira GSM, Toller EA, Camargo OP, Engel EE, Nakagawa SA, Guedes A, Becker RG. Tumor de células gigantes do rádio distal: fatores associados à recidiva local. Acta Ortop Bras. [online]. 2025;33(1):Page 1 of 5. Available from URL: http://www.scielo.br/aob.

All authors declare no potential conflict of interest related to this article.

***The study was conducted at Hospital de Clínicas de Porto Alegre, RS, Brazil.***
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Article received on 08/23/2024, approved on 10/18/2024.

## INTRODUCTION

Giant cell tumor of bone (GCTB) is a primary benign yet aggressive bone lesion, representing approximately 5% of all primary bone tumors in Western countries. It is slightly more common in women, with a peak incidence between the ages of 20 and 50. These tumors frequently occur in the epiphysis of long bones, with a preference for the knee region and the distal radius.[1-3] Clinically, patients present with pain, swelling, and occasionally pathological fractures. Although metastatic disease is infrequent, occurring in 1 to 5% of cases, some authors suggest that the distal radius presents a higher risk.[4] Death due to GCTB is very rare, with the greatest tumor morbidity related to the function of the affected bone and joint.[5]

*Campanacci*'s classification has been used to determine the aggressiveness of GCTB based on x-ray images. Grade 1 lesions are confined to the bone, grade 2 lesions show some expansion of the cortex, and grade 3 lesions break through the cortex with soft tissue involvement.[6] Management of GCTB typically involves surgery, with intralesional curettage being the preferred approach for grade 1 and 2 lesions, while resection is recommended for grade 3 lesions due to their more aggressive behavior and lack of a contained defect. However, the reported local recurrence rate for distal radius tumors is high, ranging between 25% and 50% depending on the surgical approach, tumor extent, and radiographic grade.[4,7,8]

The choice between intralesional curettage (Figure 1) and resection (Figures 2 and 3) depends on the severity of the lesion and patient characteristics.[7,9] Intralesional curettage is often associated with lower surgical morbidity and preservation of limb function because it preserves the joint surface, but has a higher recurrence rate, especially in grade 3 lesions. On the other hand, resection is more aggressive, resulting in better oncologic control but significant functional loss, particularly in large tumors.

In this study, we reviewed a multicenter cohort of patients treated for distal radius GCTB in national tumor centers in Brazil. The aim of the study was to assess patient and tumor characteristics and to describe the treatment outcomes of GCTB located in the distal radius in the context of an emerging economy.

## MATERIALS AND METHODS

This study is a retrospective review of 74 cases of GCTB of the distal radius, identified from the databases of 643 patients with GCTB from various Brazilian institutions specializing in musculoskeletal tumor treatment. The study received ethical approval from Hospital de Clínicas de Porto Alegre (HCPA) and all participating institutions (REB 94280918.0.0000.5327). All procedures were conducted in accordance with the ethical standards of Resolution 466/2012 of the Brazilian Ministry of Health's National Health Council and the Declaration of Helsinki. Informed consent was waived because of the retrospective nature of the study.

Data were collected from electronic and paper medical records by 18 participating centers between 1989 and 2021. To ensure participant confidentiality, each individual was assigned a numeric code. Data were transmitted to the coordinating center via an encrypted email system. Upon receipt, the data were thoroughly examined to resolve any discrepancies or inconsistencies. Cases with conflicting variables were returned to their respective centers

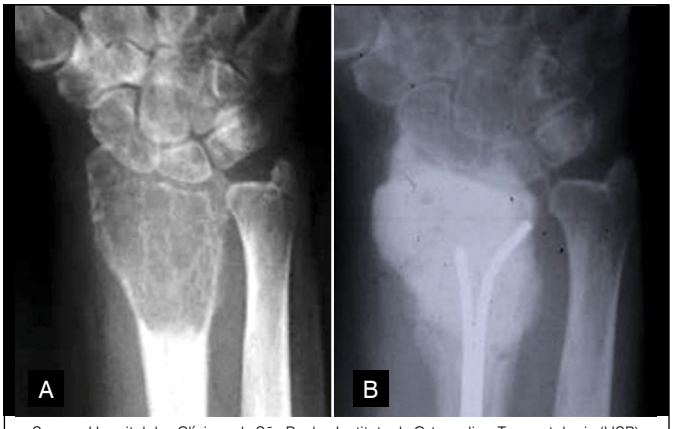


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**Figure 1.** (A) X-ray of the wrist showing a Campanacci grade 3 giant cell tumor of bone (GCTB) of the distal radius; (B) The patient was treated with intralesional curettage, adjuvants, and cement filling.

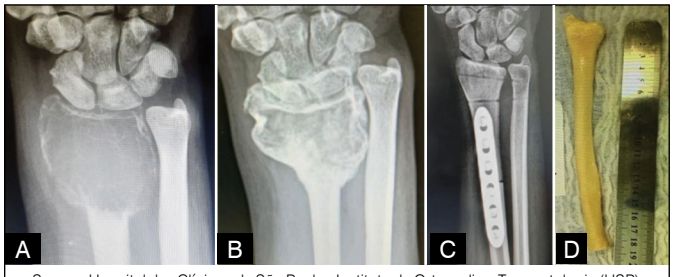


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**Figure 3.** (a) Pre-treatment and (b) post-treatment X-rays of a distal radius giant cell tumor of bone (GCTB) treated with denosumab; (c) X-ray after resection and reconstruction using (d) an allograft specimen.

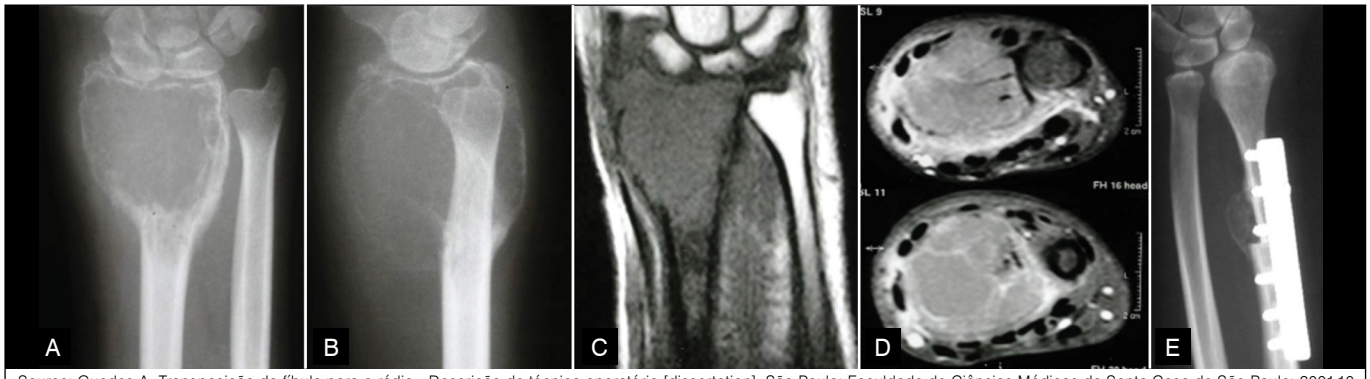


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**Figure 2.** (a) X-ray (front view) and (b) X-ray (lateral view) of the wrist illustrating a Campanacci grade 3 giant cell tumor of bone (GCTB) of the distal radius; (c) magnetic resonance imaging (MRI) T1 coronal and (d) MRI T2 axial images; (e) The tumor was treated with resection and reconstruction using a fibular autologous bone graft.

for clarification and then re-examined by the coordinating center. The collected data were stored in MS Excel and SPSS version 28.0 software programs.

The extracted variables were categorized into: demographic variables (gender, age, region of the country where the patient received treatment), clinical presentation variables (pulmonary metastasis, pathological fracture, and *Campanacci* classification based on radiographic appearance), treatment-related variables (type of surgery – intralesional curettage, resection - type of filling after curettage - cement, bone graft -, surgical adjuvants used - drilling, alcohol, ablation - and use of denosumab), and primary outcome (local recurrence rate).

Inclusion criteria were: (1) histopathological diagnosis of GCTB of the distal radius; (2) treatment of the primary tumor performed at one of the participating centers; (3) availability of patient medical records for analysis by the coordinating center. A total of 74 patients met the inclusion criteria. Collaborative efforts between the participating entities identified and corrected data discrepancies and gaps. However, among the 74 patients evaluated, instances of missing information were observed in 3 patients for pulmonary metastases, 4 patients for pathological fractures, and 2 patients for cavity filling type. These data deficiencies were predominantly due to the loss of historical medical records and inconsistencies in documentation procedures among the various participating institutions.

The primary outcome examined was the local recurrence rate, which was reviewed according to the type of surgery, the use of denosumab before intralesional curettage, the number of adjuvants used during surgery, and tumor aggressiveness according to the *Campanacci* classification.[6]

## RESULTS

### Patient and Treatment Characteristics

Table 1. In this analysis of 74 patients with GCTB of the distal radius, the mean age at diagnosis was 32.6 years. Regarding sex distribution, 43 patients (58.1%) were female, while 31 patients (41.9%) were male. Geographically, 23 patients (31.1%) were from the South region, 10 patients (13.5%) from the Northeast, 40 patients (54.1%) from the Southeast, and 1 patient (1.4%) from the North. In terms of *Campanacci* classification, 25 patients (33.8%) had tumors classified as *Campanacci* 1 or 2, while 49 patients (66.2%) had *Campanacci* 3 tumors. Pathological fracture was observed on presentation in 11 patients (15.7%). Only 1 patient (1.4%) presented with pulmonary metastasis. Denosumab was used in 13 (17.6%) patients, 11 for an effort to reduce tumor size, and 2 for local recurrence.

Intralesional curettage was performed on 37 patients and resection on 37 patients. Among the patients who underwent curettage, 7 patients (18.9%) did not receive a surgical adjuvant, 14 patients (37.8%) received a single surgical adjuvant, and 16 patients (43.2%) received combined surgical adjuvants. Specifically, 17 patients (45.9%) underwent adjuvant treatment with high-speed burr, 10 patients (27.0%) received alcohol or phenol, and 24 patients (64.9%) underwent ablation. For cavity filling, 29 patients (78.4%) had reconstruction with cement, 2 patients (5.4%) with cement and bone graft, and 5 patients (13.5%) with bone graft.

### Local Recurrence

Table 2. The local recurrence rate was 25.7% (19 patients). When analyzed by type of surgery, the local recurrence rate for patients who underwent intralesional curettage was 35.1% (13 patients), while for those who underwent resection it was 16.2% (6 patients). According to *Campanacci* classification, the local recurrence rate was 28.5% for grade 3 and 20% for grades 1 and 2. Local recurrence occurred in 13.3% of patients with pathological fractures, compared

**Table 1.** Patient and treatment characteristics.

| Variables | Total Sample (n=74) |
|---|---|
| **Age at diagnosis (years)** | **Mean ± SD: 32.6 ± 11.5** |
| **Sex – n (%)** | |
| Female | 43 (58.1) |
| Male | 31 (41.9) |
| **Campanacci classification – n (%)** | |
| I/II | 25 (33.8) |
| III | 49 (66.2) |
| **Patients per region in Brazil – n (%)** | |
| South | 23 (31.1) |
| Northeast | 10 (13.5) |
| Southeast | 40 (54.1) |
| North | 1 (1.4) |
| Pulmonary Metastasis – n (%) | 1 (1.4) |
| Pathological Fracture – n (%) | 11 (15.7) |
| **Type of Surgery – n (%)** | |
| Intralesional curettage | 37 (50.0) |
| Resection | 37 (50.0) |
| **Type of Filling – n (%)*** | |
| Cement | 29 (80.6) |
| Cement + Graft | 2 (5.6) |
| Bone Graft | 5 (13.9) |
| **Adjuvants – n (%)*** | |
| None | 7 (9.4) |
| Single | 14 (18.9) |
| Combined | 16 (21.6) |
| **Types of Adjuvants – n (%)*** | |
| Drilling | 17 (45.9) |
| Alcohol | 10 (27.0) |
| Fulguration | 24 (64.9) |
| Local Recurrence – n (%) | 19 (25.7) |
| Patients treated with Intralesional curettage | 13 (35.1) |
| Patients treated with resection | 6 (16.2) |
| Denosumab – n (%) | 13 (17.6) |

*Intralesional curettage only (n=37).

**Table 2.** Local recurrence.

| Variables | Recurrence (n=19) | No Recurrence (n=55) |
|---|---|---|
| **Sex – n (%)** | | |
| Female | 12 (63.2) | 31 (56.4) |
| Male | 7 (36.8) | 24 (43.6) |
| Age at diagnosis (years) – median | 32.2 ± 9.1 | 33.5 ± 12.3 |
| **Campanacci grade – n (%)** | | |
| I/II | 5 (26.3) | 20 (36.4) |
| III | 14 (73.7) | 35 (63.6) |
| Pulmonary Metastasis – n (%) | 1 (5.3) | 0 (0.0) |
| Pathological Fracture – n (%) | 2 (8.7) | 13 (14.4) |
| **Type of Surgery – n (%)** | | |
| Intralesional curettage | 13 (68.4) | 24 (43.6) |
| En bloc resection | 6 (31.6) | 31 (56.4) |
| **Type of Filling – n (%)*** | | |
| Cement | 8 (61.5) | 21 (87.5) |
| Cement + Graft | 0 (0.0) | 1 (4.2) |
| Bone Graft | 4 (30.8) | 1 (4.2) |
| None | 1 (7.7) | 1 (4.2) |
| **Number of Adjuvants – n (%)*** | | |
| None | 3 (23.1) | 5 (20.8) |
| Single | 5 (38.5) | 9 (37.5) |
| Combined | 5 (38.5) | 10 (41.7) |

*Intralesional curettage only (n=37).

to 86.7% in those without. One patient who presented with pulmonary metastasis also developed local recurrence.

Regarding sex, 63.2% of patients with recurrence were female, while 36.8% were male. The mean age at diagnosis for patients with recurrence was 32.2 years, while for patients without recurrence it was 33.5 years. Among patients who were treated with denosumab, 23.1% had recurrence, compared to 26.2% of patients who were not treated with denosumab. Patients treated with denosumab and intralesional curettage had a local recurrence rate of 15.3% (2/13), compared to 20% (1/5) of those treated with denosumab and resection.

Patients who did not receive any surgical adjuvants after intralesional curettage had a local recurrence rate of 37.5%, while those who received single or combined surgical adjuvant had rates of 35.7% and 33%, respectively. In terms of cavity filling after curettage, 30.8% of patients with recurrence were reconstructed with bone graft, while 61.5% were reconstructed with cement.

## DISCUSSION

The study reported on a multicenter retrospective cohort of 74 patients with GCTB of the distal radius, with a mean age of 32.6 years and a slightly higher percentage of females. Geographically, most patients were from the Southeast region of Brazil. Clinical features included a notable occurrence of pathological fractures at presentation and only one patient presenting with pulmonary metastasis. Treatment approaches were divided between intralesional curettage and resection, with varying use of adjuvant therapies such as denosumab. The study identified a considerably high rate of local recurrence of 25.7%, particularly in patients treated with curettage, highlighting the challenges of managing this aggressive benign bone tumor in this anatomic location.

The findings of this study align with existing literature on the management of GCTB of the distal radius. Pazionis et al. conducted a systematic review comparing resection and intralesional curettage. Their results indicated a higher recurrence rate for curettage (31%) compared to wide excision (8%).[7] Similarly, our study found a 35.1% recurrence rate for curettage versus 16.2% for resection. These consistent findings underscore the challenges of managing GCTB in the distal radius, where preserving function must be balanced against the risk of recurrence.[7]

Montgomery et al. emphasized the aggressive nature of GCTB and the preference for surgical management, often supplemented with adjuvant therapies to reduce recurrence.[11] However, this and other studies have reported lower overall recurrence rates than those reported herein. The higher local recurrence rate in our series may be due to the higher-than-expected percentage of patients with *Campanacci* grade 3 lesions (66.2%). Patients with grade 3 tumors tend to exhibit higher rates of local recurrence, especially after intralesional curettage.[4,8,12]

Differences in recurrence rates could also be attributed to the lack of access to advanced imaging, and the prolonged waiting times for access to a referral center, which may not have been uniformly available across the centers in our study. In their series, Wysocki et al. noted that centers with access to high-quality imaging and surgical tools tend to report better outcomes in patients with GCTB of the distal radius.[13] Similarly, treatment delays can impact both functional outcomes and local recurrence rates. This disparity underscores the critical need for standardized treatment protocols and prompt access to specialized care to enhance patient outcomes in Brazil. It is likely that meticulous surgical techniques and/or the use of adjuvant therapies may reduce local recurrence rates. The use of adjuvants after intralesional curettage in our series did not appear to reduce the rate of local recurrence. In fact, Pazionis et al. and other reviews indicate that recurrence rates can be significantly reduced with careful surgical planning with or without the use of adjuvants.[7] This highlights the potential of our study to inform future treatment guidelines and improve outcomes for patients with distal radius GCTB.[7,14,15]

The study has several limitations. Data collection spanned over three decades, during which surgical techniques and adjuvant therapies evolved, potentially introducing variability in treatment outcomes. Additionally, missing data in some variables could have affected the analysis. Finally, selection bias will have played a major role in determining surgical approach, further qualifying our conclusions. Despite these limitations, the study's strengths include its multicenter design and the relatively large sample size for a rare tumor, providing a comprehensive overview of GCTB management in Brazil.

## CONCLUSION

This study highlights the challenges and outcomes associated with treating GCTB of the distal radius in Brazil. The findings underscore the high recurrence rates in patients with distal radius GCTB, particularly when treated with intralesional curettage compared to resection. There was a high prevalence of cases with more aggressive tumors (*Campanacci* grade 3), which likely resulted in higher local recurrence rates. The use of combined or single adjuvants did not reduce recurrence rates in this series of GCTB of the distal radius.

## ACKNOWLEDGEMENTS

We thank on behalf of the ABOO - Associação brasileira de oncologia ortopédica), ICI - Instituto do Câncer Infantil, HCPA - Hospital de Clínicas de Porto Alegre and the participant centers André Mathias Baptista (Hospital das Clínicas de São Paulo - Instituto de Ortopedia e Traumatologia (USP), São Paulo/SP); Glauco José Pauka Mello (Hospital Erasto Gaertner, Curitiba/PR, Brasil); Marcelo Barbosa Ribeiro (Hospital São Marco, Teresina/PI, Brasil); Osvaldo André Serafini (Hospital São Lucas PUC, Porto Alegre/RS, Brasil); Alexandre David (Santa Casa POA, Porto Alegre/RS, Brasil); Adonai Pinheiro Barreto (Hospital Universitário da Universidade Federal de Sergipe, Aracaju/SE, Brasil); Marcos Ceita Nunes (Universidade de Passo Fundo Vice-Reitoria de Pesquisa e Pós-Graduação, Passo Fundo/RS, Brasil); Fernando Brasil do Couto Filho (Hospital Ophir Loyola, Belém/PA, Brasil); Roberto André Torres de Vasconcelos (Instituto Nacional de Câncer José Alencar Gomes da Silva – INCA, Rio de Janeiro/RJ, Brasil); Fábio Fernando Elói Pinto (Faculdade de Medicina de Botucatu/UNESP, Botucatu/SP, Brasil); Gustavo de Almeida Nunes Gil (Hospital Nossa Senhora de Pompéia, Caxias do Sul/RS, Brasil); for their support in the regulatory process, patient recruitment, and preparation of study report.

**AUTHOR'S CONTRIBUTION:** Each author contributed individually and significantly to the development of this article. RWS: writing and review of the article; GM: writing, review of the article and intellectual concept of the article; ABP: review of the article; GCR: review of the article; PJFCS: communication centers research, conducting research and collection of clinical data; SGSM, TEA: review of the article; COP: review of the article and images; EEE: review of the article; NSA: review of the article; GA: review of the article and images; BRG: writing, review of the article and intellectual concept of the article. All authors have read and approved the final version submitted and take public responsibility for all aspects of the work.

## REFERENCES


1. Camargo OP, Croci AT, Oliveira CRGCM, Baptista AM, Caiero MT, Giannotti MA. Tumor de células gigantes: evolução histórica do seu diagnóstico e tratamento junto ao Instituto de Ortopedia e Traumatologia da FMUSP. Acta Ortop Bras. 2001;9(4):46-52.
2. Baptista PPR, Próspero JD, Yonamine ES. Tumor de células gigantes. Rev Bras Ortop. 2001;36(7):239-44.
3. Chawla S, Blay JY, Rutkowski P, Le Cesne A, Reichardt P, Gelderblom H, et al. Denosumab in patients with giant-cell tumour of bone: a multicentre, open-label, phase 2 study. Lancet Oncol. 2019;20(12):1719-29.
4. Guedes A, Baptista PPR, Santili C, Yonamine ES, Garcia HRP, Martinez EC. Broad resection and fibular transposition in the treatment of GCT on radius distal end. Acta Ortop Bras. 2009;17(3):171-81.
5. Sheth DS, Healey JH, Sobel M, Lane JM, Marcove RC. Giant cell tumor of the distal radius. J Hand Surg Am. 1995;20:432-40.
6. Campanacci M. Bone and soft tissue tumours. 2nd ed. New York: Springer--Vaerlag; 1999.
7. Pazionis TJ, Alradwan H, Deheshi BM, Turcotte R, Farrokhyar F, Ghert M. A systematic review and meta-analysis of en-bloc vs intralesional resection for giant cell tumor of bone of the distal radius. Open Orthop J. 2013;7:103-8.
8. Harness NG, Mankin HJ. Giant-cell tumor of the distal forearm. J Hand Surg Am. 2004;29(2):188-93.
9. Becker RG, Galia CR, Pestilho JFCS, Antunes BP, Baptista AM, Guedes A. Giant cell tumor of bone: A multicenter epidemiological study in Brazil. Acta Ortop Bras. 2024;32(1):e273066.
10. Guedes A. Transposição da fíbula para o rádio - Descrição de técnica operatória [dissertation]. São Paulo: Faculdade de Ciências Médicas da Santa Casa de São Paulo; 2001.
11. Montgomery C, Couch C, Emory CL, Nicholas R. Giant cell tumor of bone: Review of current literature, evaluation, and treatment options. J Knee Surg. 2019;32(4):331-6.
12. He Y, Zhang J, Ding X. Prognosis of local recurrence in giant cell tumour of bone: what can we do?. Radiol Med. 2017;122:505-19.
13. Wysocki RW, Soni E, Virkus WW, Scarborough MT, Leurgans SE, Gitelis S. Is intralesional treatment of giant cell tumor of the distal radius comparable to resection with respect to local control and functional outcome?. Clin Orthop Relat Res. 2015;473(2):706-15.
14. Ruatti S, Boudissa M, Grobost P, Kerschbaumer G, Tonetti J. Radius' giant cell tumor: Allograft with conservation of distal radioulnar joint. J Wrist Surg. 2019;8(3):215-20.
15. Liu YP, Li KH, Sun BH. Which treatment is the best for giant cell tumors of the distal radius? A meta-analysis. Clin Orthop Relat Res. 2012;470(10):2886-94.

DOI: http://dx.doi.org/10.1590/1413-785220253301e280703



# FREQUENCY AND MODALITY OF EXERCISE ON PAIN AND INDEPENDENCE IN ELDERLY INDIVIDUALS WITH OSTEOARTHRITIS: A CROSS-SECTIONAL STUDY

# FREQUÊNCIA E MODALIDADE DE EXERCÍCIOS NA DOR E INDEPENDÊNCIA EM IDOSOS COM OSTEOARTRITE: UM ESTUDO TRANSVERSAL

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## ABSTRACT

Background: Regular physical exercise promotes pain relief, reducing the central facilitation of pain mechanisms. Objective: Evaluate the effect of different frequencies of physical exercise (once, twice, or three times a week) on different modalities (aerobic training, stretching training, and strength training), on the pain in the knee joint, and on the level of independence on people with knee osteoarthritis. Methods: Is cross-sectional and used the STROBE-Checklist: cross-sectional studies. A total of 193 elderly people were evaluated, pain and functional independence were analyzed. Results: For the pain variable, there was a statistical difference in favor of the intervention in the comparisons control versus strength 1 and 2 times a week and stretching 3 times a week already in the Lawton variable, only the comparison control versus aerobic 1 time a week did not prove to be statistically dignified. Conclusion: The exercise modality and the weekly frequency seem to affect the perception of pain, stretching exercises performed three times a week, as well as muscle strengthening exercises, regardless of weekly frequency are efficient in joint pain analgesia. Practicing muscle strength exercises, regardless of weekly frequency and aerobic and stretching exercises at least twice a week, increases and/or maintains IADL. ***Level of Evidence II; Cross-sectional Study.***

**Keywords:** Pain; Exercise; Aged; Osteoarthritis, Knee.

## *RESUMO*

*Introdução: O exercício físico regular promove o alívio da dor, reduzindo a facilitação central dos mecanismos álgicos. Objetivo: Avaliar o efeito de diferentes frequências de exercício físico (uma, duas ou três vezes por semana) em diferentes modalidades (treinamento aeróbico, treinamento de alongamento e treinamento de força), na dor na articulação do joelho e no nível de independência em pessoas com osteoartrite de joelho. Métodos: Este artigo é um estudo transversal e utilizou o STROBE-Checklist: estudos transversais. Foram avaliados 193 idosos. Foram analisadas dor e independência funcional. Resultados: Para a variável dor, houve diferença estatística a favor da intervenção nas comparações controle versus força 1 e 2 vezes por semana e alongamento 3 vezes por semana, já na variável Lawton, apenas a comparação controle versus aeróbico 1 vez por semana não se mostrou estatisticamente diferente. Conclusão: A modalidade de exercício e a frequência semanal parecem afetar a percepção da dor, exercícios de alongamento realizados três vezes por semana, bem como exercícios de fortalecimento muscular, independente da frequência semanal são eficientes na analgesia da dor articular. A prática de exercícios de força muscular, independente da frequência semanal e exercícios aeróbicos e de alongamento pelo menos duas vezes por semana, aumenta e/ou mantém as AIVD.* ***Nível de Evidência II; Estudos Transversais.***

***Descritores:*** *Dor; Exercício Físico; Idoso; Osteoartrite do Joelho.*

**Citation:** Bersotti FM, Silva RP, Alonso AC, Brech GC, Serrão PRMS, Ervilha UF. Frequency and modality of exercise on pain and independence in elderly individuals with osteoarthritis: a cross-sectional study. Acta Ortop Bras. [online]. 2025;33(1):Page 1 of 4. Available from URL: http://www.scielo.br/aob.

All authors declare no potential conflict of interest related to this article.

***The study was conducted at Physical Activity Sciences Laboratory, GDOR Group, School of Arts, Sciences, and Humanities, University of São Paulo.***
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Article received on 11/22/2023, approved on 02/22/2024.





<< SUMÁRIO

## INTRODUCTION

Knee osteoarthritis, a disease characterized by wear and inflammation of the articular cartilage,[1] is one of the main causes of functional disability in elderly people.[2] Pain is a frequent symptom in osteoarthritis and strongly impacts daily living tasks.[3] Inactivity is a known risk factor for osteoarthritis development.[4] Physical exercise is a key intervention proposed by health professionals for joint pain treatment, stiffness attenuation, weight control, and reducing sedentary behavior in this population.[4] While literature defines how much weekly physical activity is needed to be considered active and applies these guidelines to knee osteoarthritis,[5] no study has determined how many weekly sessions of physical activity are necessary to reduce knee osteoarthritis pain. This is important as individuals with osteoarthritis-related pain need a clear starting point to begin regular physical activity, whether once, twice, or more per week.

A useful tool for evaluating autonomy in elderly functional activities is the Lawton scale.[6] Dependence is a critical health condition in elderly people, implying self-care reliance on others, communities, or institutions. The World Health Organization defines dependence as a state where decreased functional capacity prevents performing basic daily tasks independently.[7]

Evidence suggests physical activity reduces pain perception.[8] Studies show regular physical exercise alleviates pain by reducing central pain facilitation, increasing serotonin and opioid levels in central inhibitory pathways, and utilizing endogenous inhibitory systems.[8] These physiological effects highlight the need to determine the optimal exercise dose/response to mitigate pain perception.

We hypothesize that higher exercise frequency, regardless of modality, reduces pain and improves independence in individuals with knee osteoarthritis.

This study aimed to evaluate the effect of different exercise frequencies (once, twice, or three times weekly) across modalities (aerobic, stretching, and strength training) on knee pain and independence in people with knee osteoarthritis.

## MATERIALS AND METHODS

This is an observational cross-sectional study. This article used the Strengthening the Reporting of Observational Studies in Epidemiology Checklist: cross-sectional studies. Approved by the research ethics committee of Universidade de São Paulo (CAAE nº 04867418.6.0000.5390). All elders signed the Free and Informed Consent Form.

### Participants

A total of 193 elderly individuals who had engaged in physical activity in a nursing home were selected, along with a group of 25 participants who had not. Participants were randomly assigned using sealed envelopes before exercise sessions by a person external to the study.

The physical activity groups were distributed as follows: (1) Aerobic Training; (2) Stretching Training; (3) Resistance Training. Each modality had a frequency of (a) once a week, (b) twice a week, or (c) three times a week. The control group performed no training.

### Inclusion criteria

For all groups, inclusion required a medical report and radiographic evidence of osteoarthritis (OA) according to the Kellgren and Lawrence scale.[9] Specifically, the exercise group had practiced physical activity regularly for over a year. The control group had not engaged in physical activity or rehabilitation in the past 12 months.

Exclusion criteria included: (I) previous lower limb surgery, (II) fibromyalgia diagnosis, (III) corticosteroid or intra-articular hyaluronic acid use in the past 12 months, (IV) oral anti-inflammatory use in the past 2 months, (V) physiotherapy treatment for spine, hip, or lower limbs in the past six months, (VI) regular walking for 30 minutes or more daily, (VII) heart failure, (VIII) physical dependence.

### Physical activity description

Aerobic training lasted 50 minutes, with a 5-minute warm-up walk. The protocol included: (I) 30-second brisk walks followed by 30 seconds of rest, repeated 3 times; (II) 30-second directional changes followed by 30 seconds of rest, repeated 3 times; (III) 30 seconds of jumping jacks, 3 sets of 8 repetitions, with 30 seconds of rest.

Stretching training also lasted 50 minutes, consisting of static lower limb stretches in a seated position. Each muscle group was stretched for 30 seconds with a 30-second rest (knee flexors and extensors, hip adductors, flexors, and extensors).

Resistance training was performed for 50 minutes at 50% of the 1 maximum repetition (MR). A 5-minute warm-up walk preceded 8 to 10 exercises with 3 sets of 8 repetitions, resting 1 minute between sets. Exercises included strengthening of knee flexors, extensors, hip flexors, abductors, elbow flexors, shoulder flexors, and abductors, using ankle weights.

### Procedures

Pain assessment: Knee pain was assessed using the numerical rating scale: "On a scale from 0 to 10, where 0 is no pain and 10 is the greatest pain imaginable, what is your knee pain today?"

The capacity to perform instrumental activities of daily living (IADL) was evaluated using the Lawton Scale, which consists of nine tasks such as phone use, shopping, food preparation, housework, transportation, medication preparation, and financial management. Responses were classified as: [1] performed the activity, [2] performed with help, or [3] did not perform the task.

### Statistical Analysis

Data distribution was initially checked using the Shapiro-Wilk test. The Kruskal-Wallis test ($P \leq 0.05$) was applied, followed by Dunn's post hoc test. Statistical software used was Prisma version 5.0. The Hedges g-statistic[10] of the independent t-test was applied to calculate effect size, considering different sample sizes. Effect sizes were classified as small ($0.20 \leq g < 0.50$), medium ($0.50 \leq d < 0.80$), or large ($d \geq 0.80$). SPSS v.20 was used for statistical analysis.

## RESULTS

Table 1 shows the characteristics of the participants in each of the training subgroups and the control group.

The control group is different from the other ones.

Figure 1 shows the comparison of pain scale values in the different conditions studied. The group that performed muscle strength exercises once, twice, or three times a week presented lower knee pain compared to the control group ($P < 0,001$). The group that performed stretching three times a week also reported significantly lower pain scale values when compared to the control group.

Concerning IADL, practicing strength physical exercises at least once a week or stretching or aerobic exercises at least twice a week increases and/or maintains functional independence, when compared to the control group.

Figure 02 - Lawton Scale Variable Comparisons

Table 2 and Table 3 show, respectively, the effect size (size effect) and power effect of the groups when compared to the control group.

In contrast the relationship between pain and the Lawton scale.

## DISCUSSION

The main findings highlight the importance of regular exercise, regardless of type, in managing knee osteoarthritis and improving

**Table 1.** Characteristics of the participants. Sample means (standard deviation).

| | aerobic training | | | stretching training | | | resistance training | | | group control | difference between groups |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 x/week | 2 x/week | 3 x/week | 1 x/week | 2 x/week | 3 x/week | 1 x/week | 2 x/week | 3 x/week | | |
| | 22 | 17 | 17 | 15 | 19 | 22 | 17 | 22 | 17 | 25 | |
| age, y | 71.9 (7.5) | 75.4 (8.2) | 69.6 (6.5) | 72.3 (4.4) | 70.7 (5.4) | 72.4 (6.1) | 71.5 (6.0) | 72.7 (6.2) | 72.7 (5.9) | 80.3* (5.9) | p<0.05* |
| weight, kg | 70.8 (12.8) | 68.4 (10.6) | 65.6 (12.8) | 76.6 (11.5) | 68.8 (11.6) | 67.5 (9.5) | 70.5 (9.9) | 66.5 (10.1) | 67.5 (13.0) | 66.8 (15.0) | p>0.05 |
| height, cm | 159.2 (9.3) | 155.6 (7.1) | 157.7 (5.5) | 161.0 (7.0) | 159.0 (8.3) | 157.0 (8.6) | 159.1 (7.7) | 156.4 (8.0) | 154.3 (8.6) | 154.9 (8.4) | p>0.05 |
| BMI | 27.8 (4.0) | 28.3 (4.5) | 26.3 (4.9) | 29.6 (5.3) | 27.2 (4.2) | 27.4 (3.7) | 28.1 (5.5) | 27.1 (3.3) | 28.4 (5.3) | 27.9 (6.5) | p>0.05 |

p<0.05* = proved to be significantly different from the other groups

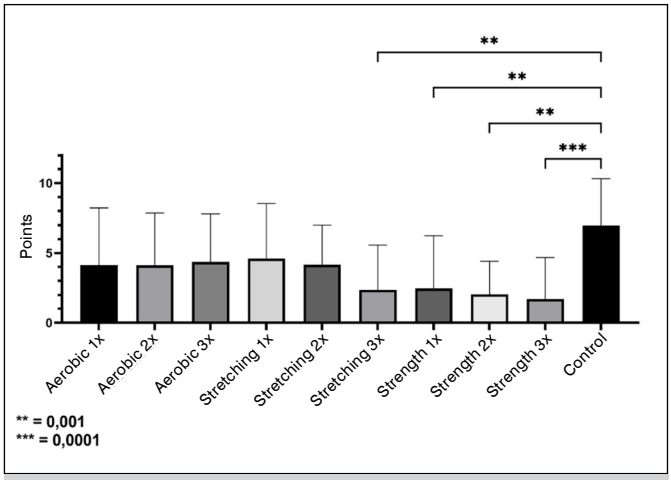


**Figure 1.** Values of the numeric rating scale acquired from the control group and aerobic training, stretching, and strength groups. 1x, 2x and 3x indicate respectively, one, two, or three training sessions per week.

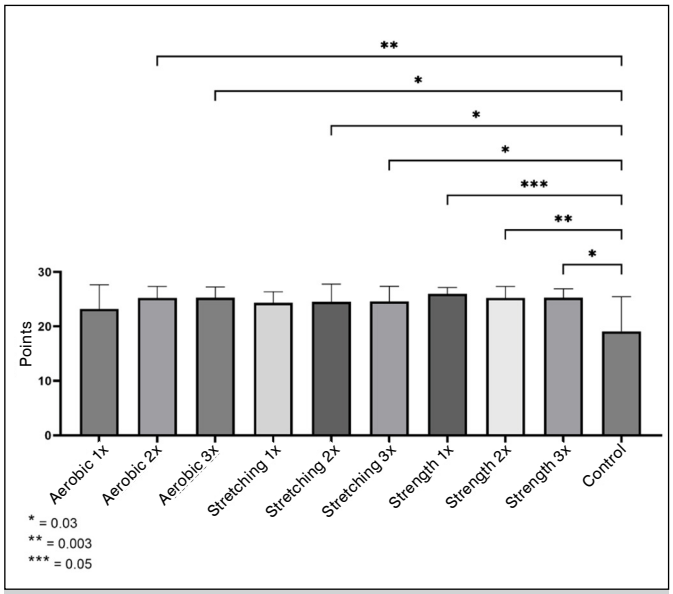


**Figure 1.** Lawton scale variable comparisons.

**Table 2.** Data From Numerical Pain Scale Comparisons.

| | Comparisons Average (Standard Deviation) | | Effect Size (d) | Power Effect |
|---|---|---|---|---|
| | X per week | Control | | |
| **Resistance Training** | | | | |
| 1 | 2,47 ( 3,76) | 6,96 ( 3,36) | 1,2733 | 0,9768 |
| 2 | 2,04 ( 2,35) | 6,96 ( 3,36) | 1,6738 | 0,9999 |
| 3 | 1,70 ( 2,97) | 6,96 ( 3,36) | 1,6361 | 0,9991 |
| **Stretching Training** | | | | |
| 1 | 4,60 ( 3,94) | 6,96 ( 3,36) | 0,6581 | 0,5018 |
| 2 | 4,15 ( 2,83) | 6,96 ( 3,36) | 0,8909 | 0,8158 |
| 3 | 2,36 ( 3,20) | 6,96 ( 3,36) | 1,3985 | 0,9967 |
| **Aerobic Training** | | | | |
| 1 | 4,13 ( 4,09) | 6,96 ( 3,36) | 0,7585 | 0,7187 |
| 2 | 4,11 ( 3,73) | 6,96 ( 3,36) | 0,8082 | 0,7084 |
| 3 | 4,35 ( 3,44) | 6,96 ( 3,36) | 0,7680 | 0,6644 |

**Table 3.** Data From Lawton Scale Comparisons.

| | **Comparisons Average (Standard Deviation)** | | **Effect Size (d)** | **Power Effect** |
|---|---|---|---|---|
| | **X per week** | **Control** | | |
| **Resistance Training** | | | | |
| 1 | 26,00 ( 1,17) | 19,12 ( 6,35) | 1,3824 | 0,9901 |
| 2 | 25,22 ( 2,13) | 19,12 ( 6,35) | 1,2556 | 0,9875 |
| 3 | 25,29 ( 1,64) | 19,12 ( 6,35) | 1,2273 | 0,9678 |
| **Stretching Training** | | | | |
| 1 | 24,33 ( 2,05) | 19,12 ( 6,35) | 1,0023 | 0,8486 |
| 2 | 24,52 ( 3,25) | 19,12 ( 6,35) | 1,0289 | 0,9103 |
| 3 | 24,59 ( 2,78) | 19,12 ( 6,35) | 1,0908 | 0,9546 |
| **Aerobic Training** | | | | |
| 1 | 23,22 ( 4,43) | 19,12 ( 6,35) | 0,7410 | 0,6990 |
| 2 | 25,23 ( 2,13) | 19,12 ( 6,35) | 1,1983 | 0,9607 |
| 3 | 25,29 ( 1,96) | 19,12 ( 6,35) | 1,2166 | 0,9653 |

functional independence. Exercise frequency plays a significant role in its effectiveness. The cross-sectional design limits the ability to establish causation, and sample size should be acknowledged as a limitation. Strength training reduces pain in individuals with knee osteoarthritis through various mechanisms, such as improving muscle strength around the knee, which provides support and stability, reducing stress on the joint. This leads to reduced pain and discomfort.[11] Additionally, it can improve joint mobility, reduce stiffness, and enhance physical function.[11,12] Strength training also improves bone density, reducing fall and fracture risks.[12] The frequency of sessions required for analgesic effects remains under study. Our findings align with Jorge et al.[11], who used a twice-weekly protocol, and Bennell et al.[12], who recommended three or more sessions a week. However, our study shows that this exercise type promotes analgesia regardless of frequency.

Stretching exercises require at least three weekly sessions for pain relief, as confirmed by Weng et al.[13], whose eight-week study reduced knee pain in OA patients. Stretching improves joint range of motion and reduces stiffness, contributing to pain relief. The physiological benefits include increased muscle extensibility and reduced muscle stiffness, improving movement and functional synergy. These acute responses are linked to chronic adaptations, such as better joint mobility and flexibility.[13]

Aerobic training, regardless of frequency, did not show significant effects on knee pain compared to the control group. Wallis et al.[14] also found no positive impact on knee pain, though improvements were observed in cardiovascular health. However, recent studies suggest aerobic exercise can reduce knee pain.[15] A systematic review by Raposo et al.[16] showed that aerobic exercise benefits pain reduction. Thus, factors like activity duration may limit the analgesic effects of aerobic training in this study.

While aerobic exercise provides cardiovascular and other health benefits, it may not be as effective in reducing knee pain compared to strength training. Repetitive movements in aerobic activities can stress the knee joint, worsening pain. Aerobic exercises also don't improve muscle strength and joint stability as effectively as strength training. Some individuals may find aerobic activities too painful, reducing their willingness to participate regularly. While aerobic exercise is beneficial, other exercises like strength training or low-impact activities may be more effective for pain relief.[17-20]

Although this study offers valuable insights, it only focuses on the role of exercise in pain reduction in knee OA. A more individualized approach, addressing specific patient needs, is required. Interdisciplinary research should explore comprehensive treatment strategies, combining exercise, medication, diet, and lifestyle changes, with potential surgery. Future studies should investigate combined treatment approaches for knee OA.

This study has clinical implications for knee osteoarthritis management, showing that exercise can effectively reduce pain and improve daily function. However, care should be taken when prescribing exercise modalities and frequencies for knee OA patients.

## CONCLUSION

Based on the findings of the study, it can be concluded that resistance training is an effective form of exercise for reducing knee pain and improving functional independence in individuals with knee osteoarthritis. This effect was seen even with a minimal frequency of once a week, although a higher frequency of training (two or three times a week) may have even greater benefits.

Stretching training was found to be effective in reducing knee pain only when performed three times a week, and improved functional independence when done two to three times a week.

Aerobic training did not show significant improvements in pain reduction, but it did have a positive effect on functional independence when performed two to three times a week.

**AUTHOR'S CONTRIBUTION:** Each author contributed individually and significantly to the development of this article. FMB: Substantial contribution to the conception or design of the work, or acquisition, analysis or interpretation of data for the work; RPS: Substantial contribution to the conception or design of the work, or acquisition, analysis or interpretation of data for the work; Writing the work or critically reviewing its intellectual content; ACA: Substantial contribution to the conception or design of the work, or acquisition, analysis or interpretation of data for the work; Writing the work or critically reviewing its intellectual content; GCB: Substantial contribution to the conception or design of the work, or acquisition, analysis or interpretation of data for the work; Writing the work or critically reviewing its intellectual content; PRMSS: Writing of the work or critical review of its intellectual content; Final approval of the version of the manuscript to be published; UFE: Writing of the work or critical review of its intellectual content; Final approval of the version of the manuscript to be published.

## REFERENCES

1. Glyn-Jones S, Palmer AJR, Agricola R, Price AJ, Vincent TL, Weinans H, et al. Osteoarthritis. Lancet. 2015;386(9991):376-87. doi: 10.1016/s0140-6736(14)60802-3.
2. Mahir L, Belhaj K, Zahi S, Azanmasso H, Lmidmani F, El Fatimi A. Impact of knee osteoarthritis on the quality of life. Ann Phys Rehabil Med. 2016;59(Suppl):e159. doi: 10.1016/j.rehab.2016.07.355.
3. Fingleton C, Smart K, Moloney N, Fullen BM, Doody C. Pain sensitization in people with knee osteoarthritis: a systematic review and meta-analysis. Osteoarthritis Cartilage. 2015;23(7):1043-56. doi: 10.1016/j.joca.2015.02.163.
4. Kraus VB, Sprow K, Powell KE, Buchner D, Bloodgood B, Piercy K, et al. Effects of physical activity in knee and hip osteoarthritis: a systematic umbrella review. Med Sci Sports Exerc. 2019;51(6):1324-39. doi: 10.1249/mss.0000000000001944.
5. Rausch Osthoff AK, Niedermann K, Braun J, Adams J, Brodin N, Dagfinrud H, et al. 2018 EULAR recommendations for physical activity in people with inflammatory arthritis and osteoarthritis. Ann Rheum Dis. 2018;77(9):1251-60. doi: 10.1136/annrheumdis-2018-213585.
6. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist. 1969;9(3):179-86.
7. Justice JN, Cesari M, Seals DR, Shively CA, Carter CS. Comparative approaches to understanding the relation between aging and physical function. J Gerontol A Biol Sci Med Sci. 2016;71(10):1243-53. doi: 10.1093/gerona/glv035.
8. Lima LV, Abner TSS, Sluka KA. Does exercise increase or decrease pain? Central mechanisms underlying these two phenomena. J Physiol. 2017;595(13):4141-50. doi: 10.1113/jp273355.
9. Kellgren LH, Lawrence JS. Radiological assessment of osteo-arthrosis. Ann Rheum Dis. 1957;16(4):494-502. doi: 10.1136/ard.16.4.494.
10. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale: Lawrence Erlbaum; 1988 [cited 2023 May 23]. Available from: https://www.utstat.toronto.edu/~brunner/oldclass/378f16/readings/CohenPower.pdf.
11. Jorge RTB, Souza MC, Chiari A, Jones A, Fernandes ARC, Lomardi IJ, et al. Progressive resistance exercise in women with osteoarthritis of the knee: a randomized controlled trial. Clin Rehabil. 2015;29(3):234-43. doi: 10.1177/0269215514540920.
12. Bennell KL, Hunt MA, Wrigley TV, Hunter DJ, McManus FJ, Hodges PW, et al. Hip strengthening reduces symptoms but not knee load in people with medial knee osteoarthritis and varus malalignment: a randomised controlled trial. Osteoarthritis Cartilage. 2010;18(5):621-8. doi: 10.1016/j.joca.2010.01.010.
13. Weng MC, Lee CL, Chen CH, Hsu JJ, Lee WD, Huang MH, et al. Effects of different stretching techniques on the outcomes of isokinetic exercise in patients with knee osteoarthritis. Kaohsiung J Med Sci. 2009;25(6):306-15. doi: 10.1016/s1607-551x(09)70521-2.
14. Wallis JA, Webster KE, Levinger P, Singh PJ, Fong C, Taylor NF. A walking program for people with severe knee osteoarthritis did not reduce pain but may have benefits for cardiovascular health: a phase II randomised controlled trial. Osteoarthritis Cartilage. 2017;25(12):1969-79. doi: 10.1016/j.joca.2016.12.017.
15. Salacinski AJ, Krohn K, Lewis SF, Holland ML, Ireland K, Marchetti G. The effects of group cycling on gait and pain-related disability in individuals with mild-to-moderate knee osteoarthritis: a randomized controlled trial. J Orthop Sports Phys Ther. 2012;42(12):985-95. doi: 10.2519/jospt.2012.3813.
16. Raposo F, Ramos M, Lúcia Cruz A. Effects of exercise on knee osteoarthritis: A systematic review. Musculoskeletal Care. 2021;19(4):399-435. doi: 10.1002/msc.1538.
17. Cohen Y, Zisberg A, Chayat Y, Gur-Yaish N, Gil E, Levin C, et al. Walking for better outcomes and recovery: the effect of WALK-FOR in preventing hospital-associated functional decline among older adults. J Gerontol A Biol Sci Med Sci. 2019;74(10):1664-70. doi: 10.1093/gerona/glz025.
18. Rocha CAQC, Guimarães AC, Borba-Pinheiro CJ, Santos CAS, Moreira MHR, de Mello DB, et al. Efeitos de 20 semanas de treinamento combinado na capacidade funcional de idosas. Rev Bras Ciênc Esporte. 2017;39(4):442-9. doi: 10.1016/j.rbce.2017.08.005.
19. Allendorf DB, Schopf PP, Gonçalves BC, Closs VE, Gottlieb MGV. Idosos praticantes de treinamento resistido apresentam melhor mobilidade do que idosos fisicamente ativos não praticantes. Rev Bras Cienc Mov. 2016;24(1):134-44.
20. Borges MRD, Moreira AK. Influências da prática de atividades físicas na terceira idade: estudo comparativo dos níveis de autonomia para o desempenho nas AVDs e AIVDs entre idosos ativos fisicamente e idosos sedentários. Motriz. 2009;15(3):562-73.

DOI: http://dx.doi.org/10.1590/1413-785220253301e285935



# SUBSCAPULAR INJURY: PROSPECTIVE COMPARISON OF PHYSICAL EXAMINATION, MRI AND ARTHROSCOPY

# LESÃO SUBESCAPULAR: COMPARAÇÃO PROSPECTIVA DO EXAME FÍSICO, RNM E ARTROSCOPIA

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## ABSTRACT

Rotator cuff injury is the most frequent etiology of shoulder pain, with 24% of these injuries involving the subscapular tendon. Objective: To correlate the findings of three clinical tests (Gerber test, Belly Press test, and Bear Hug test) with Magnetic Resonance Imaging (MRI) and arthroscopic findings of subscapular lesions. Methods: Prospective cross-sectional study, from November 2023 to March 2024, with 50 patients with rotator cuff injury, evaluating sensitivity, specificity, and accuracy among clinical tests, MRI, and arthroscopic findings. Results: 50 patients formed the sample, with 29 (58%) men and 21 (42%) women aged 42 to 86 years. We found a specificity of 88% and an accuracy of 54% in MRI. Regarding the Gerber test, the Belly Press test, and the Bear Hug test, the sensitivity was 64%, 64%, and 76%, with specificity of 75% for the Gerber and Belly Press tests and accuracy of 74% for the Bear Hug test. Conclusion: We concluded that the Bear Hug test showed higher sensitivity and accuracy in detecting subscapular tendon lesions, with MRI being the most specific method. ***Level of Evidence II; Prospective Study.***

**Keywords:** Rotator Cuff; Subscapularis; Arthroscopy; Rotator Cuff Injuries.

## *RESUMO*

*A lesão do manguito rotador é a etiologia mais frequente de dor no ombro e 24% destas lesões podem envolver o tendão subescapular. Objetivo: Correlacionar os achados de três testes clínicos (teste de Gerber, Belly Press test e Bear Hug test) com imagens de Ressonância Nuclear Magnética (RNM) e achados artroscópicos das lesões do subescapular. Métodos: Estudo transversal prospectivo, no período de novembro de 2023 a março de 2024, com 50 pacientes portadores de lesão do manguito rotador, avaliando a sensibilidade, especificidade e acurácia entre os testes clínicos, RNM e achados artroscópicos. Resultados: 50 pacientes formaram a amostra, sendo 29 (58%) homens e 21 (42%) mulheres, com idade variando de 42 a 86 anos. Encontramos uma especificidade de 88% e acurácia de 54% na RNM. Com relação aos testes de Gerber, Belly Press test e Bear Hug, a sensibilidade foi, respectivamente, de 64%, 64% e 76%, sendo a especificidade de 75% para o teste de Gerber e Belly Press test, e acurácia de 74% para o Bear Hug test. Conclusão: Concluímos que o Bear Hug test apresentou maior sensibilidade e acurácia na detecção de lesões do tendão subescapular, sendo a RNM o método mais específico.* ***Nível de Evidência II; Estudo Prospectivo.***

***Descritores:*** *Manguito Rotador; Músculo Subescapular; Artroscopia; Lesões do Manguito Rotador.*

**Citation:** Ribeiro Filho HG, Ferreira JRS, Dantas FW, Ritta RAS. Lesão subescapular: comparação prospectiva do exame físico, RNM e artroscopia. Acta Ortop Bras. [online]. 2025;33(1):Page 1 of 4. Available from URL: http://www.scielo.br/aob.

## INTRODUCTION

Rotator cuff injury is the most frequent etiology of shoulder pain with an incidence of 14.7 per 1000 patients. Although the supraspinatus tendon is the most commonly affected of the cuff muscles, approximately 24% of these injuries may involve the subscapularis tendon.[1,2] Some authors propose that 37% of these pathologies involve the subscapularis; however, it is still poorly recognized, underdiagnosed and forgotten.[3] The subscapularis is the strongest and widest muscle of the rotator cuff, allowing internal rotation of the humerus, providing anterior stability to the shoulder and being involved in the force balance of the glenohumeral joint.[4] Being responsible for 50% of the total force of the rotator cuff, its integrity is a prerequisite for a variety of reconstructive techniques in the rotator cuff and its injury leads to pain, functional disability, and shoulder instability.[5]

A variety of clinical signs and diagnostic tests have been published to assess the integrity of the subscapularis,[6] among them we highlight the Lift-off test (Gerber test) described by Gerber and Krushell et al.,[7] the Belly Press test also described by Gerber et al.,[7] and the Bear Hug test described by Barth et al.[8] Despite a

All authors declare no potential conflict of interest related to this article.

***The study was conducted at Santa Casa de Misericórdia Hospital in Maceió.***
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Article received on 04/24/2024, approved on 07/05/2024.

variety of tests, subscapularis injury continues to be undiagnosed in clinical practice, probably because of the different diagnostic values of each test used alone, with no consensus establishing which is the best clinical test with good sensitivity and specificity. None of these maneuvers, however, present satisfactory sensitivity and specificity, resulting in low positive predictive values.

MRI is considered an important tool in the diagnosis of subscapularis injuries, but its accuracy is lower than for detecting other rotator cuff injuries.[3,9,10] Despite advances in MRI technique and equipment, there is still difficulty in diagnosing subscapularis injuries, with sensitivity ranging from 25-94% and specificity from 64-100%.[11] In the study by Smith et al.,[12] sensitivity and specificity of 80% and 95%, respectively, were found for partial rotator cuff tears, and 91% and 97%, respectively, for complete rotator cuff tears.

With the advent of arthroscopy in shoulder surgery, the understanding of pathologies has been improving. Although considered the gold standard for the diagnosis of these injuries, there are limitations in the evaluation of the subscapularis tendon, especially in its inferior portion, often requiring the use of specific intraoperative maneuvers or even optics with expanded vision, such as 70° optics, which frequently are not routinely available.[3,13] In successive arthroscopies, Barth et al. observed that several lesions of the upper portion of the subscapularis tendon were not predicted by the Belly Press test and Lift-off test maneuvers, since the uppermost fibers were recruited only in internal rotation of the shoulder with the elbow in a more anterior position.[8]

The aim of this study is to correlate the findings of three clinical tests with MRI images and arthroscopic findings of subscapularis injuries, determining the diagnostic value of these tests.

## MATERIALS AND METHODS

A prospective cross-sectional study was conducted from November 2023 to March 2024, evaluating the sensitivity, specificity, accuracy, positive predictive value and negative predictive value of the correlation of three clinical tests (Lift-Off test or Gerber test, Belly Press test or Abdominal Press Test, and Bear Hug test) for the diagnosis of subscapularis tendon injury with MRI images and intraoperative arthroscopic findings. Sixty patients of both sexes, over 18 years old, diagnosed with rotator cuff injury and requiring surgical intervention, were evaluated. All clinical tests and arthroscopies were performed by the same surgeon with over 15 years of experience in shoulder and elbow surgery. Our project was submitted to the Research Ethics Committee under CAAE: 71053723.9.0000.0155. Informed consent forms were obtained from all patients following Resolution 466/12 of the National Commission for Research Ethics.

The following exclusion criteria were used: previous shoulder surgeries, polytraumatized patients, alcohol or illicit drug abuse, open injuries, neoplastic diseases, associated upper limb fractures, adhesive capsulitis, glenohumeral arthrosis, psychiatric illness, pregnancy, clinically uncompensated comorbidities, and active infection. Ten patients were not eligible for the study: 6 due to glenohumeral arthritis, 3 with a diagnosis of adhesive capsulitis, and 1 with schizophrenia.

Epidemiological data such as age, gender, and laterality were collected at the initial consultation and a preoperative clinical evaluation was performed in the outpatient clinic using the three clinical tests of Gerber, Bear Hug test, and Belly Press test. Regarding MRI evaluation, only exams performed in the last 6 months before arthroscopy were considered.

For MRI, the patient was placed in a supine position with arms in the neutral position. All MRIs were performed with a 1.5 Tesla resolution using a shoulder support. The imaging protocol included T2-weighted coronal oblique, oblique sagittal, axial with fat suppression, and T1-weighted coronal oblique and oblique sagittal sequences.

In the surgical suite, a new clinical evaluation using the three clinical tests and reevaluation of MRI were performed, followed by arthroscopic technique to confirm or rule out the presence of subscapularis injury. All patients were operated on in a beach chair position under general anesthesia and brachial plexus block. Conventional arthroscopic portals (posterior, anterior, lateral) were used. Complete joint exploration of the glenohumeral joint and subacromial space through the posterior portal using 30° and 70° optics along with the 30°-40° flexion and internal rotation maneuver to assess subscapularis injuries associated with anterior portal probing were performed. The subscapularis was evaluated and classified according to Lafosse, who subdivides it into 5 types of lesions where type 1 refers to partial tear of the upper 1/3, type 2 to complete tear of the upper 1/3, type 3 to complete tear of the upper 2/3 of the tendon, type 4 refers to a complete rupture, and type 5 to a complete irreparable rupture with static anterosuperior subluxation.[14]

Statistical analysis of the patients was performed using descriptive statistics and analyzed using the Jamovi module. The number of true positives, true negatives, false positives and false negatives were used to determine sensitivity, specificity, negative predictive value, positive predictive value and accuracy of the clinical tests and MRI with a 95% confidence interval using arthroscopic findings as the gold standard.[15]

## RESULTS

The sample consisted of 50 patients, with 29 (58%) males and 21 (42%) females, ranging in age from 42 to 86 years (mean = 60.53; SD = 9.61), with the right side being the most affected with 37 cases (74%). Of the 42 lesions confirmed by arthroscopy, 24 were classified as Lafosse type 1 (57.1%) and 17 (40.4%) were classified as Lafosse type 2 and 3 (Table 1).

### Magnetic Resonance Imaging

The reported results are from a medical decision test applied to 50 individuals, of which 42 were identified as diseased (Gold Positive) and 8 as healthy (Gold Negative) by the gold standard (arthroscopy), which is the reference method for diagnosis (Table 2).

The imaging test in question demonstrated lower sensitivity with a value of 48%, compared to the three clinical tests; however, it presented higher specificity with a value of 88%, indicating that of the 8 individuals considered healthy by the gold standard, 7 were correctly identified as healthy by the test (Test Negative). Furthermore, it presented a positive predictive value (PPV) of 95%, being higher among all, indicating that the probability of an individual with a positive result on the test actually having the disease is 95%. In contrast, it showed lower negative predictive value (NPV) and accuracy, being 24% and 54%, respectively (Table 2 and 3).

Additionally, the positive likelihood ratio was 3.81, indicating that a positive result on the test is 3.81 times more likely in diseased

**Table 1.** Epidemiological and clinical characteristics (n = 50).

| Characteristic | | M (±SD) or n (%) | |
|---|---|---|---|
| Age, years, M(SD) | | 60,53 (± 9,61) | |
| Gender | Male, n (%) | 29 | (58) |
| | Female, n (%) | 21 | (42) |
| Laterality | Right, n (%) | 37 | (74) |
| | Left, n (%) | 13 | (26) |
| Lafosse | 1 - n (%) | 24 | (57,1%) |
| | 2 and 3- n (%) | 17 | (40,4%) |
| | 4 – n (%) | 1 | (2,3%) |

Source: developed by the author, 2024.



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individuals than in healthy individuals. The 95% confidence intervals mean that, with 95% certainty, the true sensitivity of the test is between 32% and 64%, and the true specificity is between 47% and 100%. The diagnostic odds ratio was 6.36, with a 95% confidence interval ranging from 0.72 to 56.35 (Table 4).

### Gerber test

The test in question demonstrated sensitivity, specificity, PPV, and NPV values of 64%, 75%, 93%, and 29%, respectively, being similar to the values found in the Belly Press test; however, it presented lower accuracy (56%). The 95% confidence intervals for the sensitivity and specificity of the test were from 48% to 78% and from 35% to 97%, respectively (Table 3).

### Belly press test

As described above, it presented some similar data to the Gerber test but with better accuracy, at 66%, showing that it had the best proportion of correct results compared to the Gerber test. Furthermore, it presented a diagnostic odds ratio value of 5.40, with a 95% confidence interval from 0.97 to 30.16 (Table 3 and 4).

### Bear hug test

Of the 42 diseased individuals, the test correctly identified 32 as diseased (Test Positive), resulting in a sensitivity of 76%, which was higher than that found in the other clinical tests and even in MRI. This indicates that the test has a 76% chance of correctly identifying a diseased individual, with a 95% confidence interval for sensitivity between 61% and 88%. It also presented the highest accuracy, with a value of 74%, favoring having the highest proportion of correct results (true positives and true negatives) in relation to the total tests performed, compared to the other clinical tests and MRI. Additionally, it presented an NPV of 33%, higher than other clinical tests and MRI, indicating a higher probability of an individual with a negative test actually not having the disease (Table 2 and 3).

**Table 2.** Arthroscopic confirmation vs. MRI diagnosis.

| Diagnosis confirmation | Nº of cases | N (%) |
|---|---|---|
| Diseased | 42 | 84 |
| Healthy | 8 | 16 |
| Positive Tests | 21 | 42 |
| Negative Tests | 29 | 58 |
| True Test | 27 | 54 |
| Wrong Test | 23 | 46 |

Source: developed by the author, 2024.

**Table 3.** Sensitivity, specificity, accuracy, positive predictive value (PPV) and negative predictive value (NPV) by diagnostic technique.

| | MRI | Gerber Test | Belly Press Test | Bear Hug Test |
|---|---|---|---|---|
| Sensitivity | 48% | 64% | 64% | 76% |
| Specificity | 88% | 75% | 75% | 63% |
| Accuracy | 54% | 56% | 66% | 74% |
| Positive Predictive Value (PPV) | 95% | 93% | 93% | 91% |
| Negative Predictive Value (NPV) | 24% | 29% | 29% | 33% |

Source: developed by the author, 2024.

**Table 4.** Odds ratio correlation between clinical tests and MRI.

| | | 95% confidence interval | | |
|---|---|---|---|---|
| | Statistical decision | Estimate | Lower | Higher |
| MRI | Odds ratio | 6.36 | 0.72 | 56.35 |
| Gerber test | Odds ratio | 5.40 | 0.97 | 30.16 |
| Belly press test | Odds ratio | 5.40 | 0.97 | 30.16 |
| Bear hug test | Odds ratio | 5.33 | 1.08 | 26.36 |

Source: developed by the author, 2024.

## DISCUSSION

Over the years, several studies have shown that subscapularis tendon injuries are not just occasional occurrences; a consistent increase in rates has led to an increase in its prevalence.[16,17] Bennet et al.[16] demonstrated a prevalence of 27%, Bartsch et al.[6] 30%, and Barth et al.[8] 58.8% of subscapularis injuries in their studies. Our study showed a prevalence of 84%, much higher than most studies in the literature, with only patients undergoing surgical treatment for rotator cuff injuries being evaluated here. The advent of arthroscopy with the use of 70° optics, cameras with 4k definition in modern devices, LED fiber optics, in addition to the described maneuvers for intraoperative use that facilitate visualization of the subscapularis insertion on the lesser tuberosity, explains the increased diagnosis of subscapularis injuries, especially partial lesions that are more difficult to detect on MRI due to the absence of indirect signs, resulting in an increased prevalence of these injuries.

When evaluating the accuracy of MRI in detecting subscapularis injuries, we found in our study an accuracy value of 54% with an NPV of 24%, which is contrary to that described by Adams et al.[9] in their study, with an accuracy of 82% and NPV of 78%. Pfirrmann et al.[18] evaluated the result of two musculoskeletal radiologists in predicting subscapularis injury, assessing MRI and their interpretations, which were compared with intraoperative findings; regarding sensitivity, it was reported 91% for both the first and second radiologists, showing a difference compared to our study, which showed a value of 48%. Regarding specificity, the first was 86%, and the second was 79%, which is consistent with our research. Malavolta et al.[19] found in their systematic review an accuracy of 90%, with sensitivity of 68% and specificity of 90%, similar to the 88% found in our study, making it the most specific method in our results.

In this study, most of the lesions found in arthroscopy that were not detected in MRI images by radiologists were partial, whether articular or intrasubstance. Although they were made with the same protocol, MRI images were taken and evaluated in 3 different locations by different radiologists. The method has a low capacity to diagnose subscapularis injury when compared to other rotator cuff tendons, requiring greater attention from radiologists in their evaluations and the use of other imaging protocols to develop clearer signs of subscapularis tendon injury. Additionally, we emphasize that the improvement in technology for performing arthroscopies has facilitated intraoperative diagnosis.[19]

Regarding the clinical tests evaluated in this study, we observed greater sensitivity with the Bear Hug test, totaling 76%, a result also observed by Schiefer et al.[20]. Barth et al.[8] in their work describing the maneuver found a sensitivity of 60%, suggesting that the test is especially useful in detecting lesions of the upper fibers of the subscapularis. This is supported in this study when we evaluate Table 1 and find the majority of cases to be type 1 and 2, according to Lafosse's classification. The sensitivity of the Gerber test (Lift-off test) was 64% in our study, differing from several other studies found in the literature such as that of Bartsch et al.[6] with 40%, Schiefer et al.[20] with 25%, and Kappe et al.[5] with 35%. The sensitivity of the Belly Press test, which was also 64%, shows a similar percentage to what we found in the literature, such as in Barth et al.[8], with 76%. Perhaps an explanation for the discrepancy in the results found regarding the Gerber test is due to the various modifications in its execution and interpretations.

Although this study shows greater sensitivity with the Bear Hug test, especially for lesions of the upper 1/3, the sensitivity of clinical tests

proved to be limited, emphazising the importance of performing all tests along with the clinical history to detect the greatest number of lesions, hereby ensuring that this diagnosis does not go overlooked. It is also important for radiologists to develop a more detailed protocol using axial and sagittal cuts of MRI to increase accuracy in diagnosing subscapularis injuries.

Our study has some limitations, such as the small sample presented, the fact that the majority of diagnosed lesions were partial and the variability in the assessment of MRI images, considering they were not conducted in a single center.

## CONCLUSION

We conclude that the findings of our study show that the Bear Hug test was the physical examination maneuver that presented the highest sensitivity and accuracy in detecting subscapularis tendon injuries, with MRI being the most specific method.

**AUTHOR'S CONTRIBUTION:** Each author contributed individually and significantly to the development of this article. HGRF: article writing, revision, performing the surgeries, and also in the overall intellectual conception of the article; JRSF: data analysis, writing, and revision of the article; FWD: statistical analysis, creation of tables, and revision of the article; RASR: writing and revision of the article.

## REFERENCES

1. Dakkak A, Krill MK, Krill ML, Nwachukwu B, McCormick F. Evidence-Based Physical Examination for the Diagnosis of Subscapularis Tears: A Systematic Review. Sports Health. 2021;13(1):78-84. doi: 10.1177/1941738120936232.
2. Dunn WR, Kuhn JE, Sanders R, An Q, Baumgarten KM, Bishop JY, et al. Symptoms of pain do not correlate with rotator cuff tear severity: a cross--sectional study of 393 patients with a symptomatic atraumatic full-thickness rotator cuff tear. J Bone Joint Surg Am. 2014;96(10):793-800. doi: 10.2106/JBJS.L.01304.
3. Garavaglia G, Ufenast H, Taverna E. The frequency of subscapularis tears in arthroscopic rotator cuff repairs: A retrospective study comparing magnetic resonance imaging and arthroscopic findings. Int J Shoulder Surg. 2011;5(4):90-4. doi: 10.4103/0973-6042.91000.
4. Keating JF, Waterworth P, Shaw-Dunn J, Crossan J. The relative strengths of the rotator cuff muscles: A cadaver study. J Bone Joint Surg Br. 1993;75(1):137-40. doi: 10.1302/0301-620X.75B1.8421011.
5. Kappe T, Sgroi M, Reichel H, Daexle M. Diagnostic performance of clinical tests for subscapularis tendon tears. Knee Surg Sports Traumatol Arthrosc. 2018;26(1):176-81. doi: 10.1007/s00167-017-4617-4.
6. Bartsch M, Greiner S, Haas NP, Scheibel M. Diagnostic values of clinical tests for subscapularis lesions. Knee Surg Sports Traumatol Arthrosc. 2010;18(12):1712-7. doi: 10.1007/s00167-010-1109-1.
7. Gerber C, Krushell RJ. Isolated rupture of the tendon of the subscapularis muscle: Clinical features in 16 cases. J Bone Joint Surg Br. 1991;73(3):389-94. doi: 10.1302/0301-620X.73B3.1670434.
8. Barth JRH, Burkhart SS, De Beer JF. The bear-hug test: a new and sensitive test for diagnosing a subscapularis tear. Arthroscopy. 2006;22(10):1076-84. doi: 10.1016/j.arthro.2006.05.005.
9. Adams CR, Brady PC, Koo SS, Narbona P, Arrigoni P, Karnes GJ, et al. A systematic approach for diagnosing subscapularis tendon tears with preoperative magnetic resonance imaging scans. Arthroscopy. 2012;28(11):1592-600. doi: 10.1016/j.arthro.2012.04.142.
10. Malavolta EA, Assunção JH, Gracitelli MEC, Yen TK, Bordalo-Rodrigues M, Ferreira Neto AA. Accuracy of magnetic resonance imaging (MRI) for subscapularis tear: a systematic review and meta-analysis of diagnostic studies. Arch Orthop Trauma Surg. 2019;139(5):659-67. doi: 10.1007/s00402-018-3095-6.
11. Ercan N, Arican G, Taskent HC, Ozmeric A, Alemdaroglu KB. Combined clinical test and magnetic resonance imaging have similar diagnostic values in the diagnosis of subscapularis tear. Knee Surg Sports Traumatol Arthrosc. 2021;29(8):2616-23. doi: 10.1007/s00167-021-06518-7.
12. Smith TO, Daniell H, Geere JA, Toms AP, Hing CB. The diagnostic accuracy of MRI for the detection of partial- and full-thickness rotator cuff tears in adults. Magn Reson Imaging. 2012;30(3):336-46. doi: 10.1016/j.mri.2011.12.008.
13. Khil EK, Choi JA, Lee E, Oh JH. Subscapularis (SSC) tendon tears: diagnostic performance and reliability of magnetic resonance arthrography (MRA) with arthroscopic correlation and comparison with clinical tests. Skeletal Radiol. 2021;50(8):1647-55. doi: 10.1007/s00256-020-03697-1.
14. Lafosse L, Jost B, Reiland Y, Audebert S, Toussaint B, Gobezie R. Structural integrity and clinical outcomes after arthroscopic repair of isolated subscapularis tears. J Bone Joint Surg Am. 2007;89(6):1184-93. doi: 10.2106/JBJS.F.00007.
15. The jamovi project (2022). Jamovi. (Version 2.3) (Computer Software). Available from: https:/www.jamovi.org.
16. Bennett WF. Visualization of the anatomy of the rotator interval and bicipital sheath. Arthroscopy. 2001;17(1):107-11. doi: 10.1053/jars.2001.21024.
17. Gerber C, Hersche O, Farron A. Isolated rupture of the subscapularis tendon. J Bone Joint Surg Am. 1996;78(7):1015-23. doi: 10.2106/00004623-199607000-00005.
18. Pfirrmann CW, Zanetti M, Weishaupt D, Gerber C, Hodler J. Subscapularis tendon tears: detection and grading at MR arthrography. Radiology. 1999;213(3):709-14. doi: 10.1148/radiology.213.3.r99dc03709.
19. Malavolta EA, Assunção JH, Guglielmetti CLB, de Souza FF, Gracitelli MEC, Bordalo-Rodrigues M, et al. Accuracy of preoperative MRI in the diagnosis of subscapularis tears. Arch Orthop Trauma Surg. 2016;136(10):1425-30. doi: 10.1007/s00402-016-2507-8.
20. Schiefer M, Ching-San Júnior YA, Silva SM, Fontenelle C, Carvalho MGD, Faria FG, et al. Diagnóstico clínico da ruptura do tendão subescapular com a manobra semiológica bear hug. Rev Bras Ortop. 2012;47(5):588-92. doi: 10.1590/S0102-36162012000500008.

DOI: http://dx.doi.org/10.1590/1413-785220253301e285913



# CLINICAL AND RADIOLOGICAL PARAMETERS IN MALIGNANT SPINAL TUMORS: A DESCRIPTIVE ANALYSIS

# PARÂMETROS CLÍNICOS E RADIOLÓGICOS EM TUMORES MALIGNOS DA COLUNA VERTEBRAL: UMA ANÁLISE DESCRITIVA

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## ABSTRACT

Objective: To describe the clinical and radiological parameters of spine malignant tumors. Methods: This is a therapeutic study of the descriptive retrospective type. Clinical evaluation included age, sex, tumor lesions, treatments, surgical procedures, and complications. The radiological evaluation analyzed radiographic exams, computed tomographies, and MRIs, focusing on morpho-pathological characteristics and the treatments employed. Results: Among the 236 patients evaluated, the majority were female, aged 6 to 91 years. The main complaint reported was low back pain. The most commonly used surgical approach was the posterior access, including pedicle fixation and decompression of the spinal canal. The most prevalent complication observed was infection. The majority of patients had primary breast tumors. The predominantly affected segment of the spine was the thoracic. Upon analyzing the portions of the spine affected, it was observed that the posterior arch portion was the most commonly affected. Conclusion: The clinical and radiological presentation of patients with metastatic lesions in the spine in our sample was similar to reports in the literature. Surgical outcomes aligned with previous expectations. Initial symptoms were noted, varying intervals between symptoms, diagnosis, and treatment. ***Level of Evidence III; Comparative Retrospective Study.***

**Keywords:** Neoplasms; Neoplasms, Malignant; Spine; Radiology; Clinical Epidemiology; Prevalence.

## *RESUMO*

*Objetivo: Descrever os parâmetros clínicos, radiológicos dos tumores malignos da coluna vertebral. Métodos: Esse é um estudo terapêutico do tipo estudo retrospectivo descritivo. A avaliação clínica incluiu idade, sexo, lesões tumorais, tratamentos e procedimentos cirúrgicos, além das complicações. A avaliação radiológica analisou exames radiográficos, tomografias computadorizadas e ressonâncias; focando em características morfopatológicas e os tratamentos empregados. Resultados: Entre os 236 pacientes avaliados, a maioria era do sexo feminino, com idades entre 6 e 91 anos. A principal queixa reportada foi a lombalgia. A abordagem cirúrgica mais utilizada foi a via de acesso posterior, incluindo fixação pelicular e descompressão do canal vertebral. A complicação mais prevalente observada foi a infecção. A maioria dos pacientes apresentava tumores primários de mama. O segmento mais frequentemente acometido da coluna vertebral foi o torácico. Ao analisar as porções da coluna vertebral afetadas, observou-se que a porção do arco posterior foi a mais comumente comprometida. Conclusão: A apresentação clínica e radiológica dos pacientes com lesões metastáticas na coluna vertebral em nossa amostra foi semelhante aos relatos da literatura. Resultados cirúrgicos alinharam-se às expectativas prévias. Nota-se a presença de sintomas iniciais, com variação nos intervalos entre sintomas, diagnóstico e tratamento.* ***Nível de Evidência III; Estudo Retrospectivo Comparativo.***

***Descritores:*** *Neoplasias; Neoplasias Malignas; Coluna Vertebral; Radiologia; Epidemiologia Clínica; Prevalência.*

**Citation:** Menezes MD, Pontes MDS, Herrero CFPS. Clinical and radiological parameters in malignant spinal tumors: a descriptive analysis. Acta Ortop Bras. [online]. 2025;33(1):Page 1 of 4. Available from URL: http://www.scielo.br/aob.

## INTRODUCTION

Cancer is considered the second leading cause of death worldwide, and the deficiency in early diagnosis and treatment results in 70% of these deaths occurring in low-income countries.[1] In Brazil, it is estimated that more than 600,000 new cases of cancer are diagnosed each year. The most common type is skin cancer, followed by breast cancer in women and prostate cancer in men.[2] Stemming from primary cancerous lesions, metastatic lesions have been showing an increasing incidence, with the spinal column being the most commonly affected site by skeletal metastasis.[3] Previous studies have identified that approximately 70% of cancer patients present some metastasis in the spinal column and that 40% of deceased patients did not exhibit symptoms resulting from the lesion.[4]

The diagnosis of the primary lesion can vary greatly, with the most common being prostate, breast, melanoma, lung, and kidney cancers[3].

All authors declare no potential conflict of interest related to this article.

***The study was conducted at Hospital das Clínicas of Ribeirão Preto Medical School (USP).***
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Article received on 04/23/2024, approved on 07/02/2024.

However, other carcinomas are also less commonly associated with spinal column metastases, such as gastrointestinal tumors and thyroid carcinoma.[3] Additionally, metastatic tumors of the spinal column have a slightly higher prevalence in men compared to women, due to the high incidence of bone involvement in prostate cancer.[3-5] All age groups can be affected, with a higher prevalence among individuals aged 40 to 65 years.[3]

The optimal treatment for patients with metastatic spinal cord injury involves a multidisciplinary approach, and while the therapeutic advances currently used yield better results, many remain as palliative goals, reducing morbidity and improving patients' quality of life.[6] Thus, although often not used as curative, spinal surgery can play an important role in treating patients with mechanical instability, progressive tumor growth, pain unresponsive to clinical measures, and neurological symptoms.[7]

The main objective of the present study is to conduct a descriptive epidemiological study of a sample of patients with spinal metastasis who underwent surgical treatment at a tertiary hospital in the public healthcare system of a low-income country. Additionally, the secondary objective emphasizes the initial symptoms of patients, as well as the time until the diagnosis of the metastatic lesion and subsequent surgical treatment.

## METHODS

### Study Protocol

This is a single-center study that involved the descriptive use of a prospective database. A total of 236 patients with confirmed spinal metastasis were included in the study and underwent surgical treatment by a group of spine surgeons at a tertiary-level public healthcare hospital in Brazil, between the years 2005 and 2017.

Ethical Considerations

The research project was approved by the Research Ethics Committee of the Institution where the study was conducted, including the waiver of the Informed Consent Form, since the use of patient data was completely anonymized and the data collection was not influenced by any treatment decisions established (protocol HC 354/2018—CAAE: 82389518.0.0000.5440).

### Patient sample

The inclusion criteria used comprised patients with a confirmed diagnosis of metastatic lesions in the spinal column, histopathologically confirmed, undergoing treatment for vertebral metastases, of both sexes, of any race and age group. The exclusion criteria included the absence of a confirmatory diagnosis of metastatic disease in the spinal column and patients who did not undergo surgical treatment.

### Data collection (studied variables)

The data were obtained by the researchers from the Medical Records Department (MRD) of the hospital, and both medical annotations and complementary exams were utilized. The clinical variables used included patient gender; age at diagnosis; patient symptoms and the time between symptom onset and definitive diagnosis of metastatic disease; the time between diagnosis and surgical treatment of the spinal column; neurological manifestations; surgical access route and techniques employed; postoperative complications; and the need for further surgical intervention. Evaluation of complementary exams involved the use of data from histopathological exams and assessment of radiological exams such as plain radiography and magnetic resonance imaging. Variables obtained from imaging exams included morpho pathological characteristics of the lesion: affected vertebral segment and level, and the portion of the vertebral body involved in the metastatic lesion.

### Statistical Analysis

The parameters were stored in a Microsoft Excel spreadsheet, and the results were presented as percentages, means, and medians.

## RESULTS

Out of the total of 236 patients included in the study from 2005 to 2017, 105 (44.49%) were male, and 131 (55.5%) were female. The age of the patients at the time of diagnosis ranged from 6 to 91 years, with a mean of 55 years. The spinal-related symptoms presented included neck pain in 14 (5.96%) patients, low back pain in 60 (25.42%), and thoracic pain in 30 (12.71%) patients. Regarding neurological manifestations, 122 (51.7%) patients had a partial deficit, and 22 (9.32%) had a complete deficit at the time of the initial evaluation.

The study of the time between the onset of spinal-related symptoms and the diagnosis of metastasis by magnetic resonance imaging revealed results ranging from 1 day to 9 years, with a mean of 70.5 days and a median of 73.5 days. The time between diagnosis and surgical treatment of the spinal column varied from 0 days to 5 months and 15 days.

Regarding the surgical procedures performed, 210 (88.98%) patients underwent a posterior approach, 14 (5.93%) patients underwent an anterior approach, and 12 (5.08%) underwent a combined approach (anterior and posterior). Of the patients undergoing a posterior approach, all were treated with pedicle fixation and vertebral canal decompression, and among these, 51 (21.62%) patients additionally underwent corpectomy and replacement with an interbody device filled with bone cement. Additionally, kyphoplasty was the technique of choice used in 5 (2.38%) patients operated on via the posterior approach. No patient underwent an isolated anterior approach, nor a combined approach with pedicle fixation and posterior decompression associated with corpectomy and replacement with an interbody device filled with bone cement.

Seventy-one (30%) patients experienced postoperative complications, with 31 (43.66%) patients diagnosed with infection, 3 (4.22%) patients with extradural hematoma, 3 (4.22%) patients with seroma or wound dehiscence, and 3 (4.22%) patients with worsened neurological deficit. Thus, 60 (25.42%) patients required a new surgical approach to treat such complications related to the initial procedure, and 2 (0.84%) patients underwent a new procedure due to tumor recurrence and resulting new symptomatic compression.

The findings of the histopathological examination revealed 39 (16.52%) patients diagnosed with metastasis resulting from primary breast cancer, such as mammary sarcoma, invasive ductal carcinoma of the breast, breast adenocarcinoma, high-grade pleomorphic mammary sarcoma, and inflammatory breast carcinoma.

The spinal column segment most affected by metastatic lesions was the thoracic segment in 123 (52.11%) patients, followed by the lumbar segment in 83 (36.16%) patients, cervical segment in 40 (16.94%) patients, and sacral segment in 13 (5.50%) patients. The most affected vertebral portion by the tumor lesion was the posterior arch portion in 183 (77.54%) patients, followed by the vertebral body in 183 (77.54%) patients.

## DISCUSSION

In Brazil, most hospitals treating patients diagnosed with cancer are not specialized and exclusive centers, especially when it comes to public healthcare facilities.[8] Thus, although accredited for high-complexity treatments, the hospital where our study was conducted is not an exclusive referral center for the treatment of cancer patients. This may explain why the epidemiological findings differ from studies previously published by specialized cancer treatment centers and their associated complications.[8]

About the methodology employed in the study, although retrospective, the patients' data were adequately obtained from detailed descriptions in the medical records of the included patients, which were available in the Medical Records Department (MRD) of the hospital. Thus, the results regarding the number of female patients (131) being greater than the number of male patients (105) are consistent with data previously published in the literature. Regarding the age of the patients at the time of diagnosis, which ranged from 6 to 91 years, our findings are in line with the literature, which indicates that the incidence of spinal metastatic lesions increases with age, being more common in patients around the fifth decade of life.[8,9]

As expected, the most prevalent primary cancer diagnosis was breast cancer in 37 (15.67%) patients, followed by prostate cancer in 27 (11.44%) patients, which also followed results previously published by other studies.[10-12] The thoracic spine was the segment most affected by secondary lesions, with 123 (52.11%) patients, followed by the lumbar segment, with 83 (36.16%) patients, and cervical, with 40 (16.94%) patients. This finding corroborates the results of the literature, where thoracic spine metastases account for 70%, and lumbar spine for 20%.[8] Similarly, the most affected vertebral portion in our patient sample was the posterior portion in approximately 77% of patients, followed by the vertebral body in nearly 34% of patients, values similar to those established by other studies.[11]

The occurrence of pain symptoms resulting from neglected metastatic lesions by healthcare professionals is a relevant aspect that corroborates our findings.[13] In our study, pain was present in 218 (92.37%) patients, while neurological deficit was present in 144 (61%) patients. Despite this, the time between the initial symptom and the diagnosis of the metastatic lesion ranged from 1 day to 9 years, which may impact patient treatment.[8]

Regarding the outcomes of surgical treatment, previous literature data indicate neurological recovery in 22.7% of patients and worsening in 2.2% of patients.[8] In our study, 66 (28%) patients showed improvement in neurological function, while 19 (8.05%) patients experienced worsening of the deficit. The study did not aim to evaluate the use of neoadjuvant or adjuvant therapy, which should be considered in each particular case by the multidisciplinary team. The choice of surgical treatment for the metastatic lesion took into account factors already described in the literature such as the primary tumor, location of the lesion in the spinal column, and the patient's overall condition.[14] Thus, in many cases, there may be a period between the diagnosis of the lesion and the performance of surgical treatment,[8] which can explain why our results regarding the time between the diagnosis of the lesion and the establishment of surgical treatment have varied from 0 days to 5 months and 15 days.

The surgical technique considered ideal is one that adequately exposes the lesion and safely removes it.[15] The choice of surgical technique was at the discretion of the hospital's spine surgery team where the study was conducted and relied on the principles of spinal canal decompression (81.35%), followed by surgical stabilization with pedicle fixation (81%), and when necessary, corpectomy associated with vertebral body replacement by an interbody device filled with bone cement (21.62%). Furthermore, 19 (8%) patients underwent vertebral body kyphoplasty procedure, which did not present complications, as it is a rapidly performed procedure and does not require long post-surgical hospitalization periods.[15]

Regarding complications arising from surgical treatment, a literature review[16] showed that the complication rate of surgical treatment for spinal metastases ranged from 10% to 52%. In the present study, 71 (30%) patients experienced postoperative complications, and 60 (25.42%) patients required further surgical intervention. These findings are consistent with the understanding that surgeries involving pedicle fixations associated with vertebral body resection and subsequent replacement have a higher rate of complications.[11]

An important detail worth mentioning is that during the study period when the patients were treated, the percutaneous pedicle fixation technique had not been implemented in the hospital where the study was conducted. We are aware that currently percutaneous fixation is an additional available tool in the treatment of patients with metastatic spinal column lesions and may yield different results from those found in our study, as it is a less invasive technique.[8]

This study has limitations that deserve mention. Despite the quality of the medical documentation from which the data were obtained, it is a retrospective study at a single high-complexity treatment center. Thus, the data regarding the prevalence of each primary lesion may be subject to sampling bias. Nevertheless, our findings were consistent with data previously published in the literature. Another limitation is the lack of specific information about the reasons why each patient waited between the diagnosis of spinal metastatic lesions and surgical treatment, which would provide crucial insights to enhance the treatment of these patients. On the other hand, we have demonstrated the importance of early symptoms and the need for greater attention to optimize diagnosis and initiate treatment promptly, despite the development of complementary technologies.

## CONCLUSION

In our sample, the clinical and radiological presentation of patients with spinal metastatic lesions varied but was similar to those previously reported in the literature, as were our surgical treatment outcomes for these patients. However, it is important to highlight the presence of early symptoms and the variable time for diagnosis and treatment of the patients.

**AUTHOR'S CONTRIBUTION:** Each author contributed individually and significantly to the development of this article. CFH: conception, the intellectual concept of the article, and surgical procedures; MD: article review and work conception; MDM: data analysis and article writing.

## REFERENCES

1. American Cancer Society. Cancer facts & figures 2019 [Internet]. Cancer.org. 2019 [cited 2019]. Available from: https://www.cancer.org/research/cancer--facts-statistics/all-cancer-facts-figures/cancer-facts-figures-2019.html
2. Instituto Nacional de Câncer (Brasil). Institucional. Rio de Janeiro: INCA; 2019 [cited 2019 Jun 3 jun]. Available from: https://www.inca.gov.br/institucional.
3. Araujo JL, Veiga JC, Figueiredo EG, Barboza VR, Daniel JW, Panagopoulos AT. Management of metastatic spinal column neoplasms--an update. Rev Col Bras Cir. 2013;40(6):508-14.
4. Wong DA, Fornasier VL, MacNab I. Spinal metástases; the obvious, the occult, and the impostors. Spine. 1990;15(1):1-4.
5. Shobeiri P, Seyedmirzaei H, Kalantari A, Mohammadi E, Rezaei N, Hanaei S. The Epidemiology of Brain and Spinal Cord Tumors. Adv Exp Med Biol. 2023;1394:19-39.
6. Gilbert RW, Kim JH, Posner JB. Epidural spinal cord compression from metastatic tumor: diagnosis and treatment. Ann Neurol. 1978;3(1):40-51.
7. Quraishi NA, Gokaslan ZL, Boriani S. The surgical management of metastatic epidural compression of the spinal cord. J Bone Joint Surg Br. 2010;92(8):1054-60.
8. Alexandre M, Santos WZ, Góes R, Gotfryd AO, Topolniak R, Meves R. Profile of patients with spine tumor operated in a South America Reference Service: epidemiological study. Coluna/Columna. 2022;21(4):e262528.

9. Chi JH, Bydon A, Hsieh P, Witham T, Wolinsky JP, Gokaslan ZL. Epidemiology and Demographics for Primary Vertebral Tumors. Neurosurg Clin N Am. 2008;19(1):1-4.
10. Daniel JW, Veiga JCE. Diretrizes no tratamento das metástases epidurais da coluna vertebral. Atualização. Arq Bras de Neurocir. 2007;26(3):93-110.
11. Pontes MD, Pires BPF, Albuquerque FP, Herrero CFS. Assessment of the posterior approach for surgical treatment of spinal metastatic breast cancer. Acta Ortop Bras. 2020;28(1):22-5.
12. Instituto Nacional de Câncer (Brasil). Estimativa 2020: Incidência de Câncer no Brasil. Rio de Janeiro: INCA; 2019. 116 p. Available from: https://www.inca.gov.br/sites/ufu.sti.inca.local/files/media/document/estimativa-2020-incidencia-de-cancer-no-brasil.pdf
13. Perrin RG, Laxton AW. Metastatic spine disease: epidemiology, pathophysiology, and evaluation of patients. Neurosurg Clin N Am. 2004;15(4):365-73.
14. Tokuhashi Y, Matsuzaki H, Oda H, Oshima M, Ryu J. A Revised Scoring System for Preoperative Evaluation of Metastatic Spine Tumor Prognosis. Spine (Phila Pa 1976). 2005;30(19):2186-91.
15. Molina C, Goodwin CR, Abu-Bonsrah N, Elder BD, De la Garza Ramos R, Sciubba DM. Posterior approaches for symptomatic metastatic spinal cord compression. Neurosurg Focus. 2016;41(2):E11.
16. Shehadi JA, Sciubba DM, Suk I, Suki D, Maldaun MV, McCutcheon IE, et al. Surgical treatment strategies and outcome in patients with breast cancer metastatic to the spine: a review of 87 patients. Eur Spine J. 2007;16(8):1179-92.

DOI: http://dx.doi.org/10.1590/1413-785220253301e285961



# PEDIATRIC FRACTURES IN A TERTIARY PUBLIC HOSPITAL: WHAT ARE WE DEALING WITH?

# FRATURAS PEDIÁTRICAS EM HOSPITAL PÚBLICO TERCIÁRIO: COM O QUE ESTAMOS LIDANDO?

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## ABSTRACT

Objective: Orthopedic trauma is significant in modern society due to its incidence and its impact on healthcare and social interactions. Concerns include the risk of permanent sequelae affecting individual development and causing social stigma. Fractures, while not the most lethal lesion, may result in physical variable disability; publications show that about 30% of children experience fractures by skeletal maturity, primarily from low-energy trauma. This study aims to identify the fracture patterns in the immature skeleton at a tertiary-level public hospital. Methods: Individuals with skeletally immature fractures of the locomotor system, treated at a tertiary-level emergency unit from January 2016 to January 2020, were included. Data collected included social characteristics, trauma origin, fracture descriptors, and treatment modality. Age groups: infant, preschool, school-age, adolescent. Trauma energy is classified as low, moderate, or high. Results: A total of 926 cases were recorded in 505 patients, with a predominance of males. The most affected bones were the radius (29.5%), humerus (24.2%), and ulna (15.8%). The metaphysis was the most common location (46.7%), followed by the diaphysis (33.2%). Falls accounted for the largest portion, at 64.7%, with the majority (364) being low-energy trauma. High-energy trauma, such as pedestrian accidents and car accidents, represented 13.7%, and of these, 54.2% were polytraumatized. Conclusion: Fractures of the forearm persist as the most common, particularly at the distal third of the radius, with males being more exposed. Climatic seasonality and cultural traits such as soccer practice have little impact on the epidemiology of fractures. The results obtained in this investigation resemble those obtained by international literature. ***Level of Evidence III; Retrospective Cohort Study.***

**Keywords:** Child; Epidemiology; Fractures, Bone; Trauma, Physical; Child Health.

## *RESUMO*

*Objetivo: O trauma ortopédico é relevante na sociedade moderna devido à incidência e ao seu impacto na saúde e nas interações sociais. As preocupações incluem o risco de sequelas permanentes afetando o desenvolvimento individual e causando estigma social. Fraturas, embora não sejam as lesões mais letais, podem resultar em incapacidade física variável, alguns estudos mostram que cerca de 30% das crianças experimentam fraturas até a maturidade esquelética, principalmente devido a traumas de baixa energia. Esse estudo tem como objetivo identificar o padrão de fraturas do esqueleto imaturo de um hospital público de nível terciário. Métodos: Foram analisados indivíduos com fraturas do sistema locomotor, imaturos esqueleticamente, tratados em uma unidade de emergência de nível terciário entre janeiro de 2016 a janeiro de 2020. Os dados coletados incluíram características sociais, do evento traumático e da fratura; grupos etários infantil, pré-escolar, escolar, adolescente; energia do trauma classificada como baixa, moderada ou alta. Resultados: 926 casos foram registrados em 505 pacientes, com predominância de homens. Os ossos mais afetados foram o rádio (29,5%), úmero (24,2%) e ulna (15,8%). A metáfise foi o local mais comum (46,7%), seguido pela diáfise (33,2%). Quedas representaram a maior parte (64,7%), sendo a maioria consideradas traumas de baixa energia. Trauma de alta energia, como acidentes com pedestres e acidentes de carro, representaram 13,7%, e destes, 54,2% foram politraumatizados. Conclusão: As fraturas do antebraço persistem como as mais comuns, particularmente no terço distal do rádio, com os homens estando mais expostos. Consideramos que a sazonalidade climática e os traços culturais, como a prática de futebol, têm pouco impacto na epidemiologia das fraturas. Os resultados obtidos nesta investigação se assemelham aos obtidos pela literatura internacional.* ***Nível de Evidência III; Estudo de Coorte Retrospectivo.***

***Descritores:*** *Criança; Epidemiologia; Fraturas Ósseas; Trauma Físico; Saúde da Criança.*

**Citation:** Almeida LL, Engel EE, Volpon JB. Pediatric fractures in a tertiary public hospital: what are we dealing with? Acta Ortop Bras. [online]. 2025;33(1):Page 1 of 5. Available from URL: http://www.scielo.br/aob.

All authors declare no potential conflict of interest related to this article.

***The study was conducted at Hospital das Clínicas of Ribeirão Preto.***

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Article received on 04/25/2024, approved on 07/17/2024.

## INTRODUCTION

Orthopedic trauma holds increasing significance in contemporary society, giving its rising incidence and significant impact on the healthcare system and social interactions. Emergency Department in U.S. register about 10 million visits on pediatric division per year, with 10 – 15% of musculoskeletal injuries.[1] Although not typically fatal, certain fractures in children may cause permanent sequelae, which can affect individual development and lead to social stigma. In Great Britain around one-third of permanent sequelae in teenagers and young adults being related to orthopedic injuries, and in USA extremity injuries secondary to motor vehicle crash accidents in paediatric population counts for 30%.[2,3]

Approximately 30% of children and adolescents will sustain some fracture by skeletal maturity, with 60% resulting from low-energy trauma.[4] In 2010 in the USA, approximately 1% of children experienced fractures requiring emergency care, incurring an average medical expense of US$7,000.00 per person, with higher costs for cases requiring surgical intervention.[5] In addition to the economic impact, fractures disrupt family dynamics, as caregivers mobilize to aid in transportation, hygiene, and medical follow-up, with an average school absence of 14 days for upper extremity fractures and about 26 days for lower limb fractures.[6] While short and long-term psychological implications have not been fully identified, motor limitations and increased dependency may exacerbate emotional stress within families, affecting the mental well-being of up to 25% of households.[7]

The epidemiology of fractures in the immature skeleton has consistent findings across international studies. Landin *et al.* (1983) noted a higher incidence among males, predominantly in fractures of the distal radius followed by hand fractures.[8] Subsequent studies corroborated these observations, with approximately 80% of cases involving fractures of the upper limbs.[9,10] However, there was some variation regarding the age of occurrence, with certain studies indicating a peak around 7 years old, while others reported around 11 years.[5,11]

Nevertheless, disparities may exist between Europeans and North American, and tropical countries due to climatic variations, cultural factors, and differing types of sports. Therefore, our study aims to investigate the specific characteristics of our population and fracture patterns to provide data for healthcare and contribute to formulation of public health policies.

## METHODS

We included skeletally immature individuals who presented fractures of the locomotor system treated at a public referral hospital from January 2016 to January 2020. The criterion used para characterize skeletal immaturity was the presence of the epiphyseal plate in the fractured bone. The inclusion criteria encompassed children or adolescents with fractures in one or more bones of the locomotor system (lower limbs, upper limbs, shoulder girdle, pelvic girdle) treated within 2 weeks after the fracture. Exclusion criteria comprised initial treatment performed at another institution, spine fractures, and incomplete data in the clinical records or radiographs. The study participants were exempted from signing the informed consent form following approval by the ethics committee (CAAE: 77303823.8.0000.5440).

History data were collected from the patient's caregiver at the time of hospital admission and included characteristics as age, weight (kg), gender, traumatic event environment, seasonality, and trauma origin, including falls, direct trauma, sports activities, pedestrian, car accidents, and polytrauma. Fracture descriptors, such as the affected bone, side, bone topography (epiphysis, metaphysis, diaphysis), exposure of the fracture focus to the external environment, associated injuries, and treatment modality (surgical or non-surgical) were obtained from physical examination and radiographs.

Age groups were classified according to Landin et al. (1983) in the following categories: infant (0 to 1 year and 11 months old), preschool (2 years to 6 years and 11 months old), school-age (7 years to 11 years and 11 months old), adolescent (12 years old and above). Trauma energy was categorized as follows: low falls less than 50 cm), moderate (falls between 50 cm and 2 m), high (falls above 2 m).[8]

### Statistical Analysis

Descriptive and inferential statistics were conducted. The variables of interest were assessed using Student's t-test for mean comparison, Pearson's chi-square test, Pearson's chi-square test with Bonferroni correction, and Fisher's exact test for association. A significance level of 5% was adopted to all tests. Data analysis was performed using IBM SPSS statistical software (version 26.0, IBM Corporation, Armonk, New York, USA).

## RESULTS

A total of 926 fractures were documented in 505 patients, with males comprising the majority (70.4% of occurrences). The overall mean age was 7.8 years (SD 3.8), with males having a mean age of 8.5 years and females 6.2 years ($p < 0.001$) (Figure 1).

Falls accounted for the largest cause, comprising 64.7% of the cases, with the majority (364) being falls of less than 50.0 cm, categorized as low-energy trauma ($p<0,001$). High-energy trauma, including pedestrian accidents and car accidents, accounted for 13.7% of cases with 54.2% of these resulting in polytrauma (Table 1). Regarding the primary mechanisms of trauma, falls emerged as the predominant cause across all ages examined, except at 16 and 17 years of age. Sports activities started to become apparent only from the age of 6 years. Incidences of car accidents remained relatively stable until around the age of 9, after which they began to rise proportionally. Accidents involving direct trauma remained constant at all ages studied, except for individuals aged 15 and older (Figure 2).

Fracture events were distinguished based on the gender of the patient and age group. It was observed that males in the preschool, school-age, and adolescent groups experienced a higher number of traumatic events compared to females ($p < 0.001$) (Figure 3). The most affected bones were the radius (29.5%), humerus (24.2%), and ulna (15.8%) ($p < 0.001$) (Figure 4). The metaphysis was the most common location (46.7%), followed by the diaphysis (33.2%). There was no predominance of fractures on the dominant side, with an equal distribution between right and left-handed individuals Additionally, no specific fracture pattern was identified with gender variation.

Regarding long bones, three primary classifications were made: epiphysis, metaphysis, and diaphysis. Metaphyseal fractures were the most common across all age groups, with highest prevalence in the preschool group (49%) and least prevalent in the adolescent group (41%). Diaphyseal fractures were more frequent in the adolescent group, accounting for 36% of cases, and less prevalent in the preschool group (14%). Epiphyseal fractures were most common in the school-age group, with 71 cases (18%), and less common in the infant population (12%) (Figure 5).

Associated injuries were observed in 7.1% of occurrences. The most common were traumatic brain injury (31%), dislocations (20%), lacerations (17%), and peripheric neurological injuries (13%) (Figure 6). Open fractures represented 7.7% of the sample, with 71 cases recorded. It was observed that 80% of fracture cases occurred during the school period. During this specific time, 53% of traumatic events occurred in the community environment, 37% at home and 9% in schools. During school vacations, 75% of events occurred in the community environment. Throughout the entire study period, 6.0% of fractures occurred in the school environment (Table 2).

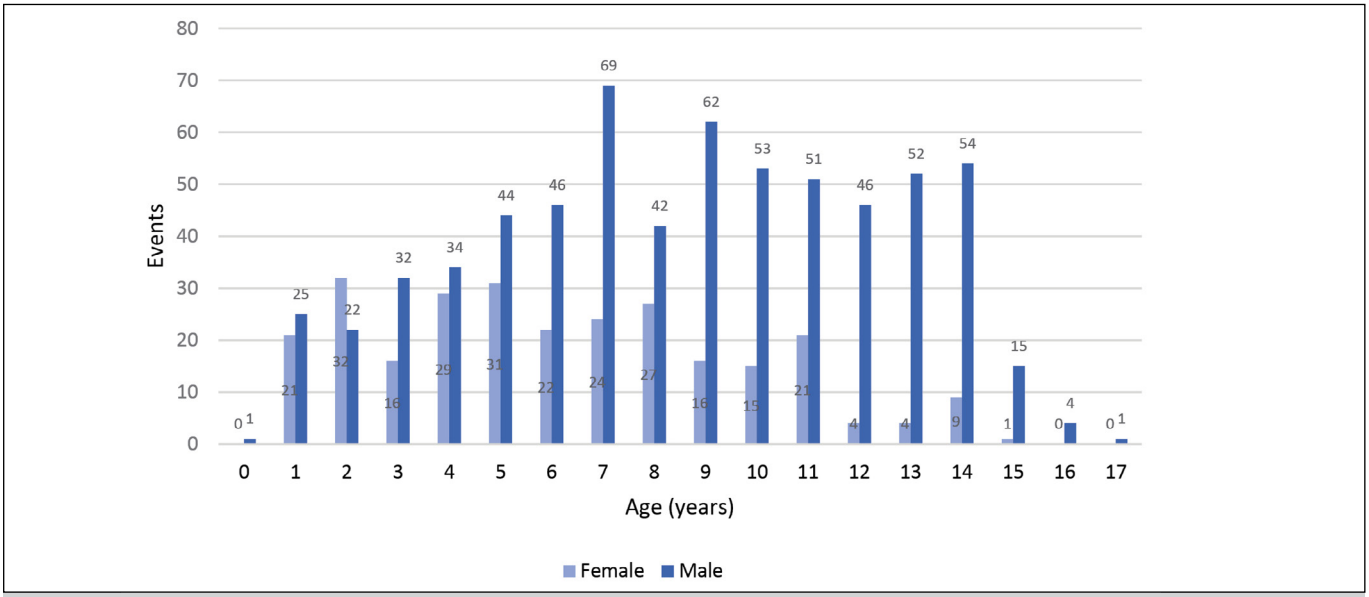


**Figure 1.** Fracture occurrence according to age demonstrates a predominance of males. After 5 years old this discrepancy becomes more increasingly evident. In boys, the significant occurrence of fractures extends up to 14 years of age and then declines. Conversely, for girls, this decline occurs around 11 years of age.

**Table 1.** Types of trauma and fractures.

| | | Total | % |
|---|---|---|---|
| Cause | Fall | 592 | 63,9 |
| | Run over | 51 | 5,5 |
| | Automobile accidents | 78 | 8,5 |
| | Daily activities | 205 | 22,1 |
| Total | | 926 | 100 |

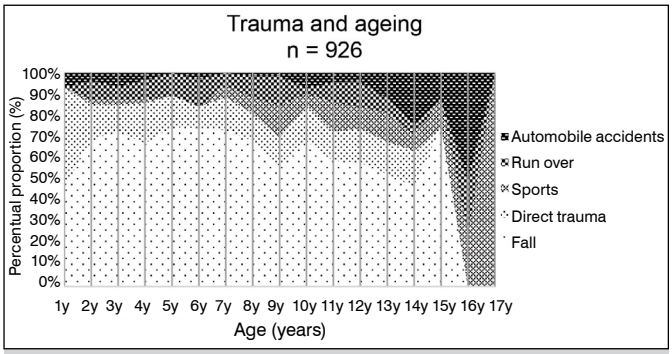


**Figure 2.** Types of trauma according to age. Overall, fractures resulting from falls were predominant. Fractures related to sports activities and car accidents were more common in older groups. Fractures caused by pedestrian accidents and direct trauma remained consistent until around 15 years of age.

Non-surgical treatment was indicated in 518 cases, representing approximately 55.9% of the sample. Among all conservatively treated fractures, only 51 (9.8%) resulted from high-energy trauma, indicating that almost 90% of conservatively treated cases originated from mild to moderate trauma. Femur fractures were predominantly managed surgically (70.2%), whereas isolated radius fractures were conservatively treated in 11% of cases ($p < 0.001$) (Figure 7). Surgical intervention was employed in 43% of combined radius and ulna fractures. Furthermore, there was a trend towards surgical management in humerus fractures (66.5%). A total of 228 cases were documented, and of these, approximately 155 were supracondylar fractures, of which 70.9% received surgical treatment.

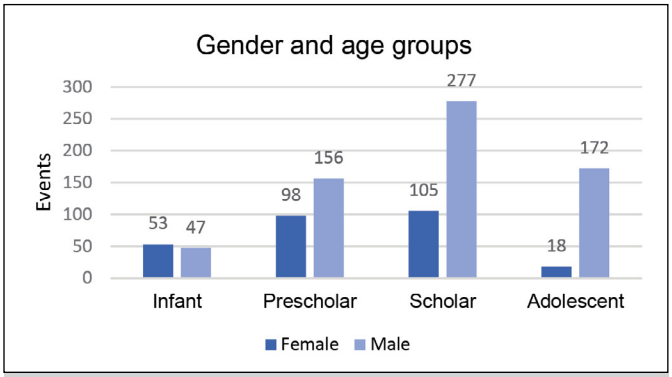


**Figure 3.** Distribution of fractures by age groups and gender.

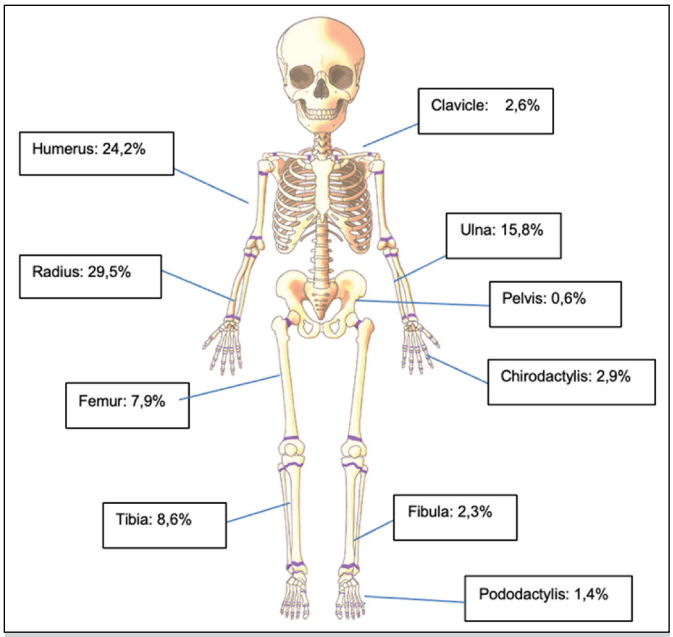


**Figure 4.** Percentage distribution of fractures. Source: Science Photo Library.

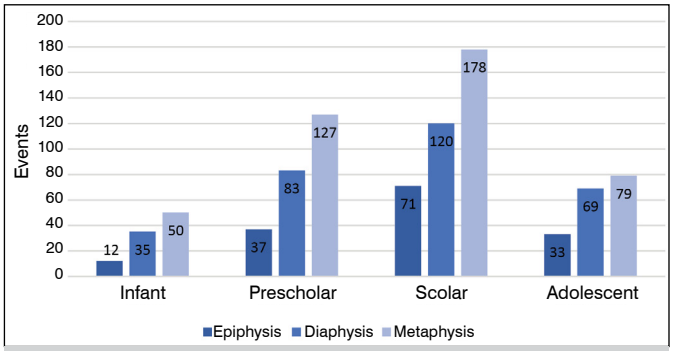


**Figure 5.** Distribution of fracture segments in relation to age group.

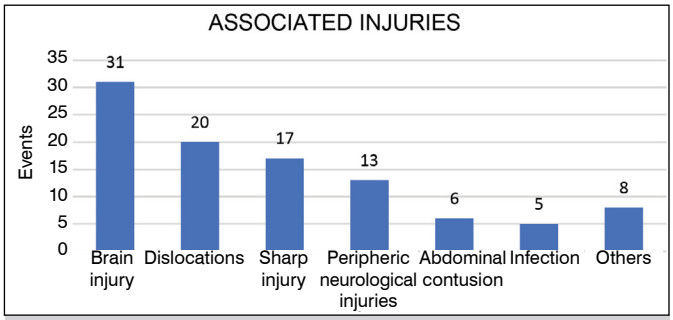


**Figure 6.** Associated injuries percentage distribution.

**Table 2.** Distribution of events according to environment and seasonality.

| Environment | Vacation | School Period | Total |
|---|---|---|---|
| Community | 140 | 400 | 540 |
| Home | 45 | 281 | 326 |
| School | 0 | 60 | 60 |
| Total | 185 | 741 | 926 |

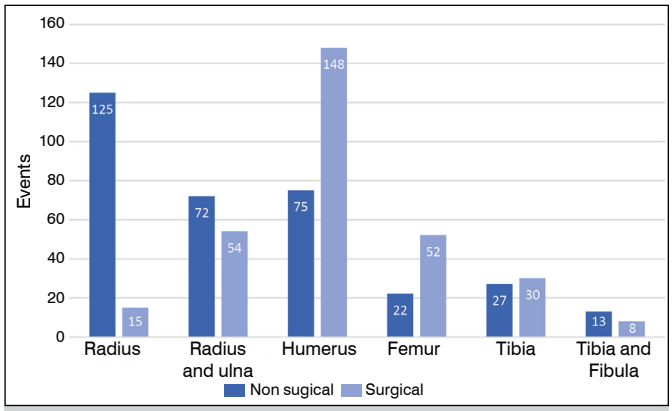


**Figure 7.** Surgical and non-surgical treatments for the long bones. The higher incidence of humerus fracture occurred at the supracondylar region.

## DISCUSSION

This study shows that forearm fractures in children persist as the most common injury, particularly highlighting the distal third of the radius, with males being more exposed than females. Simple falls proved to be the most common trauma mechanism, generally of low energy. We consider that climatic seasonality and cultural traits such as soccer practice have little impact on the epidemiology of fractures. The results obtained in this investigation resemble those obtained by authors in other countries[10,12]. However, our sample suggests a younger epidemiological peak, with the school-age group being more susceptible to traumatic events (41.3% of cases), which contrasts with studies where the highest incidence of fractures was in adolescence.[5,13] Hedström et al. (2010) justify this profile due to incentives for physical activity and greater adherence to sports practices in the adolescent population.

We hypothesize some possible justifications for our data divergence from the international literature. The increased social interaction of children in this age group, as individuals who previously had their social circle limited to family members are now exposed to other peers and activities previously unexperienced.[14] In this sense, it is worth noting the more friendly nature of latin american countries in interpersonal relationships. Another interesting aspect is progressive neuropsychomotor maturation, as around 6 years old, the child still has considerable difficulty in executing fine movements and from then on, begins to develop more complex and coordinated movements, based on an imitation pattern.[15] Unfortunately, in Brazil, there is the perception that children from low-income families have a "shortened" childhood. Data from IBGE in 2022 showed that early school dropout, even at the elementary school age, was 8.5% by age 13; for children aged 13 and older, dropout rates reach 18%. The main reason, when asked, is the need to enter the workforce or disinterest in studies, as they do not see prospects.[16]

Simple falls during recreational activities were the most common mechanism of trauma, accounting for 64.7% of the analyzed cases. We believe that this will always be the most common mechanism of trauma for childhood fractures, as positioning the hand palm-down to avoid direct contact with the face, chest, and abdomen is an instinctive and reflexive mechanism for protection. In our sample, approximately 61% of falls (364 cases) were assessed as low-energy, representing just over one-third of the cases. The complexity of neuropsychomotor development, social interactions, and morphological changes in the pediatric skeleton make it difficult to develop effective protection policies for this mechanism of trauma. We believed that soccer, a prominent feature of Brazilian culture, could impact the number of lower limb fractures, specifically ankle fractures; however, this finding was not observed. Tibia and fibula fractures combined represented about 11% of occurrences, and the epiphyseal region, characteristic of ankle torsional events, accounted for 27.5% (28 cases). Even though soccer is a sport that requires skill in the lower limbs, both soccer and other ball sports can predispose to falls, and in this case, fractures of the upper limb prevail as the most common.

A higher incidence of supracondylar humerus fractures was observed, making it the second most affected bone, representing 24.2% of the casuistry. The literature presents conflicts in this aspect, with some studies corroborating this data,[5] while others highlighting the clavicle, tibia, and fibula as more prevalent.[13] We consider that our sample may present some bias, concentrating supracondylar humerus fracture cases due to excessive difficulties associated with this fracture and, consequently, more referrals for evaluation. For these cases, in about 44% of the occurrences, surgical treatment was proposed, with supracondylar humerus fractures and femoral shaft fractures being predominantly treated in this way (approximately 70% of cases). These numbers differ from some studies where conservative treatment is more prevalent, despite the progressive increase in surgical indications.[17,18] There are questions about whether the trend toward surgical treatment results from the reception of more complex cases by the Institution or reflects a global trend of indicating surgeries more frequently for cases previously treated conservatively. Additionally, it is considered possible that families are more demanding regarding treatment outcomes, making the conservative approach less

acceptable, which previously relied on bone remodeling and tolerance for slight residual deviations that did not compromise functionality.[19]

Sudden changes in the population's lifestyle, such as the recent SARS-COVID-19 pandemic, have impacted the epidemiology of fractures, not only in the pediatric population. Social distancing, including the suspension of sports and leisure activities, resulted in a significant reduction (2.5 times) in the incidence of pediatric fractures, as shown by a recent study.[20] However, this study period was not included in our survey.

The climatic seasonality analysis was based on the perception that warm weather encouraged young people to engage in recreational and sports activities. However, an analysis revealed a variable distribution of traumatic events throughout the year, with summer months not showing an increase in case incidence. As a matter of fact, only 22% of events occurred during the school vacation months, between December and February. Unlike countries in the northern hemisphere, where climatic seasons are more defined, in our country the climate is predominantly hot and dry, reaching uncomfortable levels of heat for much of the year. In places like the USA and Ireland, where summer months coincide with school vacations, there is a cultural expectation regarding outdoor activities, reflecting increases of up to 2.5 times in fracture incidence, a fact not observed in our sample.[21]

A similar study to the proposed here conducted in Colombia concludes that upper limb fractures continue to be the most incident injury (66% of cases), citing falls from own height as the most common trauma mechanism, and that males were the most affected.[22] Colombian population have socio-cultural characteristics similar to Brazil, and no atypical epidemiological findings were observed when compared to European countries and the USA.

We conclude that seasonal and cultural aspects do not appear to have influence on the overall incidence of fractures, indicating that a child's capacity for abstraction and creativity for leisure is universal, regardless of ethnicity, family financial support, and other social aspects.

**AUTHOR'S CONTRIBUTION:** Each author contributed individually and significantly to the development of this article. LLA: writing and revision of the article; EEE: revision of the article and intellectual conception of the article; JBV: revision of the article and intellectual conception of the article.

## REFERENCES

1. Sarraff LM, Haines CJ. Common Orthopedic Injuries in the Pediatric ED Part II. Pediatr Emerg Med Rep. 2010;15(7):77-92.
2. Barker M, Power C, Roberts I. Injuries and the risk of disability in teenagers and young adults. Arch Dis Child. 1996;75(2):156-8.
3. Gaffley M, Weaver AA, Talton JW, Barnard RT, Stitzel JD, Zonfrillo MR. Age--based differences in the disability of extremity injuries in pediatric and adult occupants. Traffic Inj Prev. 2019;20(Suppl 2):S63-8.
4. Cooper C, Dennison EM, Leufkens HGM, Bishop N, van Staa TP. Epidemiology of childhood fractures in Britain: a study using the general practice research database. J Bone Miner Res. 2004;19(12):1976-81.
5. Naranje SM, Erali RA, Warner WC, Sawyer JR, Kelly DM. Epidemiology of Pediatric Fractures Presenting to Emergency Departments in the United States. J Pediatr Orthop. 2016;36(4):e45-8.
6. Kopjar B, Wickizer TM. Fractures among children: incidence and impact on daily activities. Inj Prev. 1998;4(3):194-7.
7. Stancin T, Kaugars AS, Thompson GH, Taylor HG, Yeates KO, Wade SL, et al. Child and Family Functioning 6 and 12 Months after a Serious Pediatric Fracture. J Trauma. 2001;51(1):69-76.
8. Landin LA. Fracture patterns in children. Analysis of 8,682 fractures with special reference to incidence, etiology and secular changes in a Swedish urban population 1950-1979. Acta Orthop Scand Suppl. 1983;202:1-109.
9. Rennie L, Court-Brown CM, Mok JYQ, Beattie TF. The epidemiology of fractures in children. Injury. 2007;38(8):913-22.
10. Joeris A, Lutz N, Wicki B, Slongo T, Audigé L. An epidemiological evaluation of pediatric long bone fractures - a retrospective cohort study of 2716 patients from two Swiss tertiary pediatric hospitals. BMC Pediatr. 2014;14:314.
11. Hedström E, Crnalic S, Kullström A, Waernbaum I. Socioeconomic variables and fracture risk in children and adolescents: a population-based study from northern Sweden. BMJ Open. 2021;11(10):e053179.
12. Randsborg PH. Fractures in children: Aspects on health service, epidemiology, and risk factors. Acta Orthop Suppl. 2013;84(350):1-24.
13. Hedström EM, Svensson O, Bergström U, Michno P. Epidemiology of fractures in children and adolescents. Acta Orthop. 2010;81(1):148-53.
14. Carvalho AMA, Beraldo KEA. Interação criança-criança: ressurgimento de uma área de pesquisa e suas perspectivas. Cad Pesqui. 1989;(71):55-61.
15. Chu VWT. Assessing Proprioception in Children: A Review. J Mot Behav. 2017;49(4):458-66.
16. IBGE. Pesquisa Nacional por Amostra de Domicílios Contínua - Educação 2023. Instituto Brasileiro de Geografia e Estatística. 2024. Available from: https://educa.ibge.gov.br/jovens/conheca-o-brasil/populacao/18317-educacao.html
17. Cheng JC, Ng BK, Ying SY, Lam PK. A 10-year study of the changes in the pattern and treatment of 6,493 fractures. J Pediatr Orthop. 1999;19(3):344-50.
18. Helenius I, Lamberg TS, Kääriäinen S, Impinen A, Pakarinen MP. Operative Treatment of Fractures in Children Is Increasing. A population-based study from Finland. J Bone Joint Surg. 2009;91(11):2612-6.
19. Volpon JB. Osteossíntese das fraturas diafisárias da criança com hastes intramedulares flexíveis. Rev Bras Ortop (Sao Paulo). 2008;43(7):261-70.
20. Bram JT, Johnson MA, Magee LC, Mehta NN, Fazal FZ, Baldwin KD, et al. Where Have All the Fractures Gone? The Epidemiology of Pediatric Fractures during the COVID-19 Pandemic. J Pediatr Orthop. 2020;40(8):273-9.
21. Masterson E, Borton D, O'Brien T. Victims of our climate. Injury. 1993;24(4):247-8.
22. Martínez-Cano JP, Zamudio-Castilla L, Mantilla JC, Caicedo DC, Vernaza Obando D, Martínez Rondanelli A. Fracturas en niños: experiencia en un centro de alta complejidad del suroccidente Colombiano. Salud UIS. 2019;51(4):309-15.

DOI: http://dx.doi.org/10.1590/1413-785220253301e276452



# IMPACT OF COVID-19 ON HAND AND WRIST ORTHOPEDIC SURGERIES IN A PRIVATE SERVICE

# IMPACTO DA COVID-19 NAS CIRURGIAS ORTOPÉDICAS DE MÃO E PUNHO EM SERVIÇO PRIVADO

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## ABSTRACT

Objective: Evaluate the impact of COVID-19 on elective and emergency hand and wrist surgeries operated in a private orthopedic center. Methods: A retrospective study included hand and wrist surgeries in a private orthopedic center. The total surgeries were computed and separated into elective or emergency surgeries. The numbers were analyzed by month, quarter, and year before and after the pandemic (March 2020). Results: Eight hundred and forty-three surgeries from March 2018 to February 2022 were included. The mean monthly cases of the initial 12 months of the pandemic (15.3) were statistically equal to previous periods (17.3 and 17.2), but the period from March 2021 to February 2022 showed an increase (20.5; p = 0.037). The first four months of the pandemic had a mean (8.3) lower than the previous period (14.0; p = 0.002), but soon there was a significant increase in the following four months (19.3; p = 0.002). As a historical standard, elective surgeries were greater than an emergency in this institution. Still, in the first two quarters of the pandemic, there was a reduction in elective cases, equaling the emergency. Conclusion: An important but relatively brief impact on surgical volume was observed in hand and wrist surgeries during COVID-19. A significant reduction in elective cases happened at the pandemic's beginning followed by a fast recovery after four months. ***Nível de Evidência II; Estudo Retrospectivo.***

**Keywords:** COVID-19; Hand Injuries; Wrist Injuries; Elective Surgical Procedures; Emergency Treatment.

## *RESUMO*

*Objetivo: Avaliar o impacto da COVID-19 em cirurgias eletivas e emergenciais de mão e punho realizadas em um centro ortopédico privado. Métodos: Foi realizado um estudo retrospectivo que incluiu cirurgias de mão e punho em um centro ortopédico privado. Todas as cirurgias foram computadas e classificadas como eletivas ou de emergência. Os números foram analisados por mês, trimestre e ano antes e depois da pandemia (março de 2020). Resultados: Foram incluídas 843 cirurgias de março de 2018 a fevereiro de 2022. A média de casos mensais dos 12 meses iniciais da pandemia (15,3) foi estatisticamente igual aos períodos anteriores (17,3 e 17,2), mas o período de março de 2021 a fevereiro de 2022 apresentou um aumento (20,5; p = 0,037). Os primeiros quatro meses da pandemia tiveram uma média (8,3) menor do que o período anterior (14,0; p = 0,002), entretanto, logo houve um aumento significativo nos quatro meses seguintes (19,3; p = 0,002). Como um padrão histórico, as cirurgias eletivas foram maiores do que as emergenciais nessa instituição. Ainda assim, nos dois primeiros trimestres da pandemia, houve uma redução nos casos eletivos, igualando-se à emergência. Conclusão: Um impacto importante, mas relativamente curto, no volume cirúrgico foi observado nas cirurgias de mão e punho durante a COVID-19. Uma redução significativa nos casos eletivos ocorreu no início da pandemia, seguida de uma rápida recuperação após quatro meses.* ***Nível de Evidência II; Estudo Retrospectivo.***

***Descritores:*** *COVID-19; Traumatismos da Mão; Traumatismos do Punho; Procedimentos Cirúrgicos Eletivos; Tratamento de Emergência.*

**Citation:** Wataya EY, Rodriguez KVT, Macedo LS, Escudero RB, Sorrenti L, Althoff BF, Herrera AKA, Rodrigues MP, Costa AC, Saito M, Nakamoto JC. impact of Covid-19 on hand and wrist orthopedic surgeries in a private service. Acta Ortop Bras. [online]. 2025;33(1):Page 1 of 5. Available from URL: http://www.scielo.br/aob.

## INTRODUCTION

The coronavirus pandemic (COVID-19) has disrupted health services worldwide, testing service's physical and administrative infrastructure, especially in developing countries.[1]

Orthopedic services, in particular, were obliged to reorganize themselves at all levels of activity, from adopting new safety protocols and use of personal and collective protective equipment to restructuring the flows and processes of all wards of clinics and

All authors declare no potential conflict of interest related to this article.

***The study was conducted at Instituto Vita, São Paulo, SP, Brazil.***
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Article received on 07/10/2023, approved on 02/16/2024.

hospitals, passing through emergency rooms to infirmaries and intensive care units.[2-4]

The demand for orthopedic care during COVID-19 generally decreased during the stricter restriction, but trauma and orthopedic involvement continued to demand attention from services.[5,6] This reduction in cases mainly affected the elective surgeries rate.[3] Emergency surgeries, such as fractures and infection, continued to occur, but with a reduced number.[7]

The reduction in surgeries also influenced resident physician's and subspecialist's training. As a result, school hospitals responsible for education and training had to create alternative ways to meet this lack of demand, such as electronic teaching and telemedicine.[8,9]

The objective of this study is to evaluate the impact of COVID-19 on elective and emergency hand and wrist surgeries performed by the Hand Surgery and Microsurgery group in a private orthopedic center in São Paulo – Brazil.

## MATERIAL AND METHODS

A cross-sectional study was performed, with retrospective data collection from the medical records of patients treated at a large private orthopedic service in São Paulo – Brazil, submitted to elective or emergency surgery by the Hand and Microsurgery group from March 2018 to February 2022. This study was evaluated and approved by the Institution Research Ethics Committee (CAAE: 67277423.6.0000.5474).

The number of surgeries performed during COVID-19 (March 2020 to February 2022) was compared with those in the previous two years (March 2018 to February 2020), a period without interference from the pandemic. The data used was age, gender, and date of the procedures performed (elective and emergency) and were analyzed through electronic medical records.

The variables evaluated were presented in tables with absolute and relative frequency distribution. The descriptive analysis was performed in addition to means between the two groups and was compared using the Student's t-test. A specific three-month moving mean was calculated by the mean number of surgeries from the previous two months and the corresponding month. This mitigates the data by creating a constantly updated mean number and mitigates the impacts of short-term random fluctuations. The significance level adopted was 95%, and the tests were performed in the SPSS software.

## RESULTS

From March 2018 to February 2020 (pre-pandemic period), the total elective surgery was 284, and emergency was 130, totaling 414. Between March 2020 and February 2022 (during the pandemic), the elective surgery was 312, and emergency was 117, totaling 429. Throughout the period (2018–2022), the mean age of the operated patients was 45 years, and 49% were women.

Figure 1 shows the monthly distribution of operated cases, and Figure 2 shows the distribution of surgeries classified as elective

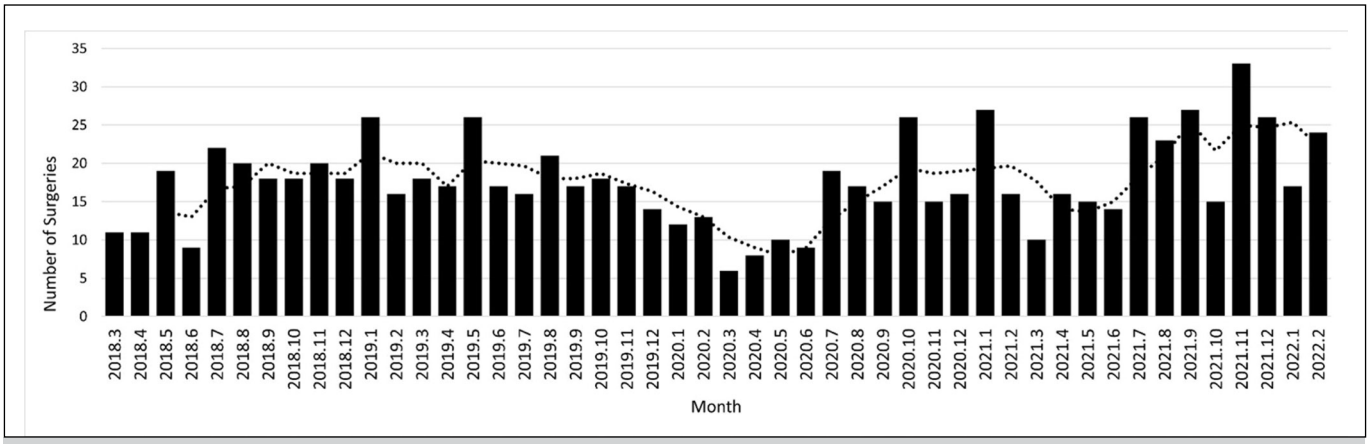


**Figure 1.** Total number of surgeries performed in different quarters two years before and two years after the onset of COVID-19. The bars represent the number of surgeries, and the dotted line represents the 3-month moving mean.

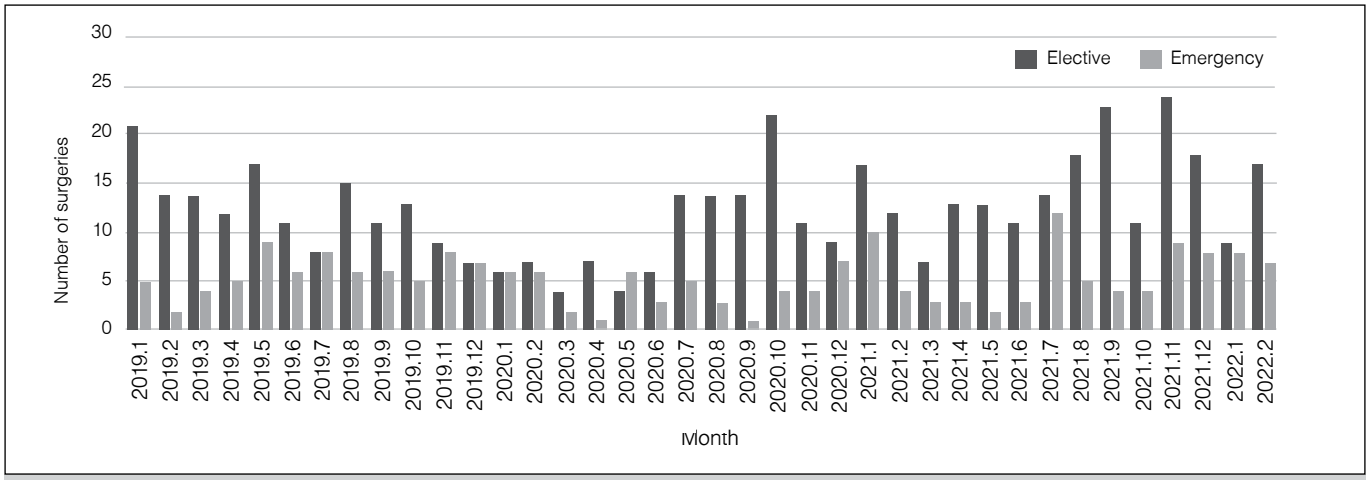


**Figure 2.** Number of surgeries performed in different quarters two years before and two years after the onset of COVID-19 divided into elective surgeries (dark bars) and emergency surgeries (light bars).

or emergency. The qualitative analysis of surgeries throughout the period shows that historically there has been an oscillation in surgeries over the months, but it shows two periods of most considerable reduction, both during the pandemic, between December 2019 and June 2020, and March 2021 and June 2021.
The cumulative numbers of surgery performed 12 months before (March 2019 – February 2020) and 12 months after the pandemic (March 2020 – February 2021) show a similarity of elective surgeries (130 vs. 134, respectively) but a reduction in emergency surgeries (76 vs. 50, respectively).
The mean monthly surgeries during the entire period evaluated was 17.6. There was no statistical difference ($p = 0.348$) between the mean monthly surgeries two years before the pandemic (March 2018 – February 2020), with 11.8 surgeries per month, compared to two years during the pandemic (March 2020 – February 2022), with 13 surgeries per month (Table 1). The month with the lowest number of surgeries was March 2020, with six surgeries. The month with the highest number of surgeries was November 2021, with 27 surgeries.
The discriminative analysis between emergency vs. elective surgeries (Figure 2) demonstrated that the elective surgeries was historically higher than emergency, except for November 2018 (9 vs. 11), July 2019 (8 to 8), December 2019 (7 to 7), January 2020 (6 to 6), and May 2020 (4 to 6).
The quarterly analysis of the mean number of surgeries (Table 1) showed that the most critical period in relation to the reduction in surgical volume was the first four months of the pandemic (between March 2020 and June 2020), with a mean of 8.3 surgeries, with a statistical difference ($p < 0.05$) with all other 4-month periods, except the beginning of 2018 (March 2018 – June 2018, $p = 0.062$)
The analysis of the mean annual surgeries per month (Table 1) showed a tendency to maintain the mean in 2018 (17.3), 2019 (17.2), and 2020 (15.3), with a subsequent increase in 2021, which had a mean monthly of 20.5 surgeries ($p = 0.037$).

The comparison between the number of elective and emergency surgeries performed in different periods of four months, one year, and two years before and two years after the beginning of COVID-19 is shown in Table 2. All comparisons in the 4-month periods had significant differences, except for November 2019 to February 2020 ($p = 0.552$), March 2020 to June 2020 (0.144), and November 2021 to February 2022 ($p = 0.060$). The comparisons year by year and every two years (period before and during COVID-19) were also statistically significant.

## DISCUSSION

COVID-19 interfered with health systems worldwide by prioritizing the treatment of large numbers of patients with often severe clinical respiratory demands and by generating greater attention to prevention measures regarding respiratory isolation in the general population. Consequently, medical services in surgical areas initially significantly reduced admissions and the volume of surgeries in adults and children in several countries.[10,11]
This need for a higher attention to the respiratory condition may have also decreased the number of orthopedic surgeries. Blum et al.,[6] in a systematic review, also concluded that there was a reduction not only in consultations or elective and emergency visits but also in the general trauma surgeries (around 21.2% to 66.7%) and even more in elective surgeries (33.3% to 100%) during the pandemic period. In Brazil, the reduction in surgical volume during the highest period of the pandemic occurred mainly in the Unified Health System (SUS). In nine months there was a reduction of about 46% in elective surgeries attributed to COVID-19.[12]
As demonstrated in our study, during the first two years of COVID-19 in Brazil, considering the reality of the service in question, there was an important change in the flow of surgeries in the hand surgery subspecialty, but only occasionally, in the first four months following

**Table 1.** Comparison between surgeries performed in different periods of four months, one year, and two years, two years before and two years after the onset of COVID-19.

| | Mean ± SD | p-value vs. Mar20 – Jun20 | p-value vs. Mar20 –Feb21 | p-value vs. Previous period |
|---|---|---|---|---|
| **Period of 4 months** | | | | |
| Mar18 – Jun18 | 12.5 ± 4.4 | 0.062 | na | na |
| Jul18 – Oct18 | 19.5 ± 1.9 | < 0.001 | na | 0.014 |
| Nov18 – Feb19 | 20.0 ± 4.3 | 0.001 | na | 0.420 |
| Mar19 – Jun19 | 19.5 ± 4.4 | 0.001 | na | 0.438 |
| Jul19 – Oct19 | 18.0 ± 2.2 | < 0.001 | na | 0.280 |
| Nov19 – Feb20 | 14.0 ± 2.2 | 0.002 | na | 0.003 |
| Mar20 – Jun20 | 8.3 ± 1.7 | - | na | 0.020 |
| Jul20 – Oct20 | 19.3 ± 4.8 | 0.002 | na | 0.002 |
| Nov20 – Fen21 | 18.5 ± 5.7 | 0.007 | na | 0.423 |
| Mar21 – Jun21 | 13.8 ± 2.6 | 0.006 | na | 0.090 |
| Jul21 – Oct21 | 22.8 ± 5.4 | 0.001 | na | 0.012 |
| Nov21 – Feb22 | 25.0 ± 6.6 | 0.001 | na | 0.309 |
| **Period of 1 year** | | | | |
| Mar18 – Feb19 | 17.3 ± 4.9 | na | 0.204 | na |
| Mar19 – Feb20 | 17.2 ± 3.7 | na | 0.205 | 0.463 |
| Mar20 – Feb21 | 15.3 ± 6.6 | na | na | 0.205 |
| Mar21 – Feb22 | 20.5 ± 6.9 | na | 0.037 | 0.037 |
| **Period of 2 years** | | | | |
| Mar18 – Feb20 | 11.8 ± 3.7 | na | na | na |
| Mar20 – Feb22 | 13.0 ± 5.6 | na | na | 0.348 |

SD: Standard deviation

**Table 2.** Comparison between the number of elective vs. emergency surgeries performed in different periods of four months, one year, and two years, two years before and two years after the onset of COVID-19.

| | Electives Mean ± SD | Urgency Mean ± SD | p-value |
|---|---|---|---|
| **Period of 4 months** | | | |
| Mar18 – Jun18 | 10.3 ± 2.5 | 2.3 ± 2.6 | 0.005 |
| Jul18 – Oct18 | 14.0 ± 2.6 | 5.5 ± 1.9 | 0.002 |
| Nov18 – Feb19 | 14.3 ± 5.0 | 5.8 ± 3.8 | 0.037 |
| Mar19 – Jun19 | 13.5 ± 2.6 | 6.0 ± 2.2 | 0.005 |
| Jul19 – Oct19 | 11.8 ± 3.0 | 6.3 ± 1.3 | 0.027 |
| Nov19 – Feb20 | 7.3 ± 1.3 | 6.8 ± 1.0 | 0.552 |
| Mar20 – Jun20 | 5.3 ± 1.5 | 3.0 ± 2.2 | 0.144 |
| Jul20 – Oct20 | 16.0 ± 4.0 | 3.3 ± 1.7 | 0.004 |
| Nov20 – Fen21 | 12.3 ± 3.4 | 6.3 ± 2.9 | 0.037 |
| Mar21 – Jun21 | 11.0 ± 2.8 | 2.8 ± 0.5 | 0.009 |
| Jul21 – Oct21 | 16.5 ± 5.2 | 6.3 ± 3.9 | 0.022 |
| Nov21 – Feb22 | 17.0 ± 6.2 | 8.0 ± 0.8 | 0.060 |
| **Period of 1 year** | | | |
| Mar18 – Feb19 | 12.8 ± 3.7 | 4.5 ± 3.1 | < 0.001 |
| Mar19 – Feb20 | 10.8 ± 3.5 | 6.3 ± 1.4 | 0.001 |
| Mar20 – Feb21 | 11.2 ± 5.5 | 4.2 ± 2.6 | 0.001 |
| Mar21 – Feb22 | 14.8 ± 5.3 | 5.7 ± 3.1 | < 0.001 |
| **Period of 2 years** | | | |
| Mar18 – Feb20 | 11.8 ± 3.7 | 5.4 ± 2.5 | < 0.001 |
| Mar20 – Feb22 | 13.0 ± 5.6 | 4.9 ± 2.9 | < 0.001 |

SD: Standard deviation

the decree of the World Health Organization that confirmed that we were facing a pandemic.

Certainly, the reasons for certain services to present a more or less significant reduction in the surgical volume were diverse and heterogeneous. However, we can draw a parallel between the surgical volume curve and the epidemiological situation experienced in the city where the work was performed (Figure 3). This analysis suggests an inversely proportional relationship between the periods of lower volume of surgeries with the period of stricter restriction.

local health scenario, which at that time was experiencing a gradual reopening and was heading for a vaccination rate (1st dose) of 50% of the eligible population, which occur in August 2021, reaching the mark of 80% of the country's population at the end of December 2021. The timeline shown in Figure 3 illustrates the epidemiological scenario of COVID-19 in the state where this study was performed, the first and most affected by the pandemic in the country.

The limitations of this study start with the specificity of the study in a single center, so we must be careful in extrapolating these

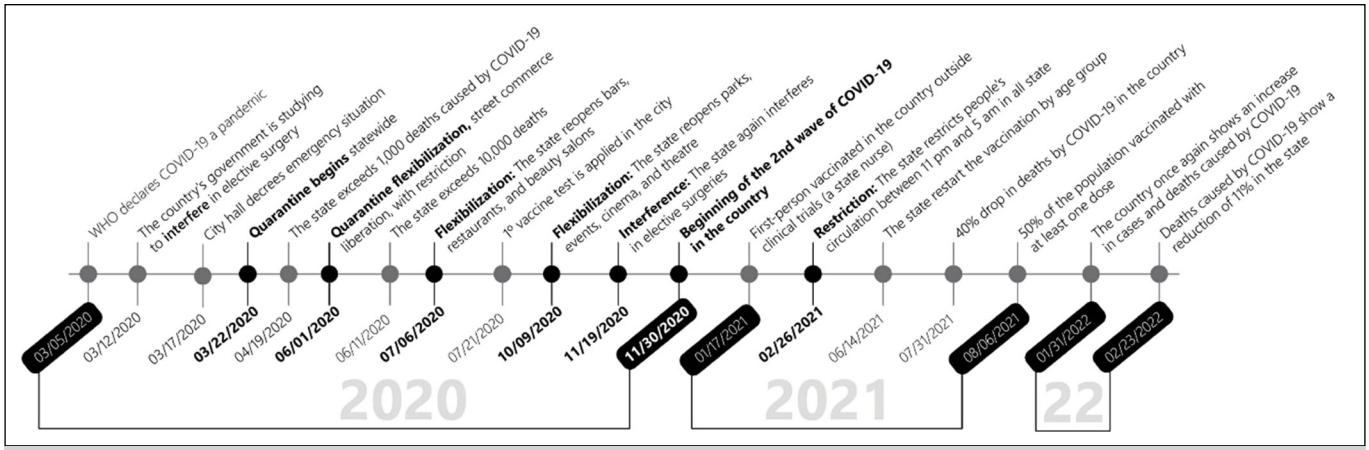


**Figure 3.** COVID-19 timeline in the state where work was performed.

The reduction in the mean monthly surgeries in the first four months of the pandemic was similar to other studies.[5,6] However, in our study, this tendency did not continue in the subsequent months, including a demand similar to the two pre-pandemic years. Possibly, the fact that our institution did not directly serve patients with respiratory demand, combined with the effectiveness of organizational measures and administrative flows, made it possible that the reduction in surgical volume did not occur sustainably. In addition, the type of health service may have had a great influence on the rapid recovery of these numbers since it may have been seen as a place of safety for patients with orthopedic demand who did not want to be exposed to hospitals that were treating cases of COVID-19.[2]

The higher period of surgeries in the institution among the four years evaluated was after July 2021. We can also contextualize with the results. Still, we must remember that the occasional fluctuation in the number of cases can also occur due to other factors, population vacation periods, and habitual seasonality of certain pathologies, among others.

## CONCLUSION

Our study showed a significant reduction in surgeries at the beginning of the pandemic, with elective surgeries most affected. However, after four months, there was already a quick recovery, and the numbers were re-established. COVID-19 was a major organizational challenge for health services in all countries. However, we showed a rapid recovery in a private institution with exclusive performance in orthopedics, showing the importance of the flow of the demands of the cases studied.

**AUTHOR'S CONTRIBUTION:** Each author made significant individual contributions to the development of this manuscript. EYW: conceptualization, data curation, formal analysis, investigation, methodology, project administration; supervision; validation; writing - original draft; writing - review & editing; KVTR: conceptualization, data curation, investigation, methodology; writing - review & editing; LSM: data curation, investigation, methodology, project administration; resources; writing - original draft; writing - review & editing; RBE: conceptualization, writing - review & editing; LS: conceptualization, writing - review & editing; BFA: conceptualization, writing - review & editing; AKAH: conceptualization, writing - review & editing; MPR: conceptualization, writing - review & editing; ACC: conceptualization, writing - review & editing; MS: conceptualization, writing - review & editing; methodology, project administration; supervision; validation; JCN: conceptualization, writing - review & editing; methodology, project administration; supervision; validation.

## REFERENCES

1. Mazingi D, Navarro S, Bobel MC, Dube A, Mbanje C, Lavy C. Exploring the Impact of COVID-19 on Progress Towards Achieving Global Surgery Goals. World J Surg. 2020;44(8):2451-7. doi: 10.1007/s00268-020-05627-7.
2. Mariani NM, Ceretti AP, Fedele V, Barabino M, Nicastro V, Giovenzana M, et al. Surgical Strategy During the COVID-19 Pandemic in a University Metropolitan Hospital in Milan, Italy. World J Surg. 2020;44(8):2471-6. doi: 10.1007/s00268-020-05595-y.
3. Liebensteiner MC, Khosravi I, Hirschmann MT, Heuberer PR, Board of the AGA-Society of Arthroscopy and Joint-Surgery, Thaler M. Massive cutback in orthopaedic healthcare services due to the COVID-19 pandemic. Knee Surg Sports Traumatol Arthrosc. 2020;28(6):1705-11. doi: 10.1007/s00167-020-06032-2.
4. de Caro F, Hirschmann MT, Verdonk P. Returning to orthopaedic business as usual after COVID-19: strategies and options. Knee Surg Sports Traumatol Arthrosc. 2020;28(6):1699-704. doi: 10.1007/s00167-020-06031-3.
5. Wong JSH, Cheung KMC. Impact of COVID-19 on Orthopaedic and Trauma Service: An Epidemiological Study. J Bone Joint Surg Am. 2020;102(14):e80. doi: 10.2106/JBJS.20.00775.
6. Blum P, Putzer D, Liebensteiner MC, Dammerer D. Impact of the Covid-19 Pandemic on Orthopaedic and Trauma Surgery - A Systematic Review of the Current Literature. In Vivo. 2021;35(3):1337-43. doi: 10.21873/invivo.12386.
7. Thaler M, Khosravi I, Hirschmann MT, Kort NP, Zagra L,Epinette JA, et al. Disruption of joint arthroplasty services in Europe during the COVID-19 pandemic: an online survey within the European Hip Society (EHS) and the European Knee Associates (EKA). Knee Surg Sports Traumatol Arthrosc. 2020;28(6):1712-9. doi: 10.1007/s00167-020-06033-1.

8. Megaloikonomos PD, Thaler M, Igoumenou VG, Bonanzinga T, Ostojic M, Couto AF, et al. Impact of the COVID-19 pandemic on orthopaedic and trauma surgery training in Europe. Int Orthop. 2020;44(9):1611-9. doi: 10.1007/s00264-020-04742-3.
9. Adesunkanmi AO, Ubom AE, Olasehinde O, Wuraola FO, Ijarotimi OA, Okon NE, et al. Impact of the COVID-19 Pandemic on Surgical Residency Training: Perspective from a Low-Middle Income Country. World J Surg. 2021;45(1):10-7. doi: 10.1007/s00268-020-05826-2.
10. Dick L, Green J, Brown J, Kennedy E, Cassidy R, Othman S, et al. Changes in Emergency General Surgery During Covid-19 in Scotland: A Prospective Cohort Study. World J Surg. 2020;44(8):3590-4. doi: 10.1007/s00268-020-05760-3.
11. Park P, Laverde R, Klazura G, Yap A, Bvulani B, Ki B, et al. Impact of the COVID-19 Pandemic on Pediatric Surgical Volume in Four Low- and Middle-Income Country Hospitals: Insights from an Interrupted Time Series Analysis. World J Surg. 2022;46(5):984-93. doi: 10.1007/s00268-022-06503-2.
12. Frio GS, Russo LX, de Albuquerque CP, da Mota LMH, Barros-Areal AF, Oliveira APRA, et al. The disruption of elective procedures due to COVID-19 in Brazil in 2020. Sci Rep. 2022;12(1):10942. doi: 10.1038/s41598-022-13746-5.

DOI: http://dx.doi.org/10.1590/1413-785220253301e285052



# BEST PROSTHESIS FOR UNICOMPARTMENTAL KNEE ARTHROSIS: FIXED OR MOBILE?

# MELHOR PRÓTESE PARA ARTROSE UNICOMPARTIMENTAL DO JOELHO: FIXO OU MÓVEL?

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## ABSTRACT

This study aimed to compare fixed-bearing and mobile-bearing knee unicompartmental arthroplasty implants in adults (in the medial compartment) to determine which is better for each patient and their particularities. The research focused on post-operative assessments with a follow-up of at least a 2-year, examining both quality of life and mid-term functionality in the medium term. A systematic keyword search was executed in the PubMed, EMBASE, and Cochrane databases, employing a filter for randomized clinical trials and without language limitations. The search yielded 113 articles from March 28, 2024, including 83 from PubMed, 12 from EMBASE, and 18 from the Cochrane Library. The study found insufficient evidence to establish the superiority of one prosthetic type over the other regarding post-operative function, pain, complications, revisions, and quality of life after a 2-year follow-up. Literature highlights uncertainties in comparing UKA types due to varied assessment tools. No conclusive evidence favors either type regarding post-op function, pain, complication rates, revisions, or quality of life after 2 years. Urgent need for standardized, long-term, multicenter studies to inform evidence-based clinical practice. ***Level of Evidence I; Systematic review of randomized controlled trials.***

**Keywords:** Arthroplasty; Knee Joint; Prostheses and Implants; Weight-Bearing.

## *RESUMO*

*Este estudo teve como objetivo comparar os implantes de artroplastia unicompartimental do joelho, fixos e móveis, em adultos (no compartimento medial), para determinar qual é melhor para cada paciente e suas particularidades. A pesquisa concentrou-se em avaliações pós-operatórias com um acompanhamento de pelo menos 2 anos, examinando tanto a qualidade de vida quanto a funcionalidade a médio prazo. Foi realizada uma busca sistemática de palavras-chave nas bases de dados PubMed, EMBASE e Cochrane, empregando um filtro para ensaios clínicos randomizados, e sem limitações de idioma. A busca resultou em 113 artigos a partir de 28 de março de 2024, incluindo 83 do PubMed, 12 do EMBASE e 18 da biblioteca Cochrane. O estudo encontrou evidências insuficientes para estabelecer a superioridade de um tipo de prótese sobre o outro em termos de função pós-operatória, dor, complicações, revisões e qualidade de vida após um acompanhamento de 2 anos. A literatura destaca incertezas na comparação entre os tipos de artroplastia unicompartimental de joelho devido a ferramentas de avaliação variadas. Não há evidências conclusivas que favoreçam um dos tipos em relação à função pós-operatória, dor, taxas de complicações, revisões ou qualidade de vida após 2 anos. Há uma necessidade urgente de estudos padronizados, de longo prazo e multicêntricos para informar a prática clínica baseada em evidências.* ***Nível de Evidência I; Revisão sistemática de ensaios clínicos randomizados e controlados.***

***Descritores:*** *Artroplastia; Articulação do Joelho; Próteses e Implantes; Suporte de Carga.*

**Citation:** Cardoso FL, Gomez DCS, Severino FR, Fucs PMMB. Best prosthesis for unicompartmental knee arthrosis: fixed or mobile? Acta Ortop Bras. [online]. 2025;33(1):Page 1 of 9. Available from URL: http://www.scielo.br/aob.

## INTRODUCTION

The knee is considered the most complex joint in the human body, defined as a synovial hinge joint.[1] It consists of three articulations: the medial tibiofemoral joint, the lateral tibiofemoral joint, and the patellofemoral joint.[1] Its stability relies on the ligaments that connect the femur and tibia, as well as the force and action of the adjacent muscles and their tendons.

Like other joints in the human body, the knee is a strong candidate to undergo degenerative processes, either due to overload or the natural course of aging.[2] Osteoarthritis or degenerative joint disease (called gonarthrosis when it affects the knee) is clinically characterized by protokinetic pain, claudication, morning stiffness, deformity, and joint enlargement resulting from the interaction between biological and mechanical factors on the articular cartilage,

All authors declare no potential conflict of interest related to this article.

***The study was conducted at Department of Orthopedics and Traumatology of Santa Casa de Misericórdia de São Paulo, "Pavilhão Fernandinho Simonsen" (Director – Prof. Dr. Maria Fernanda Silber Caffaro).***
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Artigo recebido em 03/28/2024, aprovado em 06/13/2024.

subchondral bone, and synovial fluid.[2] Radiographically, a reduction in joint space, subchondral sclerosis, bone cysts, and osteophytes are observed.

The condition is considered multifactorial, and among the intrinsic and extrinsic factors that contribute to its development are: age over 60 years (most important), female sex, obesity (most important modifiable factor), genetic predisposition, race, diet, bone metabolism, associated inflammatory or endocrinometabolic comorbidities, activity, occupation, joint/bone, strength, and alignment.[3] Etiologically, gonarthrosis can be classified as primary or secondary. If there is no well-established known cause, it is called primary, which results from a degenerative process linked to aging; if there is a known cause, it is then referred to as secondary osteoarthritis.

Gonarthrosis can be systematically divided into three types:[4] I) Inflammatory, resulting from osteoarthritis (a degenerative inflammatory process or due to inflammatory or infectious arthritis, where the subchondral bone lesion is the most relevant); II) Post-Traumatic, which occurs as a consequence of traumas that damage the joint surface, such as fractures and osteochondritis (where the cartilage is most affected); and III) Mechanical, which is a result of axis deviations or joint instabilities, affecting both the cartilage and the subchondral bone.

Although there is a profound understanding of the physiopathology of osteoarthritis, little is still known about the genesis of pain in these patients at the molecular level. Fundamentally, it is known that the possible causes of pain are related to increased intraosseous pressure due to vascular congestion of the subchondral bone, synovitis and inflammation, capsular fibrosis, osteophyte growth, muscle contracture, and weakness.[5] The maintenance of chronic pain seems to involve both the central and peripheral nervous systems. Initially, hypersensitivity is observed only at the affected site, then mechanisms of central and peripheral sensitization come into play, contributing to the maintenance of painful conditions, independent of the peripheral process that originated the pain, making it refractory.[5,6]

Refractory pain to clinical treatment, non-pharmacological measures (intra-articular injection of hyaluronic acid, shockwave therapy, physiotherapy, among others), or surgical procedures (such as knee arthroscopy, synovectomies, osteotomies, among others) are the main factors that lead to the indication for knee arthroplasty.[7]

Similar to other joints, the knee can also develop a form of osteoarthritis resulting from the progression of muscular imbalance[2], which stimulates the development of a mechanical type of osteoarthritis with well-defined characteristics. Specifically in the knee, this condition affects the medial compartment, promoting a varus deformity[4], and in the absence of treatment, the degenerative process evolves progressively.

Arthroplasties aim to relieve pain, correct deformities, improve joint motion, and enhance quality of life[7]. Unicompartmental knee arthroplasty (UKA) has been performed since the early 1970s,[8] with advancements in implant design and surgical techniques in recent decades improving outcomes. UKA is indicated for localized knee degeneration, maintaining ACL integrity and limb alignment, and requiring good bone quality. It benefits patients with low activity levels or localized osteoarthritis, potentially offering faster recovery compared to total knee arthroplasty (TKA). However, UKA suitability should be carefully assessed by a specialized orthopedic surgeon, considering individual patient characteristics and needs.

In UKA, distinguishing between types is vital for selecting the appropriate prosthetic device based on patient needs and anatomy.[7,9] Key factors include tibial component fixation (cemented versus uncemented), component material (fully poly versus metallic), and replacement location (medial versus lateral). UKA implants are categorized as fixed-bearing (FB), where a polyethylene structure is fixed between femoral and tibial components, and mobile-bearing (MB), which allows anterior and posterior mobility of the polyethylene, unlike MB implants in total knee replacements, which also permit rotational movements.[7,9]

In UKA, the choice between FB and MB involves considerations of distinct advantages and disadvantages.[7,9] As of the present moment, the literature has not clearly defined the superiority of one implant type over the other when compared (FB vs. MB). Both have advantages, disadvantages, and indications related to intrinsic and extrinsic factors of the patient are crucial in choosing the best prosthesis type for the treatment of knee conditions. FB offers stability and simplicity of design, facilitating surgery and reducing the risk of dislocation. Additionally, wear tends to be more uniform, extending the prosthesis lifespan. However, it may limit range of motion and increase stress on the joint, potentially contributing to adjacent bone wear. On the other hand, MB allows for greater range of motion and more natural load distribution, reducing stress on the joint and potentially minimizing adjacent bone wear. However, surgery may be more complex due to the need to ensure adequate stability of the mobile implant, and there is a slightly increased risk of dislocation.

The objective of this study is to determine the most suitable prosthesis type for individual patients by comparing their indications in the adult population. Post-operative evaluations of patients with a minimum follow-up of 2 years were conducted, focusing on aspects such as quality of life and medium-term post-operative function. The choice of a 2-year follow-up period is considered medium-term as it allows for the assessment of both short-term recovery and early outcomes as well as the beginning of potential long-term effects.

## MATERIALS AND METHODS

This systematic review (Level of evidence: 1) was submitted in its inception to the PROSPERO platform[10] under the registration number CRD42022383120 with the aim of minimizing the risk of publication bias and the duplication of reviews to address the same clinical question.

A literature search was conducted in the search engines of the following databases: PubMed, EMBASE, and Cochrane library, using the following keywords: "Fixed AND Mobile AND knee arthroplasty, unicompartmental." The search was refined to include only randomized clinical trials without language restrictions, up March 28, 2024.

The inclusion criteria were as follows: (I) Full articles of randomized clinical trials comparing the use of FB with MB unicompartmental knee arthroplasty (UKA) in the treatment of unicompartmental knee osteoarthritis; (II) Studies that evaluated patients with a follow-up of at least two years (2) post-operatively, allowing for shorter post-operative assessments as long as they were compared with an evaluation of at least two years of follow-up. The exclusion criteria were: I) Duplicated articles, where the abstract is published in one journal and the full article in another (opting for the full article and excluding the abstract) and; II) Articles that appeared in more than one database (using only one of the articles in the quantification and review). After organized the articles following the PRISMA flowchart.[11]

In order to use data that support evidence-based medicine, the PICO strategy[12] represents an acronym for Patient, Intervention, Comparison, and Outcomes. These four components are fundamental elements for formulating a good research question and constructing the clinical question for literature search for evidence.[12]

The components are specified as follows:

Patient: Adult population, regardless of race, sex, and health history, with unicompartmental knee osteoarthritis.

Intervention: Surgical treatment of unicompartmental knee osteoarthritis with MB or FB partial knee prosthesis.
Comparison: Clinical outcomes and complications of unicompartmental (partial) knee prosthesis between the groups: MB vs. FB, using evaluation tools.
Outcome: Pain, knee joint function, quality of life, post-operative complications, and revisions, considering a minimum follow-up of 2 years.
The data treatment of Table generated after applying the PICO tool[12] was conducted using a double-check technique by two authors. Each author's input was reviewed, and contributions and additions were made by the other author, aiming to avoid data selection bias and include the main aspects covered in each of the studies used as the basis for the systematic review.
Furthermore, the ROBIS tool[13] (Risk of Bias in Systematic Reviews) was used: an instrument applied to assess the risk of bias in systematic reviews. This tool was designed to evaluate bias risk with questions related to interventions, etiology, diagnosis, and prognosis. Therefore, it is considered an appropriate choice of tool for the scope of this systematic review work: evidence-based medicine in the field of orthopedics and traumatology, specifically concerning orthopedic prostheses applied to knee surgery.
In the initial step of assessing relevance, it was determined that the subject discussed in the review is aligned with the research question intended to be addressed. The second stage involved the assessment of four domains to cover the main review processes: 1) study eligibility criteria; 2) identification and selection; 3) data collection and evaluation of studies; and 4) synthesis and results. The study answered all questions leaving no doubts about its pre-established methodology and registered on the PROSPERO® platform.[10] In the third and final stage, the assessment focused on evaluating the risk of bias. The first question in this phase revealed that the interpretation of the findings encompassed all potential risks and no biases were identified. Additionally, this phase comprised three questions related to the interpretation of the review findings. These questions demonstrated that the conclusions were grounded on the presented evidence, the relevance of the included studies was taken into account, and the authors refrained from solely emphasizing results based on statistical significance. Such considerations are vital for properly interpreting the findings of a review, as they are potential areas where biases could have been introduced into the study.
Using all the tools mentioned above, it is possible to ensure the reproducibility of the study.

## RESULTS

A total of eighty-three (83) articles were found in PubMed, twelve (12) articles in EMBASE, and eighteen (18) search results in the Cochrane library, associated with the described themes up to March 28, 2024, totaling one hundred and thirteen (113) search results. After analyzing the articles following the PRISMA® flowchart[11] (Figure 1), there were seven (7) remaining references.
The references were manually reviewed and arranged in chronological order of publication. Seven (7) articles were included, all written in English and published between 2003 and 2024 (Table 1). The total number of patients evaluated in the studies[14-20] that composed this systematic review was 525, with 538 knees operated and evaluated with a minimum follow-up of 2 years. The overall mean age of the studies was 68,67 years.
Table 2 displays information derived from the PICO data treatment strategy,[12] following a meticulous data processing procedure executed by two authors employing a double-check technique. After using the ROBIS tool,[13] no bias was identified in our study.

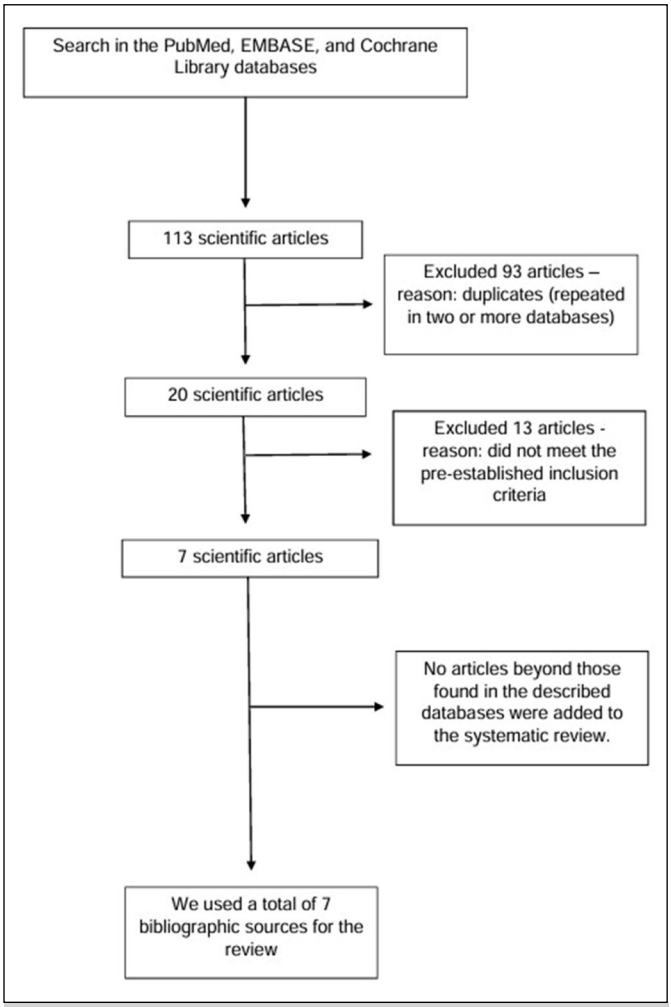


**Figure 1.** Flowchart designed for the search and selection of studies for the review.

## DISCUSSION

Knee unicompartmental osteoarthritis is a relatively common condition;[21] however, determining the best type of surgical treatment or the optimal prosthetic type remains controversial. The UKA, with its promise of being a less invasive alternative to total knee arthroplasty (TKA) and proximal tibial and distal femoral osteotomies in suitable patients, continues to attract surgeons and patients. The usual options for partial prostheses are the MB and FB options.
Arliani et al.,[22] in their study conducted ten years ago on surgical indications, interviewed 113 knee specialists. The majority of participants (89.3%) considered patients under the age of 65 as ideal candidates for UKA, with 95.6% indicating high tibial osteotomy and 74.3% recommending UKA for young patients (<55 years) with high physical demands. Currently, Belsey et al.[23] suggest in their systematic review that the ideal patient for osteotomy would have compartmental osteoarthritis, tibial deformity, knee mobility greater than 120 degrees, be below 60 years of age, and have a body mass index (BMI) less than 30 kg/m. Conversely, the ideal candidates for UKA would be patients with degeneration, mainly compartmental, but aged over 60 years, with deformity less than 15 degrees, and in both groups, no significant instability should be present.[23-25] The overall mean age of the studies was 68,67 years (indicating that the elderly population is responsible for the majority of procedures) and the most frequent was primary osteoarthritis in all studies.[14-20]

**Table 1.** Material used in the review.

| Order | Authors | Journal [Database] | Year | Authors' country | Language |
|---|---|---|---|---|---|
| **Artigos das bases de dados** | | | | | |
| 1 | Gleeson RE; Evans R; Ackroyd CE; Webb J; Newman JH[14] | The Knee [Pubmed; Cochrane Library] | 2003 | United Kingdom (England) | English |
| 2 | Confalonieri N; Manzotti A; Pullen C[15] | The Knee [Pubmed; EMBASE; Cochrane Library] | 2004 | Italy Australia | English |
| 3 | Li MG; Yao F; Joss B; Ioppolo J; Nivbrant B; Wood D[16] | The Knee [Pubmed; EMBASE; Cochrane Library] | 2006 | Australia | English |
| 4 | Gilmour A; MacLean AD; Rowe PJ; Banger MS; Donnelly I; Jones BG; et al[17] | The Journal of Arthroplasty [Pubmed; EMBASE; Cochrane Library] | 2018 | United Kingdom (Scotland) | English |
| 5 | Koppens D; Rytter S; Munk S; Dalsgaard J; Sørensen OG; Hansen TB; et al.[18] | Acta Orthopaedica [Pubmed; EMBASE; Cochrane Library] | 2019 | Denmark | English |
| 6 | Wu L; Mayr HO; Zhang X; Huang Y; Chen Y; Li Y[19] | Orthopaedic Surgery [Pubmed; EMBASE; Cochrane Library] | 2022 | China Germany | English |
| 7 | D'Ambrosi, R.; Valli, F.; Nuara, A.; Mariani, I.; Di Feo, F.; Ursino, N.; Formica, M.; Mangiavini, L.; Hantes, M.; Migliorini, F.[20] | European Journal of Orthopaedic Surgery & Traumatology | 2023 | Italy Greece Germany | English |

**Table 2.** Detailed data of the references.

| Order | Tipe of Study | Pacient Population | Intervention | Comparison | Outcomes |
|---|---|---|---|---|---|
| 1[14] | Randomized Clinical Trial | Period and recruited population: Between January 1999 and December 2001, 91 patients (104 knees) were recruited for the study. One patient had different arthroplasties implanted in each knee.<br><br>Preoperative diagnoses and previous surgical procedures: The preoperative diagnosis was primary osteoarthritis in all cases, except for two (one case of osteonecrosis and one of rheumatoid arthritis). Previous surgeries included arthroscopic procedures, medial meniscectomies, and, in one case, anterior cruciate ligament (ACL) reconstruction.<br><br>Excluded population: Patients with prior tibial plateau fracture or knee osteotomy were excluded. Chondrocalcinosis was not considered a contraindication, and no patients were excluded based on excess weight.<br><br>Division of the comparison groups and characteristics of each group (sex, number of patients, mean age, mean body weight): St. George Group (Fixed-Bearing): 57 knees in 49 patients; Mean age: 66.7 years; 29 males and 20 females; 26 right knees, 31 left knees; Mean body weight: 83.0 kg<br><br>Oxford Group (Mobile-Bearing): 47 knees in 43 patients; Mean age: 64.7 years; 26 females, 17 males; 25 right knees, 22 left knees; Mean body weight: 77.7 kg | Types of prostheses used: Mobile-Bearing Unicompartmental Knee Prosthesis (Oxford) and the Fixed-Bearing Unicompartmental Knee Prosthesis (St. George).<br><br>Clinical indications for surgery: The indications for unicompartmental knee prosthesis were: Incapacitating knee pain with medial compartmental disease; Intact anterior cruciate ligament (ACL) and collateral ligaments; Fixed flexion deformity less than 108 degrees; Minimal subluxation; and correctable varus deformity less than 108 degrees. | Comparison proposed by the work: The complications and clinical outcomes of the St. Georg Sled, a fixed-bearing unicompartmental knee prosthesis, with the mobile-bearing Oxford unicompartmental knee prosthesis over a two-year postoperative period.<br><br>Assessment tools and time of evaluation (preoperative, postoperative, or both): The Bristol Knee Score (BKS) and Oxford Knee Score were used to assess knee function preoperatively, at 8 months, and 2 years postoperatively. Preoperative weight, range of motion, and knee scores for each group were the variables studied. No patients were lost in follow-up, and 88 out of 91 patients attended the 2-year postoperative evaluation. | Função:<br>Bristol Knee Score and Oxford Knee Score: At the 2-year follow-up, both socres showed better outcomes for the St. Georg Sled Group (fixed-bearing). There were also more excellent and good results in the St. Georg Sled Group. However, there was no significant difference compared to the Oxford Group (mobile-bearing).<br><br>Mean 2 years after post-op Bristol knee score<br>FB / MB<br>89 / 84.1<br><br>Mean 2 years after post-op Oxford score<br>FB / MB<br>36.5 / 33.4<br><br>Mean total pain score (component of Bristol knee score, max=40)<br>FB / MB<br>34.9 / 30.7<br><br>Mean total function score (component of Bristol knee score, max=27)<br>FB / MB<br>23 / 22<br><br>Mean of flexion post-op (range of motion)<br>FB / MB<br>121.68 / 118.68<br><br>Pain:<br>The pain component of the Bristol Knee Score was significantly better for the St. Georg Sled Group, fixed-bearing (p-value = 0.013).<br><br>Postoperative complications and revisions:<br>In the Oxford Group (mobile-bearing), three patients experienced bearing dislocation, and four patients required revisions with an average revision time of 3 years. In the St. Georg Sled Group (fixed-bearing), three patients required revisions with an average revision time of 3.4 years.<br><br>Comparative conclusions on quality of life:<br>These results demonstrate that, in the short term, the Oxford mobile-bearing prosthesis has a higher reoperation rate, while the fixed-bearing St. George sled prosthesis achieves better pain relief. The functional scores of both groups were similar. |

**Table 2.** Detailed data of the references.

| Order | Tipe of Study | Pacient Population | Intervention | Comparison | Outcomes |
|---|---|---|---|---|---|
| 2[15] | Randomized Clinical Trial | Period and recruited population: Between February 1996 and December 1997, 40 patients who underwent medial unicompartmental knee arthroplasty were recruited and randomly divided into two groups.<br><br>Preoperative diagnoses and previous surgical procedures: Primary osteoarthritis<br>Excluded population:<br><br>Division of the comparison groups and characteristics of each group (sex, number of patients, mean age, mean body weight):<br>Group A - 20 knees in 20 patients; mean age 69.5 years; 8 males and 12 females; 11 left knees; 9 right knees.<br>Group B - 20 knees in 20 patients; mean age 71 years; 11 males and 9 females; 8 left knees; 12 right knees. | Types of prostheses used:<br>Group A -<br>Allegretto, Centerpulse, Baar, Switzerland (Fixed-bearing) and Group B - - AMC-Unicondylar-Knie-Prothese, Alphanorm, Quiershied, Alemanha (Mobile bearing)<br><br>Clinical indications for surgery: | Comparison proposed by the work:<br>Pre- and postoperative follow-up with clinical and statistical evaluations using scores, with an average postoperative follow-up period of 5.7 years.<br><br>Assessment tools and time of evaluation (preoperative, postoperative, or both):<br>The patients were evaluated preoperatively by two independent orthopedists who were not involved in the surgical procedure and were blinded to the type of prosthesis implanted. Additionally, the Knee Society scoring instrument, the G.I.U.M. (Unicompartmental Knee Prosthesis Outcome Score developed by the Italian Orthopaedic UKR□s Users Group), and the Functionality Score were used for comparison.. | Function:<br>Both in the preoperative and at the last follow-up consultation, no statistically significant differences were detected between the two groups according to the GIUM Score, the Knee Society Score, or the functional evaluation of the patients.<br>Group A: pre / post<br>Knee Society: 44,6 / 87.5<br>Functional: 48.7 / 76.3<br>GIUM: 51.3 / 73.8<br><br>Group B: pre / post<br>Knee Society: 48.3 / 88.05<br>Functional: 48.7 / 77.0<br>GIUM: 52.4 / 75.5<br><br>Pain:<br>Postoperative complications and revisions:<br>After 18 months, one patient in Group A underwent a revision of the prosthesis due to persistent pain in the tibial component region, with only partial reduction of the pain complaint after the procedure. In one patient from Group B, an intraoperative medial tibial plateau fracture occurred, which was treated with screw fixation before implantation of the tibial component and did not affect the final outcome or postoperative follow-up. One patient with the fixed component had a TVP, but the condition was treated without complications. There were no cases of superficial or deep infections.<br><br>Comparative conclusions on quality of life:<br>These results demonstrated that despite more extensive usage, it was not possible to detect advantages of the mobile-bearing prosthesis over the fixed-bearing prosthesis in terms of clinical performance and longevity. |
| 3[16] | Randomized Clinical Trial | Period and recruited population: Between May 2001 and June 2003, 56 knees in 48 patients, 34 males, 14 females, with a mean age of 72 years and a diagnosis of osteoarthritis were randomly assigned to two groups for knee arthroplasty.<br><br>Preoperative diagnoses and previous surgical procedures: Non-inflammatory osteoarthritis of the medial compartment and/or mechanical deformity.<br><br>Excluded population:<br><br>Division of the comparison groups and characteristics of each group (sex, number of patients, mean age, mean body weight):<br>Fixed-Bearing Group (Miller/Galante, Zimmer, Warsaw, USA): 28 knees: 19 males, 9 females; Mean age: 70 years; Mean BMI: 27.6<br><br>Mobile-Bearing Group (Oxford, Biomet, UK): 28 knees: 20 males, 8 females; Mean age: 74 years; Mean BMI: 26.5<br><br>Eight patients received bilateral implants (always with one knee receiving an Oxford implant and the other receiving a Miller/Galante implant). | Types of prostheses used:<br>Fixed bearing (Miller/Galante, Zimmer, Warsaw, USA<br><br>Mobile bearing (Oxford, Biomet, UK)<br><br>Clinical indications for surgery: Non-inflammatory osteoarthritis of the medial compartment, mechanical axial deformity <10□ varus or 5□ valgus; intact ACL without medial-lateral subluxation; Flexion contracture <15□; Body weight <90 kg. | Comparison proposed by the work:<br>Comparison of fixed-bearing and mobile-bearing knee prostheses, with a focus on knee kinematics, tibial component radiolucency, and clinical follow-up over a period of 2 years.<br><br>Assessment tools and time of evaluation (preoperative, postoperative, or both):<br>The comparison was conducted based on the following three criteria:<br>Kinematic:<br>1) Internal rotation of the tibia relative to the femur.<br>2) Anterior-posterior translation of the medial femoral condyle.<br>3) Anterior-posterior translation of the contact point.<br>4) Movement of the mobile-bearing.<br><br>Radiographic:<br>Comparison of postoperative radiographs immediately after the procedure with those taken after 2 years.<br>Alignment assessed through the Hip-Knee-Ankle (HKA) angle.<br>Radiolucency at the bone-implant interface.<br>Progression of osteoarthritis in the patellofemoral joint and the lateral component.<br>Positioning and alignment of the tibial and femoral components.<br><br>Clinical:<br>Independent observers evaluated preoperatively and annually during follow-up using scores such as Knee Society Scores, WOMAC, and SF-36 | Function:<br>The mobile-bearing prosthesis showed a closer approximation to the normal knee kinematics, with greater and more consistent tibial internal rotation, a more stationary medial femoral condyle, and rollback of the lateral femoral condyle. It also presented a lower incidence of radiolucency (with increased radiolucency being a possible sign that the fixation quality may be compromised in this group, though longer follow-up time is necessary to confirm this fact).<br>Fixed / Mobile<br>Range of motion: 110 (85–140) / 112 (90–135)<br>Knee score: 91 / 89<br>Function score 84 / 85<br><br>Pain: After 2 years<br>Fixed / Mobile<br>46 / 44<br>SF-36 score<br>Preoperative physical: 27 / 29<br>2 years, physical 37 / 40<br>2 years, mental 52 / 50<br>Womac score<br>Pre 46 / 54<br>2 years 74 / 79<br><br>Postoperative complications and revisions:<br>Two patients with a mobile-bearing prosthesis require prosthesis revision before two years: one due to infection and the other due to aseptic loosening of the tibial component.<br><br>Two patients with 3 prostheses (one mobile-bearing and two fixed-bearing) died from unrelated causes before two years. They were excluded from the final comparison but included in the initial study data.<br><br>Comparative conclusions on quality of life:<br>Both SF-36, Womac, and Knee Society scores improved during the two-year follow-up period with no significant differences between the two groups. |

**Table 2.** Detailed data of the references.

| Order | Tipe of Study | Pacient Population | Intervention | Comparison | Outcomes |
|---|---|---|---|---|---|
| 4[17] | Randomized Clinical Trial | Period and recruited population: Between October 2010 and December 2012, a total of 139 participants were recruited.<br><br>Preoperative diagnoses and previous surgical procedures: Excluded population: Patients with ligament insufficiency, inflammatory arthritis, deformity requiring augmentation, neuromotor diseases, pathologies of the feet, ankles, hips, or contralateral knee causing significant pain or gait alteration, as well as those requiring total knee replacement.<br><br>Division of the comparison groups and characteristics of each group (sex, number of patients, mean age, mean body weight): Dividided into two groups:<br><br>Fixed-Bearing Group: 69 initial participants; 64 underwent the procedure; 58 were followed for 2 years; 32 males and 26 females; Mean age of 61.8 years<br><br>Mobile-Bearing Group: 70 initial participants; 65 underwent the procedure; One patient crossed over from the other group; 54 were followed for 2 years; 28 males and 26 females; Mean age of 62.6 years; Two patients were not followed due to the need for total knee replacement revision. | Types of prostheses used: Fixed-Bearing: Surgical technique assisted by a robotic arm using the RESTORIS MCK (MAKO Surgical Corp, Fort Lauderdale, FL) with the MAKO Robotic-Arm Interactive Orthopedic system.<br><br>Mobile-Bearing: Conventional surgical technique using the Oxford Phase 3 (Biomet, Warsaw, IN) prosthesis.<br><br>Clinical indications for surgery: Osteoarthritis of the medial compartment of the knee requiring surgery | Comparison proposed by the work: Unicompartmental knee prosthesis with robotic-assisted surgical technique and conventional prosthetic technique, performed by one of the three surgeon authors with at least 5 years of experience in independent practice.<br><br>Assessment tools and time of evaluation (preoperative, postoperative, or both): For the comparison, several scores were used, including OKS (Oxford Knee Score), AKSS (American Knee Society Score), Forgotten Joint Score (FJS), Pain Catastrophizing Scale, Pain Visual Analog Scale, Stiffness Visual Analog Scale (SVAS), patient satisfaction, range of motion (ROM), and University of California Los Angeles (UCLA) Activity Scale. Complications and revisions over the 2-year period were also taken into account.<br><br>Data collection was performed by an associate/research nurse who was blinded to the group data at the investigative hospital. | Function:<br>The SVAS was significantly higher in the manual group, while the ROM was greater in the robotic-assisted surgery group, and both remained consistent after 2 years of follow-up.<br><br>Pain: After 2 years<br>Mobile / Fixed<br>Pre: 55.1 / 52.7<br>After 2 years: 5.0 / 3.0<br><br>Postoperative complications and revisions:<br>From the mobile-bearing group, two patients were lost to follow-up due to the need for total prosthesis revision. Regarding the evaluation of survival differences (100% in the assisted group and 96.3% in the conventional group), long-term follow-up is necessary.<br><br>Comparative conclusions on quality of life:<br>At two years, no significant differences were detected by the study□s analysis tools. However, in the subgroup of patients with a preoperative University of California Los Angeles Activity Scale value >5, a higher postoperative mean of the Oxford Knee Score was observed after two years, indicating a possible greater benefit of robotic-assisted surgery for more active patients. Nevertheless, longer follow-up time is required to draw conclusive results. |
| 5[18] | Randomized Clinical Trial | Period and recruited population: Between January 2014 and November 2015, a total of 62 patients were followed through stereometric analysis by radiography..<br><br>Preoperative diagnoses and previous surgical procedures: Excluded population: Patients with inflammatory arthritis, contralateral knee prosthesis, disseminated malignancy, severe systemic disease, female patients of childbearing age, and patients unable to provide written consent.<br><br>Division of the comparison groups and characteristics of each group (sex, number of patients, mean age, mean body weight): Mobile-Bearing Group (Oxford UKA): 33 patients, of which 2 did not undergo the procedure (due to no LCA); Mean age of 64 years; 16 males and 17 females; Mean BMI of 29<br><br>Fixed-Bearing Group (Sigma UKA): 32 patients, of which 1 did not undergo the procedure and 1 was excluded due to infection 5 weeks after the procedure; Mean age of 61 years; 17 males and 15 females; Mean BMI of 28. | Types of prostheses used: Mobile bearing (Oxford UKA)<br><br>Fixed bearing (Sigma UKA)<br><br>Clinical indications for surgery: Patients above 18 years of age eligible for unicompartmental knee prosthesis according to the criteria established by Murray et al. (1998) and DePuy International (2009). | Comparison proposed by the work: The unicompartmental knee prostheses implanted by two experienced orthopedic surgeons using minimally invasive techniques. During the surgery, tantalum beads measuring 4-6 mm were implanted in the femoral and tibial periprosthetic regions for subsequent RSA.<br><br>Assessment tools and time of evaluation (preoperative, postoperative, or both): Radiostereometric analysis (RSA) was performed on postoperative day one and subsequently at 4, 12, and 24 months. All RSA data were analyzed using the same system, and patients with fewer than 3 visible markers were excluded from the analysis.<br><br>In addition to RSA, the study also utilized the Oxford Knee Score and a general health questionnaire (RAND-36) to assess overall health. Furthermore, the strength of the thigh extensors was evaluated, with both lower limbs being tested preoperatively and again after 24 months. | Function:<br>Oxford Knee Score<br>MB / FB<br>Pre: 26 / 28<br>4 months: 38 / 37<br>12 months: 42 / 41<br>24 months: 40 / 41<br><br>Pain: Após 2 anos<br>RAND-36<br>MB / FB<br>Pre: 65 (44) / 72 (38)<br>4 months: 77 (38) / 87 (32)<br>12 months: 85 (36) / 81 (34)<br>24 months: 87 (32) / 91 (23)<br><br>Postoperative complications and revisions:<br>Mobile-bearing: 02 patients did not undergo the procedure (absence of ACL).<br><br>Fixed-bearing: 01 patient did not undergo the procedure, and 01 patient was excluded due to infection 5 weeks after the procedure.<br><br>Comparative conclusions on quality of life:<br>No statistically significant or clinically relevant differences were observed. There was recovery of function and strength of the extensor muscles, with no noted changes between the limbs after 24 months of follow-up, and good fixation was observed during the same period. |

**Table 2.** Detailed data of the references.

| Order | Tipe of Study | Pacient Population | Intervention | Comparison | Outcomes |
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| 6[19] | Randomized Clinical Trial | Period and recruited population: From September 2015 to February 2017, a prospective, randomized, parallel, and single-center study was conducted with 180 patients<br><br>Preoperative diagnoses and previous surgical procedures: Medial compartmental knee osteoarthritis was performed<br><br>Excluded population: (i) Patients with lateral compartment knee osteoarthritis, knee arthroplasty in the contralateral knee, inflammatory arthritis, and disseminated malignancies such as AIDS, syphilis, and hepatitis B; (ii) Severe systemic diseases, such as rheumatoid arthritis and malignancies; (iii) Revisional arthroplasty and post-infection cases; (iv) Female patients of childbearing age; (v) Patients unable to provide written informed consent.<br><br>Division of the comparison groups and characteristics of each group (sex, number of patients, mean age, mean body weight): 78 men and 102 women, with an overall mean age of 63.3 6.9 years, divided as follows:<br><br>MB: 60 patients, mean age of 63 years, mean BMI of 24<br>FB: 60 patients, mean age of 63 years, mean BMI of 24<br>TKA: 60 patients (data not used in this review as it concerns total knee replacement). | Types of prostheses used: Unicompartmental knee prosthesis with fixed or mobile bearing, or total knee arthroplasty.<br><br>Mobile: Oxford phase 3 MB UKA<br>Fixed: Link FB UKA<br>Total: Depuy Sigma PFC PFC TKA<br><br>Clinical indications for surgery: The inclusion criteria were: (i) Patients aged between 50 and 80 years at the time of recruitment, with clinical and radiographic evidence (including anteroposterior and lateral knee radiographs and knee computed tomography [CT]) of non-lateral compartment knee osteoarthritis, with Kellgren-Lawrence X-ray classification levels 2-4. (ii) Competent and willing to participate in the study. (iii) Absence of signs of any severe neurological disorders. (iv) Provided informed consent for the treatment and testing program. | Comparison proposed by the work: A similar perioperative management and fast-track surgery program were implemented for all patients. Knee scores at the 3-year follow-up after the operation, as well as the clinical outcomes of these three patient groups, were recorded, investigated, and compared.<br><br>Various parameters were also recorded, investigated, and compared, including operative time, intraoperative bleeding, time to the first walk without crutches, independent stair ascent and descent after the operation, postoperative complications, and a series of knee scores.<br><br>Assessment tools and time of evaluation (preoperative, postoperative, or both): The following scores were used:<br><br>Hospital for Special Surgery Knee Score (HSS)<br>Western Ontario and McMaster Universities Index (WOMAC)<br>Pontuação da Knee Society (KSS)<br>Visual Analog Scale (VAS)<br>Oxford Knee Score (OKS)<br>Maximum knee flexion angle<br>Forgotten Joint Score (FJS)<br><br>Follow up exceeding 36 months | Function:<br>Overall, there was no significant difference in all knee scores and maximum knee flexion angles between the MB UKA and FB UKA groups.<br><br>Pain: After 3 years<br>WOMAC<br>Pre: MB - 47,5 / FB - 47.5<br>3 years: 91<br>VAS<br>Pre: MB - 9.0 / FB - 9.0<br>3 years: 1.0<br><br>Postoperative complications and revisions:<br>There was one case of the original dislocation of the bearing in the MB UKA group. In the FB UKA group, one patient had femoral component dislocation caused by a fall injury, and another patient lost their life in a car accident.<br><br>Comparative conclusions on quality of life:<br>This study indicates that there are no significant differences, with similar Knee Scores between patients with MB and FB. A randomized control study using radiostereometric analysis at the 2-year follow-up showed that both groups have good fixation of the tibial components and both demonstrate good clinical progress. The groups also showed significant improvement in pain and function, evolving significantly up to 12 months postoperatively. |
| 7[20] | Randomized Clinical Trial | Period and recruited population: A total of 54 patients were recruited during the period from September 2015 to December 2019.<br><br>Preoperative diagnoses and previous surgical procedures: Patients with idiopathic or secondary osteoarthritis of the medial femoral compartment of the knee.<br><br>Excluded population: The exclusion criteria were: (1) age < 80 years; (2) revi sion arthroplasty; (3) previous surgery of the affected knee (except meniscectomy); (3) uncontrolled systemic disease; (5) patient unable to understand the nature of the present study<br><br>Division of the comparison groups and characteristics of each group (sex, number of patients, mean age, mean body weight):<br><br>FB PKA Persona Partial Knee (PPK) group: 25 patients; mean age 82.3 2.0; 23 women and 2 men.<br><br>MB PKA Oxford: 29 patients; mean age 81.9 1.0; 25 women and 4 men. | Types of prostheses used: The first group received FB PKA Persona Partial Knee (PPK) ® (Zimmer Biomet, Warsaw, Indiana, USA);<br><br>The second received MB PKA Oxford with Microplasty instrumentation (Zimmer Biomet, Warsaw, Indiana, USA).<br><br>Clinical indications for surgery: Patients with idiopathic or secondary osteoarthritis of the medial femoral compartment of the knee; Varus or valgus deformity < 3□; Knee flexion > 100□; Flexion contracture < 10□; Integrity of cruciate and collateral ligaments. | Comparison proposed by the work:<br><br>The patients were assessed at T0 (preoperative), T1 (1 year post-surgery), and T2 (3 years post-surgery).The hypothesis of the current study was that MB implants would perform better than FB implants in PKA in octogenarians.<br><br>Assessment tools and time of evaluation (preoperative, postoperative, or both):<br><br>Using visual analogue scale (VAS), Knee Society Score (KSS), and Oxford Knee Score (OKS). Additionally, data on implant survival and range of motion (ROM) were collected. Furthermore, the following radiographic parameters were measured: Varus/valgus of the femoral component; Varus/valgus of the tibial component; Anteroposterior slope. | Function:<br>No difference between FB and MB in KSS, and OKS.<br><br>KSS<br>Pre: FB 37.3 8.2 / MB 37.1 9.6 (p=0.9)<br>3 year: FB 90.8 5.5 / MB 90.9 4.9 (p=0.9)<br><br>OKS<br>Pre: FB 21.8 3.7 / MB 21.2 3.7 (p=0,05)<br>3 year: FB 43.8 1.7 / MB 43.8 1.7<br><br>Pain:<br>No difference between FB and MB in VAS.<br><br>VAS<br>Pre: FB 7.4 1.2 / MB 7.4 1.5 (p=0.9)<br>3 year: FB 1.4 0.9 / MB 1.5 0.9 (p=0.8)<br><br>Postoperative complications and revisions:<br>At last follow-up (3 years), FB group reported three failures caused by aseptic loosening. Four failures were observed in the MB cohort: two for bearing dislocation and two for aseptic loosening. The Kaplan–Meier Curve found no differences in implant survivorship.<br><br>Comparative conclusions on quality of life:<br>According to the main findings of the present clinical trial, MB implants performed similar to FB in PKA in octogenarians. The FB group demonstrated shorted surgical time. No difference was found in patient reported outcome measures, ROM, implant positioning, and survivorship. |

However, the consideration that candidates for UKA should be older and less active has been questioned in the literature, as described by Salman et al.[26] in their meta-analysis of 6130 knees, which concluded that young age was not associated with a higher rate of revisions or lower functional scores, and age alone is not a contraindication for UKA. Regarding the mean BMI of patients undergoing partial knee prostheses in the studies that utilized this index, it was 26.5 (overweight or pre-obese), which differs from the study by Camanho et al.,[8] which was conducted 15 years ago when obesity was considered an absolute contraindication for UKA due to limitations in the surgical technique.

Among the preoperative diagnoses, the most frequent was primary osteoarthritis in all studies.[14-20] This fact demonstrates that osteoarthritis of inflammatory etiology or degenerative nature without inflammation predominates over post-traumatic and mechanical causes.

Function: Despite the variety of tools used by different studies to compare the function of UKA, only one of the studies[14] showed a difference in results, favoring the FB, but also highlighting the technical difficulty of using the Oxford prosthesis (MB). This isolated result in favor of the FB is contradicted by the meta-analysis conducted by Migliorini et al.[27], where 4696 patients were assessed and the authors reported not being able to identify the superiority of one implant type over the other, with no differences found in the range of motion ($p = 0.05$), Knee Scoring System ($p = 0.9$), function subscale ($p = 0.2$), and Oxford Knee Score ($p = 0.4$).

Pain after 2 years: Only one study[14] showed a slightly lower pain component in the Bristol score in favor of the FB prosthesis (St. Georg Sled). The meta-analysis by Zhang et al. assessed 17 studies involving 2612 knees (with a mean follow-up time ranging from 7 months to 17.2 years) and no significant differences were observed in clinical and radiological outcomes between MB and FB prostheses.

Postoperative complications and revisions: Some cases of bearing dislocation were recorded in the MB groups,[14-20] but the rates of prosthesis revision did not show significant differences between the groups. Other postoperative complications that were not explored in this study, such as postoperative infection, also did not have statistically significant values to distinguish between the groups. This finding aligns with the results found by Migliorini et al.,[27] who described no difference in revision rate ($p = 0.2$), aseptic loosening ($p = 0.9$), deep infections ($p = 0.99$), fractures ($p = 0.6$), and additional extension of osteoarthritis to the contralateral joint compartment ($p = 0.2$) between the two prosthesis types in the 4696 patients analyzed in their meta-analysis. The data is also in line with the systematic review by Ko et al.[28], which evaluated the overall reoperation rate per hundred component years in 1,019 knees from 887 patients. This rate was similar between mobile bearings (1.392) and fixed bearings (1.377).

Comparative conclusions on Quality of Life: In this aspect, no differences were detected, with significant improvement observed for both groups. Regarding sports activities after UKA, Arliani et al.[22] reported that the most authorized sports by physicians were swimming (96.5%) and tennis (51.3%), while football was disallowed in the postoperative period by all participating surgeons. There are no studies in the literature demonstrating differences in the return to sports after surgery in patients undergoing UKA with FB or MB prostheses. However, the study by Belsey et al.[23] compared UKA with high tibial osteotomy and concluded that both techniques allow a return to sports activity at a similar or even higher level than the preoperative period. Patients undergoing osteotomies usually exhibit a higher level of physical activity in the pre and postoperative periods. Surprisingly, patients with UKA showed a greater increase in physical activity in the postoperative period compared to what they practiced preoperatively.

The study recognizes several limitations that should be considered when interpreting its findings. Challenges include the difficulty in reaching definitive conclusions due to the lack of standardization in assessment tools, introducing variability that may impact outcome precision. Additionally, the limited availability of relevant literature poses a challenge, with few studies demonstrating the superiority of one model over another in postoperative aspects. The inclusion criteria further narrowed the selection to a small quantity of articles (7 articles), emphasizing the need for caution in generalizing findings to a broader context.

## CONCLUSION

Based on what is described in the literature, there are still numerous questions regarding the comparison of the two types of UKA. The major challenge in reaching conclusions is the standardization of assessment tools, as different variables can be observed depending on the tool used. What is known so far is that there are not enough studies to prove the superiority of one prosthesis type over the other concerning postoperative function, pain after a 2-year follow-up, complication rates, postoperative revisions, and quality of life. Prospective and multicenter long-term studies with standardized methodologies need to be conducted to clarify the doubts that still surround the scientific community to provide evidence-based clinical practice.

**AUTHOR'S CONTRIBUTION:** Each author made significant individual contributions to the development of this manuscript. FC: Conceptualization, conception, writing original draft, design, methodology, visualization, investigation, review of literature, analysis and manuscript preparation; DG: visualization, investigation, review of literature, analysis and manuscript preparation; FS: Conceptualization, conception, writing original draft, design, methodology, analysis, reviewing and editing; PF: design, methodology, analysis and manuscript preparation, reviewing and editing, translation reviewing, journal recommendation for publication.

## REFERENCES

1. Thompson J, Netter F, Machado C, Craig J. Netter Orthopedic Anatomy Atlas. 2nd ed. Rio de Janeiro: Guanabara Koogan; 2020. p. 286-305.
2. Sandersoln RO, Beata C, Flipo RM, Genevois JP, Macias C, Tacke S, et al. Systematic review of the management of canine osteoarthritis. Vet Rec. 2009;164(14):418-24.
3. Neogi T, Zhang Y. Epidemiology of osteoarthritis. Rheum Dis Clin North Am. 2013;39(1):1-19.
4. Camanho G. Medial knee osteoarthritis: A progressive pathology. Rev Bras Ortop. 2021;56(2):133-7.
5. Camanho GL, Imamura M, Arendt-Nielsen L. Genesis of pain in osteoarthritis. Rev Bras Ortop. 2011;46(1):14-17.
6. Imamura M, Imamura ST, Kaziyama HH, Targino RA, Hsing WT, de Souza LPM, et al. Impact of nervous system hyperalgesia on pain, disability, and quality of life in patients with knee osteoarthritis: a controlled analysis. Arthritis Rheum. 2008;59(10):1424-31.
7. Barretto J, Mendonça R. Artroplastia total do joelho. In: Motta G, Barros T (eds.). Ortopedia e Traumatologia. Rio de Janeiro: Elsevier; 2017. p. 1130-44.
8. Camanho G, Viegas A, Camanho L, Camanho C, Forgas A. Unicompartmental knee arthroplasty in the treatment of medial knee osteoarthritis. Rev Bras Ortop. 2007;42(9):285-9.
9. Azar F, Beaty J, Canale S, Campbell W. Campbell's Operative Orthopaedics. 14th ed. Philadelphia: Elsevier; 2021.
10. PROSPERO International prospective register of systematic reviews [Internet]. Crd.york.ac.uk. 2022 [cited 2022 September]. Available from: https://www.crd.york.ac.uk/PROSPERO/display_record.php?RecordID=354500.
11. Moher D, Liberati A, Tetzlaff J, Altman D. Preferred Reporting Items for

Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med. 2009;6(7):e1000097.
12. da Costa Santos CM, de Mattos Pimenta CA, Nobre MR. The PICO strategy for the research question construction and evidence search. Rev Lat Am Enfermagem. 2007;15(3):508-11.
13. Whiting P, Savović J, Higgins JP, Caldwell DM, Reeves BC, Shea B, et al. ROBIS: A new tool to assess risk of bias in systematic reviews was developed. J Clin Epidemiol. 2016;69:225-34.
14. Gleeson RE, Evans R, Ackroyd CE, Webb J, Newman JH. Fixed or mobile bearing unicompartmental knee replacement? A comparative cohort study. Knee. 2004;11(5):379-84.
15. Confalonieri N, Manzotti A, Pullen C. Comparison of a mobile with a fixed tibial bearing unicompartimental knee prosthesis: A prospective randomized trial using a dedicated outcome score. Knee. 2004;11(5):357-62.
16. Li MG, Yao F, Joss B, Ioppolo J, Nivbrant B, Wood D. Mobile vs. fixed bearing unicondylar knee arthroplasty: A randomized study on short term clinical outcomes and knee kinematics. Knee. 2006;13(5):365-70.
17. Gilmour A, MacLean AD, Rowe PJ, Banger MS, Donnelly I, Jones BG, et al. Robotic-Arm-Assisted vs Conventional Unicompartmental Knee Arthroplasty. The 2-Year Clinical Outcomes of a Randomized Controlled Trial. J Arthroplasty. 2018;33(7S):S109-15.
18. Koppens D, Rytter S, Munk S, Dalsgaard J, Sørensen OG, Hansen TB, et al. Equal tibial component fixation of a mobile-bearing and fixed-bearing medial unicompartmental knee arthroplasty: A randomized controlled RSA study with 2-year follow-up. Acta Orthop. 2019;90(6):575-81.
19. Wu L, Mayr HO, Zhang X, Huang Y, Chen Y, Li Y. Knee scores of patients with non-lateral compartmental knee osteoarthritis undergoing mobile, fixed-bearing unicompartmental knee and total knee arthroplasties: A randomized controlled trial. Orthop Surg. 2021;14(1):73-87.
20. D'Ambrosi R, Valli F, Nuara A, Mariani I, Di Feo F, Ursino N, et al. No difference in mobile and fixed bearing partial knee arthroplasty in octogenarians: a clinical trial. Eur J Orthop Surg Traumatol. 2023;33(12):3081-8. doi: 10.1007/s00590-023-03537-7.
21. Camanho GL. Medial Knee Arthrosis: A Pathology with a Progressive Evolution. Rev Bras Ortop (Sao Paulo). 2021;56(2):133-7.
22. Arliani GG, Yazigi Júnior JA, Angelini FB, Ferlin F, Hernandes AC, Astur DC, et al. Unicompartmental knee arthroplasty: Current perspectives and trends in Brazil. Rev Bras Ortop. 2012;47(6):724-9.
23. Belsey J, Yasen SK, Jobson S, Faulkner J, Wilson AJ. Return to Physical Activity After High Tibial Osteotomy or Unicompartmental Knee Arthroplasty: A Systematic Review and Pooling Data Analysis. Am J Sports Med. 2021;49(5):1372-80.
24. Zuiderbaan HA, van der List JP, Kleeblad LJ, Appelboom P, Kort NP, Pearle AD, et al. Modern Indications, Results, and Global Trends in the Use of Unicompartmental Knee Arthroplasty and High Tibial Osteotomy in the Treatment of Isolated Medial Compartment Osteoarthritis. Am J Orthop (Belle Mead NJ). 2016;45(6):E355-61.
25. Brinkman JM, Lobenhoffer P, Agneskirchner JD, Staubli AE, Wymenga AB, van Heerwaarden RJ. Osteotomies around the knee: patient selection, stability of fixation and bone healing in high tibial osteotomies. J Bone Joint Surg Br. 2008;90(12):1548-57.
26. Salman LA, Abudalou A, Khatkar H, Ahmed G, Dakin SG, Kendrick B, et al. Impact of age on unicompartmental knee arthroplasty outcomes: a systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2023;31(3):986-97.
27. Migliorini F, Maffulli N, Cuozzo F, Elsner K, Hildebrand F, Eschweiler J, et al. Mobile Bearing versus Fixed Bearing for Unicompartmental Arthroplasty in Monocompartmental Osteoarthritis of the Knee: A Meta-Analysis. J Clin Med. 2022;11(10):2837.
28. Ko YB, Gujarathi MR, Oh KJ. Outcome of Unicompartmental Knee Arthroplasty: A Systematic Review of Comparative Studies between Fixed and Mobile Bearings Focusing on Complications. Knee Surg Relat Res. 2015;27(3):141-8.