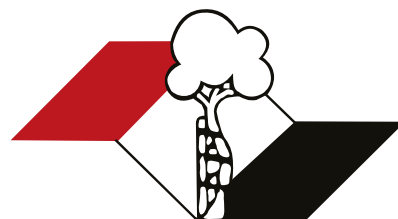


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ISSN 1413-7852

Acta Ortopédica Brasileira



Volume 33 – Number 3 – Year 2025

Special

Acta Ortopédica Brasileira



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

Affiliated with Associação Brasileira de Editores Científicos



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COST AND POLLUTANTS EMISSION REDUCTION WITH A TELEMEDICINE PROGRAM FOR HIP SURGERY IN BRAZIL

REDUÇÃO DE CUSTOS E EMISSÕES DE POLUENTES COM PROGRAMA DE TELEMEDICINA PARA CIRURGIA DO QUADRIL NO BRASIL

FABIO SEIJI MAZZI YAMAGUCHI¹ , HECTOR FUGIHARA KROES² , GABRIEL BENEVIDES VALIATE MARTINS¹ ,
GUSTAVO ESTEFAN LAGE¹ , VITOR MATHEUS SILVA² , HENRIQUE MELO DE CAMPOS GURGEL¹ 

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ABSTRACT

Objective: To evaluate the economic and environmental impacts of telemedicine use and the correlation of socioeconomic variables with telemedicine preference in patients with hip pathologies at a tertiary referral center in São Paulo, Brazil. **Methods:** A cross-sectional study (January-June 2024) analyzed telemedicine patients, collecting data on preferences, socioeconomic profile, travel, and costs (transport and food). Avoided distance, time, and pollutant emissions were calculated using Google Maps and emission factors. The preference for telemedicine was correlated with socioeconomic data. Statistical analyses used Wilcoxon, chi-square, and logistic regression tests. **Results:** 148 patients were included, of whom 77.7% preferred telemedicine. The mean round-trip distance avoided was 168.84 km, and the mean time saved was 223.97 minutes. Estimated out-of-pocket savings were USD 12.62 for public transport users and USD 28.95 for private car users. Telemedicine also reduced emissions by approximately seven metric tons of carbon dioxide in total. Higher income was positively associated with telemedicine preference ($p=0.0283$); other variables showed no significant associations. **Conclusion:** Telemedicine reduced time, costs, and emissions, improving access. Preference was higher among wealthier patients, indicating barriers for low-income groups. Further studies should explore low adherence among socioeconomically disadvantaged populations. **Level of Evidence IV; Economic and Decision Analysis.**

Keywords: Telemedicine; Hip Joint; Orthopedics; Air Pollution; Carbon Dioxide; Costs and Cost Analysis.

RESUMO

Objetivo: Avaliar os impactos econômicos e ambientais da telemedicina e a correlação de variáveis socioeconômicas com a preferência por telemedicina em pacientes com patologias do quadril atendidos em centro de referência terciário em São Paulo, Brasil. **Métodos:** Estudo transversal (janeiro a junho de 2024) com pacientes atendidos por telemedicina, com dados sobre preferências, perfil socioeconômico, deslocamento e custos (transporte/alimentação). Distância, tempo e emissões evitadas foram estimados com o Google Maps e fatores de emissão. Correlacionou-se a preferência por telemedicina com dados socioeconômicos. Utilizaram-se testes de Wilcoxon, qui-quadrado e regressão logística. **Resultados:** Participaram 148 pacientes, dos quais 77,7% preferiram a telemedicina. A média de distância de deslocamento evitada foi de 168,84 km, com economia média de tempo de 223,97 minutos. Pacientes que utilizavam transporte público e carro particular economizaram, respectivamente, US\$ 12,62 e US\$ 28,95. A telemedicina também reduziu as emissões de poluentes, evitando aproximadamente sete toneladas de dióxido de carbono. A preferência pela telemedicina esteve positivamente associada à maior renda ($p = 0,0283$). As demais variáveis não apresentaram associações estatisticamente significativas. **Conclusão:** A telemedicina reduziu o tempo, custos e as emissões, melhorando o acesso. A preferência foi maior entre pacientes com maior renda, indicando barreiras para os grupos de baixa renda. Novos estudos devem explorar a baixa adesão entre populações em situação de vulnerabilidade socioeconômica. **Nível de Evidência IV; Análises econômicas e de decisão.**

Descritores: Telemedicina; Quadril; Ortopedia; Poluição do Ar; Dióxido de Carbono; Custos e Análise de Custo.

Citation: Yamaguchi FSM, Kroes HF, Martins GBV, Lage GE, Silva VM, Gurgel HMC. Cost and pollutants emission reduction with a telemedicine program for hip surgery in Brazil. Acta Ortop Bras. [online]. 2025;33(3) Esp.: Page 1 of 6. 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 Instituto de Ortopedia e Traumatologia do Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo, R. Dr. Ovidio Pires de Campos, 333, Cerqueira Cesar, São Paulo, SP, Brazil. 05402-000.

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Article received on 04/17/2025 approved on 06/27/2025.



INTRODUCTION

Telemedicine delivers healthcare services remotely using technologies such as videoconferencing and phone calls. This approach enables consultations, diagnoses, and monitoring without in-person visits.¹ Following the onset of the COVID-19 pandemic in March 2020, many healthcare services adopted telemedicine programs as an alternative to in-person consultations, ensuring continuity of care and significantly increasing its use.²

Numerous studies have analyzed the socioeconomic impacts of telemedicine, highlighting its expansion of patient access to healthcare services, particularly where distance and travel time are significant barriers.³⁻⁵ Furthermore, research has demonstrated the potential of this approach to mitigate environmental impacts by reducing pollutant emissions from fuel combustion during patient travel.^{6,7} Such studies are particularly relevant to Brazil, considering the large regional and sociodemographic disparities in access to healthcare, as well as the adverse effects of pollutant emissions on public health and, consequently, on the country's public health system.⁸⁻¹¹

This study evaluates the socioeconomic and environmental impact of an orthopedic telemedicine program for Hip Group patients at a tertiary referral hospital in São Paulo. Launched in 2021, the program primarily serves residents of the capital but also includes patients from other municipalities and states. We compare travel distance, time, and out-of-pocket costs, together with transport-related emissions, including greenhouse gases and air pollutants, between telemedicine visits and hypothetical in-person consultations at the same hospital.

METHODS

This cross-sectional study was conducted with patients receiving care via telemedicine. Ethical approval was obtained from the Research Ethics Committee of the Hospital das Clínicas, Faculty of Medicine, University of São Paulo (approval number 5.022.929; CAAE: 51877521.0.0000.0068). Patients provided consent through a digital informed consent form (ICF). During virtual consultations, participants were invited to join the study by completing a structured questionnaire. The questionnaire collected data on demographic characteristics, place of residence, modes of transportation used for in-person consultations, the need for companions, and expenses related to transportation and meals.

Population

The study included patients who attended telemedicine outpatient consultations provided by the Hip Group between January and June 2024. Exclusion criteria included individuals who did not sign the informed consent form, those who failed to respond to all questions in the questionnaire, and participants who withdrew from the study at any stage.

Distance and travel time

The distance and travel time between the patients' residences and the hospital in São Paulo were calculated using Google Maps, considering the fastest route. Travel time was estimated based on the mode of transportation indicated by the patient, with a fixed arrival time of 8:00 AM. The same route was used to estimate both distance and travel time. Final values were doubled to account for the round trip.

Cost calculation

Transportation and meal costs were calculated based on the round-trip journey from the patient's residence to the hospital. For individuals using a private car, fuel consumption was estimated at 10 km/L, with the price of gasoline set at BRL 5.74 per liter as of

March 2024.¹²⁻¹³ For public transportation, costs were based on round-trip ticket prices according to Google Maps. Additionally, meal expenses were estimated at BRL 15.00 for unaccompanied patients and BRL 30.00 for those accompanied. All costs were presented in USD and calculated with the purchasing power parity exchange rate of BRL 2.3 per USD as per CCEMG-EPPI Centre Cost Converter, designed to facilitate international comparison of costs.¹⁴

Pollutant emissions

For the calculation of emissions, travel distances were multiplied by standardized emission factors for "Passenger Cars and Light Commercial Vehicles" and "Urban and Intercity Buses," as published by Diana Maria Cancelli and Nelson Luís Dias. To estimate the reduction in emissions, only the pollutants generated by fuel combustion were considered, assuming the patient had opted for an in-person consultation.¹²

Statistical analysis and figure generation

The relationship between continuous variables and the preference for telemedicine was analyzed using the Shapiro-Wilk test for normality. Depending on the normality, either the Student's t-test or the Wilcoxon test was applied to continuous variables. Logistic regression was used to explore significant relationships, and the chi-square test was employed to evaluate associations with categorical variables. Mean and standard deviation were used for descriptive statistics (significance level: 0.05). The Clipcoords v0.1.0 software¹⁵ was used for geocoding, and all analyses were performed using R v4.3.1 (RStudio v2023.09.1).

RESULTS

Data were collected from 150 patients, of whom 2 were excluded for using modes of transportation not covered by the study, resulting in 148 eligible participants. Of these, 3 were further excluded from the analyses of distance, travel time, and pollutant emissions due to geocoding failures.

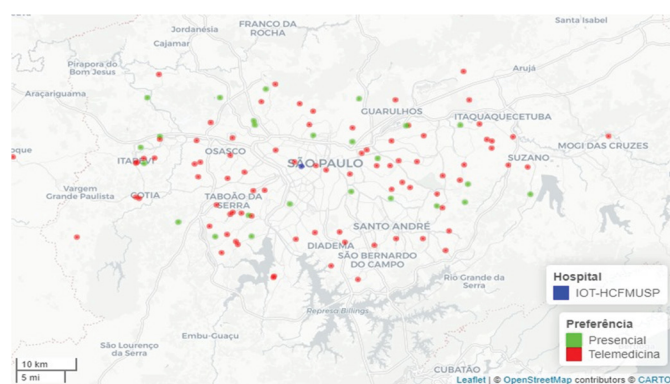
Among the 148 eligible participants, 115 (77.7%) preferred telemedicine, while 33 (22.3%) preferred in-person consultations (Table 1). Most of the patients lived either in the municipality of São Paulo (43%) or other municipalities within the state (52%), and only a minority (5.5%) in other states (Figures 1-3). The median distance for all patients would be 62 km (IQR: 40–118.50 km), with a minimum of 4 km and a maximum of 5,046 km. This distance would be travelled with a median duration of 156 minutes (IQR: 120.50–216.50), with durations ranging from 20 to 4,320 minutes. The distribution of this data is present in Figure 1. To travel, 78 (53%) would use private cars, and 70 (47%) would rely on public transportation (Table 1). The median income found was 2.00 (IQR 1.00–3.00) Brazilian minimum wages (BRL 1,412.00 / USD 613.91). The median cost associated with attending in-person consultations was USD 13.47 (IQR 10.32–21.59), with a median cost-to-income ratio of 1.53% (IQR 0.67–2.93). Additionally, 72 patients (49%) required an accompanying person. Patient absence from work was necessary for 51 patients (34%), while 36 patients (24%) also indicated their accompanying person would need to miss work (Table 2).

Data analysis revealed a positive and statistically significant association between patients' income and their preference for online consultations ($p = 0.0283$), although the logistic regression model used did not reach statistical significance (coefficient = 0.2840; $p = 0.1531$). The mean income in the group favouring telemedicine was 2.10 ± 1.08 minimum wages, compared to 1.78 ± 1.22 minimum wages in the group preferring in-person consultations.

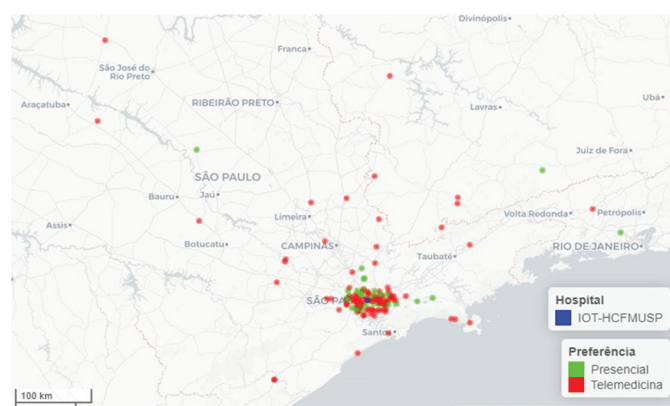
While the average distance and travel time for the telemedicine group (179.45 ± 498.83 km and 230.46 ± 408.62 minutes) were higher than those for the in-person consultation group ($132.48 \pm$

Table 1. Data on travel to IOT-HCFMUSP categorized by preferred consultation modality.

Variables	Telemedicine N = 115	In-person consultation N = 33	Total
Round-trip distance saved (km)			
Mean (SD)	179.45 (498.83)	132.48(214.06)	168.84 (450.22)
Median (IQR)	62.00 (40.00, 120.00)	58.00 (40.00, 90.00)	62.00 (40.00, 118.50)
Range (min, max)	4.00; 5,046.00	12.00; 818.00	4.00; 5,046.00
Sum	20,278.00	4,372.00	24,650.00
Round-trip time saved (min)			
Mean (SD)	230.46 (408.62)	201.76 (165.34)	223.97 (367.63)
Median (IQR)	160.00 (122.00, 244.00)	146.00 (120.00, 174.00)	156.00 (120.50, 216.50)
Range (min, max)	20.00; 4,320.00	50.00; 752.00	20.00; 4,320.00
Sum	26,042.00	6,658.00	32,700.00
Means of Transportation			
Private Car	64 (56%)	14 (42%)	78 (53%)
Public Transport	51 (44%)	19 (58%)	70 (47%)
Patients' Place of Origin			
City of São Paulo	45 (40%)	17 (52%)	62 (43%)
Other Cities within the State of São Paulo	61 (54%)	14 (42%)	75 (52%)
Out of State	6 (5.4%)	2 (6.1%)	8 (5.5%)



Source: Authors' elaboration based on data collected in the IOT-HCFMUSP telemedicine program (2022–2023); Basemap: © OpenStreetMap contributors; Tiles: © CARTO; Rendered With: Leaflet.

Figure 1. Geographic distribution of patients served by the orthopedic telemedicine program, covering the city of São Paulo.

Source: Authors' elaboration based on data collected in the IOT-HCFMUSP telemedicine program (2022–2023); Basemap: © OpenStreetMap contributors; Tiles: © CARTO; Rendered With: Leaflet.

Figure 2. Geographic distribution of patients served by the orthopedic telemedicine program, covering the state of São Paulo.

214.06 km and 201.76 ± 165.34 minutes), no significant relationship was observed between these variables and the preference for consultation type. Similarly, no significant associations were found with municipality of residence, cost, use of public transportation, presence of a companion, or the need for the patient or companion to take time off work.



Source: Authors' elaboration based on data collected in the IOT-HCFMUSP telemedicine program (2022–2023); Basemap: © OpenStreetMap contributors; Tiles: © CARTO; Rendered With: Leaflet.

Figure 3. Geographic distribution of patients served by the orthopedic telemedicine program, covering all regions of Brazil.

During data collection regarding transportation for a hypothetical in-person consultation, some patients were unable to reliably report information such as fares, fuel consumption, or parking costs. Therefore, it was only possible to calculate environmental impact estimates for 119 of the 148 participants. Patients who would have used public buses ($n = 42$) avoided the emission of a median of 24.92 kg of carbon dioxide (CO_2), 28.0 g of nitrogen oxides (NO_x), 504.0 g of non-methane hydrocarbons, and 11.2 g of particulate matter (PM) per consultation. Similarly, for patients using private vehicles and with successfully calculated distances ($n = 77$), telemedicine prevented the release of 13.44 kg of CO_2 , 25.6 g of NO_x , 0.64 g of aldehydes, 25.6 g of non-methane hydrocarbons, 0.96 g of PM, and 9.6 g of methane (CH_4) per consultation (Table 3).

DISCUSSION

No national studies were identified that would allow a direct comparison with our findings. However, when analyzing international studies and adjusting values based on Purchasing Power Parity (PPP) to U.S. dollars (USD),¹⁴ the following data were observed: in the U.S., Dullet NW et al. reported average savings of 447 km, 245 minutes, and USD 195.¹⁶ In a Colombian population, Prada SI et al. documented an average reduction of 73 km, 108 minutes,

Table 2. Socioeconomic elements divided by consultation modality preference.

Variables	Telemedicine N = 115	In-person consultation N = 33	Total
Income (minimum wages)			
Mean (SD)	2.10 (1.08)	1.78 (1.22)	2.03 (1.12)
Median (IQR)	2.00 (1.00, 3.00)	1.00 (1.00, 2.00)	2.00 (1.00, 3.00)
Range (min, max)	0.00, 6.00	0.80, 5.00	0.00, 6.00
Cost			
Mean (SD)	48.66 (49.06)	49.51 (57.21)	48.85 (50.80)
Median (IQR)	30.84 (23.80, 55.54)	31.65 (23.80, 47.60)	31.07 (23.80, 49.80)
Range (min, max)	4.02, 303.22	0.00, 264.77	0.00, 303.22
Sum	5,547.43	1,633.77	7,181.20
Cost/Income (%)			
Mean (SD)	2.31 (2.97)	3.11 (4.51)	2.49 (3.38)
Median (IQR)	1.45 (0.60, 2.66)	1.80 (1.15, 3.14)	1.53 (0.67, 2.93)
Range (min, max)	0.11, 18.06	0.00, 20.06	0.00, 20.06
Meal-related expenses			
Yes	84 (73%)	27 (82%)	111 (75%)
No	31 (27%)	6 (18%)	37 (25%)
Presence of companion			
Yes	55 (48%)	17 (52%)	72 (49%)
No	60 (52%)	16 (48%)	76 (51%)
Patient work absenteeism			
Yes	44 (38%)	7 (21%)	51 (34%)
No	71 (62%)	26 (79%)	97 (66%)
Companion work absenteeism			
Yes	28 (24%)	8 (24%)	36 (24%)
No	87 (76%)	25 (76%)	112 (76%)

Table 3. Emissions avoided through the implementation of a telemedicine consultation strategy, divided by means of Transportation.

Variables	Public Transport N = 42	Private Car N = 77	Total
Carbon dioxide (kg)			
Mean (SD)	105.25 (351.87)	35.18 (43.30)	59.91 (212.97)
Median (IQR)	24.92 (15.13, 36.05)	13.44 (9.66, 48.72)	17.80 (10.71, 38.72)
Range (min, max)	3.56; 2,245.47	2.94, 199.92	2.94; 2,245.47
Sum	4,420.63	2,709.00	7,129.63
Nitrogen oxides (g)			
Mean (SD)	118.26 (395.36)	67.01 (82.47)	85.10 (243.51)
Median (IQR)	28.00 (17.00, 40.50)	25.60 (19.40, 92.80)	25.60 (17.30, 55.60)
Range (min, max)	4.00; 2,523.00	5.60, 380.80	4.00; 2,523.00
Sum	4,967.00	5,160.00	10,127.00
Non-methane hydrocarbons (g)			
Mean (SD)	2,128.71 (7,116.43)	67.01 (82.47)	794.67 (4,310.44)
Median (IQR)	504.00 (306.00, 729.00)	25.60 (18.40, 92.80)	107.20 (22.40, 325.60)
Range (min, max)	72.00; 45,414.00	5.60, 380.80	5.60; 45,414.00
Sum	89,406.00	5,160.00	94,566.00
Particulate matter (g)			
Mean (SD)	47.30 (158.14)	2.51 (3.09)	18.32 (95.70)
Median (IQR)	11.20 (6.80, 16.20)	0.96 (0.69, 3.48)	3.03 (0.84, 8.37)
Range (min, max)	1.60; 1,009.20	0.21, 14.28	0.21; 1,009.20
Sum	1,986.80	193.50	2,180.30
Methane (g)			
Mean (SD)	-	25.13 (30.93)	25.13 (30.93)
Median (IQR)	-	9.60 (6.90, 34.80)	9.60 (6.90, 34.80)
Range (min, max)	-	2.10, 142.80	2.10, 142.80
Sum	-	1,935.00	1,935.00
Aldehydes (g)			
Mean (SD)	-	1.68 (2.06)	1.68 (2.06)
Median (IQR)	-	0.64 (0.46, 2.32)	0.64 (0.46, 2.32)
Range (min, max)	-	0.14, 9.52	0.14, 9.52
Sum	-	129.00	129.00

USD 10 in fuel, and USD 17.5 in public transportation costs.¹⁷ In Mali, Bagayoko CO et al. reported approximate savings of USD 50 in transportation costs.¹⁸ Direct comparison between populations with such distinct socioeconomic profiles is complex. While Dullet et al. reported significant savings, their study focused on a rural population in California, where patients travelled proportionally longer distances than observed in other studies, including the present one.¹⁶ While Prada et al. reported the smallest savings, reflecting a Colombian population that mostly resided within the same city as the hospital, when considering subpopulations outside the “Valle del Cauca” region, the observed savings align more closely with our study.¹⁷ Lastly, although Bagayoko CO did not detail distances, times, or criteria used to calculate transportation costs, the reported values are similar to those identified in our analysis.¹⁸ Similarly to what Bagayoko highlighted in his article, in Brazil—a country with significant income inequality—such expenditures represent a substantial burden for a large portion of the population, with the costs of a single in-person consultation amounting to up to 20% of a patient’s monthly income.

Barriers to healthcare access are a widely discussed topic in the literature. Among these barriers, hospital distance and access to transportation are particularly relevant, especially in vulnerable populations disproportionately burdened by diseases.^{19,20} These difficulties may result in poor adherence to medical appointments, increased hospitalizations, and worse management of chronic conditions. National studies addressing the Brazilian context support these trends, highlighting the need for measures to mitigate these barriers.^{8,9} In this context, telemedicine emerges as a promising alternative, enabling patients with access difficulties to receive high-quality remote care. However, our analysis identified a significant positive correlation between income and preference for telemedicine, which raises questions, as an inverse correlation was expected, given that low-income populations face greater access barriers. This underscores the complexity of factors influencing healthcare access, highlighting potential barriers for lower-income populations. Levesque JF et al. describe five essential capacities to effectively interact with healthcare services: perceiving service availability, willingness to use it, having access, affording the costs, and engaging.²¹ To better explore these dimensions in the telemedicine context, a more comprehensive analysis of socioeconomic factors affecting usability is needed.

From the perspective of pollutant emission reductions, the fuel savings for the 119 patients with a single online consultation equate to the monthly per capita emissions of approximately 39 Brazilians.²² During data collection regarding transportation for a hypothetical in-person consultation, some patients were unable to reliably report information such as fares, fuel consumption, or parking costs. Therefore, it was only possible to calculate environmental impact estimates for 119 of the 148 participants. Furthermore, there

was a significant reduction in emissions of nitrogen oxides (NO_x), non-methane hydrocarbons, particulate matter, and aldehydes—pollutants directly associated with fossil fuel combustion, known to exacerbate respiratory and cardiovascular diseases. Reducing these pollutants contributes not only to better air quality but also to fewer hospitalizations and lower mortality, positively impacting public health and reducing healthcare costs.^{6,7,23}

Reducing greenhouse gas (GHG) emissions, such as carbon dioxide, nitrogen oxides, and methane, directly contributes to mitigating climate change. Less GHG in the atmosphere means reduced global warming and its consequent impacts, such as rising sea levels, extreme weather events, and ecosystem changes. The decrease in particulate matter improves air quality, reducing respiratory and cardiovascular problems among the population. The reduction in non-methane hydrocarbons also enhances air quality and decreases photochemical smog, minimizing health and environmental impacts.²⁴

Limitations of the current study include the limitation on the information about the transportation methods used by the patients in the event of an in-person consultation. The methodology employed in this study included a standard emission measure that considers only the vehicle category, as specific details about individual fuel types for each vehicle were not available. While this approach provides a generalized estimation of avoided emissions, it highlights the need for improved data collection methods in future studies to achieve greater specificity. This limitation is an inherent challenge in studies analyzing the environmental impacts of telemedicine, but it does not detract from the clear benefits demonstrated by this analysis. Additionally, the lack of detailed information on the usability of telemedicine as perceived by patients may introduce confounding factors, complicating the interpretation of our findings. Administering validated questionnaires and evaluating their usability could help clarify these factors.

CONCLUSION

This study demonstrated that orthopedic Telemedicine in Brazil provides significant economic and environmental benefits. The adoption of this modality substantially reduced patient travel time and costs, while also contributing to a decrease in pollutant emissions generated by the combustion of fossil fuels. This reduction in emissions highlights telemedicine’s potential to improve health access, mitigate the effects of socioeconomic inequalities and climate change and its impacts on public health, particularly in São Paulo, where improved air quality may help reduce expenses related to respiratory and cardiovascular diseases. However, additional research is necessary to better understand the barriers and preferences associated with telemedicine use, especially among low-income populations.

AUTHOR’S CONTRIBUTION:

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EVALUATION OF A DECADE OF ONCOLOGICAL-ORTHOPEDIC PROCEDURES IN BRAZIL (2015–2024) AND THE IMPACT OF COVID-19

AVALIAÇÃO DE UMA DÉCADA DE PROCEDIMENTOS ONCOLÓGICO-ORTOPÉDICOS NO BRASIL (2015–2024) E O IMPACTO DA COVID-19

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ABSTRACT

Objective: To evaluate the regional distribution of hospital admission authorizations (AIH), total and average hospitalization cost (AHC), average length of stay, number of deaths and mortality rate related to oncological-orthopedic procedures funded by the Unified Health System (SUS) between 2015 and 2024, with an emphasis on the impact of the COVID-19 pandemic. **Methods:** Ecological study with time series based on data obtained from the SUS Hospital Information System, analyzed by Brazilian regions in the pre-pandemic, pandemic and post-pandemic periods. Regional differences were calculated using ANOVA or Kruskal-Wallis. The impact of the pandemic was analyzed using T-tests and ARIMA with intervention. Statistical analysis was performed in R. **Results:** 9,120 AIHs were recorded, mostly in the Southeast (4,375) and South (2,252) regions. Multiple regional variations were found for all the variables evaluated. Only the AHC was impacted – there was an increase in costs per procedure; The other variables maintained the trend after the beginning of the pandemic. **Conclusions:** Despite the increase in the AHC, we did not observe significant variation in the number of AIH, ALS, and MR when analyzing the pre-pandemic and pandemic periods, suggesting that there was no direct impact on the performance of the analyzed procedure. **Level of Evidence III; Retrospective^f comparative study^e.**

Keywords: Bone Neoplasms; Prostheses and Implants; Orthopedic Procedures; Unified Health System; COVID-19.

RESUMO

Objetivo: Avaliar a distribuição regional das autorizações de internação hospitalar (AIH), custos total e médio de internação hospitalar (CMH), tempo médio de permanência, número de óbitos e taxa de mortalidade relacionados aos procedimentos oncológico-ortopédicos financiados pelo Sistema Único de Saúde (SUS) entre 2015 e 2024, com ênfase no impacto da pandemia de COVID-19. **Métodos:** Estudo ecológico com séries temporais baseadas em dados obtidos do Sistema de Informações Hospitalares do SUS, analisados por regiões brasileiras, nos períodos pré-pandemia, pandêmico e pós-pandemia. As diferenças regionais foram calculadas por ANOVA ou Kruskal-Wallis. O impacto da pandemia foi analisado por meio de testes T e ARIMA com intervenção. A análise estatística foi realizada no R. **Resultados:** Foram registradas 9.120 AIHs, a maioria nas regiões Sudeste (4.375) e Sul (2.252). Múltiplas variações regionais foram encontradas para todas as variáveis avaliadas. Apenas o CMH foi impactado – houve aumento nos custos por procedimento; as demais variáveis apresentaram manutenção da tendência após o início da pandemia. **Conclusões:** Apesar do aumento do CMH, não foi observada variação significativa no número de AIH, TMP e TM quando analisados os períodos pré-pandêmico e pandêmico, sugerindo que não houve impacto direto no desempenho do procedimento analisado. **Nível de Evidência III; Estudo^e Comparativo Retrospectivo^f.**

Descritores: Neoplasias Ósseas; Próteses e Implantes; Procedimentos Ortopédicos; Sistema Único de Saúde; COVID-19.

Citation: Guedes A, Camargo OP, Matos EP, Carreiro MC, Rios FF, Guimarães AHS, Meyer KA, Lima NFL, Barreto BG, Mattos ESR, Antunes Júnior CR, Barreto ESR. Evaluation of a decade of oncological-orthopedic procedures in Brazil (2015–2024) and the impact of COVID-19. Acta Ortop Bras. [online]. 2025;33(3) Esp.: Page 1 of 5. Available from URL: <http://www.scielo.br/aob>.

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

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Article received on 05/26/2025 approved on 08/04/2025.



INTRODUCTION

The treatment of bone tumors through resection followed by prosthetic replacement or reconstruction with fixation has revolutionized orthopedics. Advances in medical and implant technologies have contributed to improved outcomes, both oncological and functional, leading to enhanced quality of life for patients.¹

The Hospital Information System (SIH) of Brazil's Unified Health System (SUS) provides a comprehensive database for analyzing hospital admissions across the country.² Studying the regional distribution of procedures funded by SUS is essential for guiding effective healthcare strategies, enabling the identification of potential challenges and opportunities for improving care for patients with bone neoplasms.

The COVID-19 pandemic imposed major challenges on healthcare systems worldwide, affecting the capacity to perform elective procedures, including bone tumor resection surgeries,³ due to the reallocation of resources toward managing COVID-19.⁴ To date, the impact of the COVID-19 pandemic on resection procedures involving prosthetic replacement (endoprosthesis) or reconstruction with fixation within the SUS system has not been evaluated.

This study aimed to describe the regional distribution of hospital admission authorizations (AIH), total hospitalization costs (THC), average hospitalization costs (AHC), average length of stay (ALS), number of deaths (ND), and mortality rate (MR) related to resection procedures with prosthetic replacement (endoprosthesis) or reconstruction with fixation in oncology, funded by SUS over a ten-year period (2015-2024), with particular emphasis on the impact of the COVID-19 pandemic.

METHODS

This ecological time-series study analyzed bone tumor resection procedures involving either prosthetic replacement (endoprosthesis) or reconstruction with fixation in oncology, categorized under code 04.16.09.010-9 in the SUS Procedure, Medication, Orthoses, Prostheses, and Special Materials Management System (SIGTAP). The primary focus was to assess the potential impact of the COVID-19 pandemic. Epidemiological data were examined for the period from January 1, 2015, to December 31, 2024, encompassing three distinct phases: pre-pandemic (January 2015 to January 2020), pandemic (February 2020 to May 2022), and post-pandemic (June 2022 to December 2024).

Data were obtained from the SUS Hospital Information System (SIH/SUS),² which compiles information on procedures performed within Brazil's public healthcare system. Analyses were stratified by geographic region (Midwest, North, Northeast, Southeast, and South). The variables examined included the AIH, THC, AHC, ALS, ND, and MR.

Statistical Analysis

Continuous variables were first assessed for normality using the Shapiro-Wilk test. Variables with normal distributions were summarized

as means and standard deviations, while non-normally distributed data were presented as medians and interquartile ranges (Q1–Q3). Comparisons across the three time periods were performed using Student's T-test for normally distributed variables, accounting for variance differences where applicable. For non-normal data, the Mann-Whitney U test was applied. Regional comparisons were conducted using one-way ANOVA for normally distributed variables or the Kruskal-Wallis test for non-normal data.

To analyze temporal trends and detect structural changes potentially associated with the onset of the pandemic, autoregressive integrated moving average models with intervention (intervention ARIMA) were employed. The intervention point was set in February 2020. The auto.arima function was used to automatically identify optimal model parameters (p, d, q) based on the corrected Akaike Information Criterion (AICc). These models estimated the pandemic's impact on time series levels while adjusting for trend, seasonality, and autocorrelation components.

Model adequacy was assessed through residual analysis, including the Ljung-Box test for serial autocorrelation and first-order autocorrelation inspection (ACF1). Predictive accuracy was quantified using the Mean Absolute Percentage Error (MAPE), calculated by comparing observed values with model-adjusted estimates.

All analyses were conducted using R software (version 4.3.1), employing the forecast, tibble, lubridate, dplyr, and ggplot2 packages. A p-value of <0.05 was considered statistically significant for all tests.

Ethical Considerations

Ethics committee approval was not required for this study, as it used secondary data derived from publicly available sources, in accordance with Resolution No. 510/2016 of the Brazilian National Health Council.

RESULTS

During the study period, a total of 9,120 hospital admission authorizations (AIHs) were issued under SIGTAP-SUS code 04.16.09.010-9, distributed as follows: 545 in the Midwest, 1,463 in the Northeast, 485 in the North, 4,375 in the Southeast, and 2,252 in the South. Regional analyses of AHC, ALS, and MR are presented in Table 1. The THC for SUS during the period was BRL 78,317,313.75, with an estimated AHC of BRL 8,296.15 (± 985.86). Considerable variation was observed among regions. The Midwest had the lowest average monthly AHC (BRL 6,896.75 $\pm 2,343.40$), while the South recorded the highest (BRL 9,700.71 $\pm 1,624.23$). Statistically significant differences were found across regional combinations. The South showed significantly higher AHC values than all other regions, except for the North ($p = 0.25$). Conversely, the Midwest exhibited significantly lower AHCs, especially in comparison with the South, North, and Northeast.

The national average ALS was 7.13 days, but substantial regional variability was observed. The North reported the highest average (11.90 days; IQR: 6.90–13.50), while the Northeast had the lowest (4.98 days; IQR: 3.68–5.60). Statistical tests identified significant

Table 1. Regional comparison of hospital outcomes in the SUS: number of procedures, cost, length of stay and mortality rate (2015–2024).

	North	Northeast	Southeast	South	Midwest	Total	p
Number of procedures (median Q1 – Q3)	4.0 (2.0 - 6.0)	12.0 (8.0 - 16.0)	37.0 (32.3 - 42.0)	19.0 (15.0 - 23.0)	4.0 (2.0 - 6.0)	78.0 (68.00 - 87.75)	<0.001
Mean value (R\$) (mean standard deviation)	9025.37 (3532.30)	8363.57 (2220.35)	7683.34 (986.04)	9700.71 (1624.23)	6896.75 (2343.40)	8296.15 (985.86)	<0.001
Length of stay in days (median, Q1 – Q3)	10.0 (6.9 - 13.5)	4.40 (3.68 - 5.60)	7.0 (6.2 - 8.2)	7.25 (6.33 - 8.70)	4.60 (3.30 - 6.90)	6.90 (6.40 - 7.68)	<0.001
Mean mortality rate (%) (median, Q1 – Q3)	0.0 (0.0 - 0.0)	0.0 (0.0 - 5.88)	2.60 (0.0 - 5.71)	4.35 (0.0 - 7.34)	0.0 (0.0 - 0.0)	3.53 (2.18 - 5.14)	<0.001

differences across multiple regional comparisons. The North had significantly longer ALSs than all other regions. In contrast, the Northeast had significantly shorter ALSs compared to the North, South, and Southeast, indicating a trend of shorter hospital stays in that region.

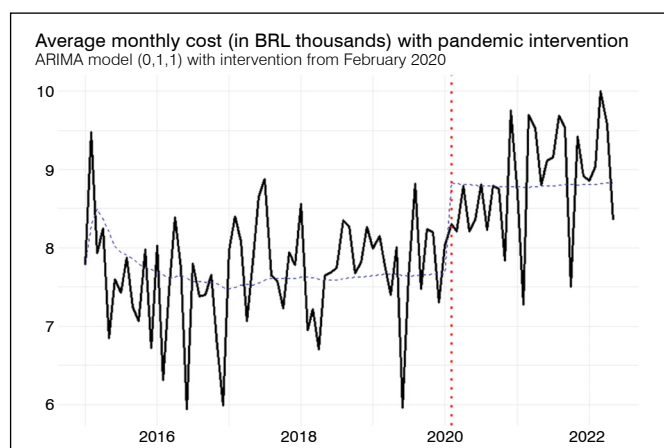
During this period, 357 deaths were recorded. The overall MR in Brazil was 3.77 deaths per 100 hospitalizations, with notable regional differences. The Northeast had the lowest MR (2.79%), whereas the South registered the highest (4.86%). Significant differences were found between some regional pairs. Specifically, the South had a significantly higher MR than the North, Northeast, and Southeast. Additionally, the Midwest presented a significantly higher MR compared to the Northeast.

In the pre-pandemic period, the mean number of monthly authorized AIHs was 72.51 (± 14.01), increasing to 85.04 (± 10.63) during the pandemic, with a statistically significant difference ($p < 0.001$). In the time series analysis with intervention, ARIMA (0,1,1)(1,0,0)[12], the estimated intervention coefficient was -7.76 and not statistically significant ($p = 0.216$), indicating no sustained structural change in the series level associated with the onset of the pandemic. Residual analysis confirmed adequate model fit, with no significant autocorrelation (Ljung-Box test: $Q = 12.89$; $df = 16$; $p = 0.681$), near-zero first-order autocorrelation ($ACF1 = -0.017$), and a MAPE of 10.46%, indicating satisfactory forecasting performance. Figure 1 illustrates the variation in the number of AIHs over the study period. During the pre-pandemic period, the average monthly AHC was BRL 7,670.90 (± 691.02), increasing to BRL 8,828.04 (± 691.13) during the pandemic, a statistically significant difference ($p < 0.001$). To investigate the temporal dynamics and estimate the structural impact of the pandemic, an intervention time series model was applied. In the ARIMA (0,1,1), the intervention was associated with an estimated level increase of BRL 1,157.22, which was statistically significant ($p < 0.001$). Residual analysis indicated adequate model fit, with no signs of autocorrelation (Ljung-Box test: $Q = 17.46$; $df = 17$; $p = 0.4235$), near-zero first-order autocorrelation ($ACF1 = 0.03$), and a MAPE of 6.82%. Figure 2 shows the variation in AHC over the study period.

In contrast, a direct comparison between pre-pandemic and pandemic periods showed that median ALS decreased from 7.00 days (IQR: 6.60–8.25) to 6.70 days (IQR: 6.10–7.25), a statistically significant difference ($p = 0.027$). However, the ARIMA (0,1,1) intervention model did not identify a significant structural change associated with the pandemic onset. Residual analysis confirmed no significant autocorrelation ($p = 0.2861$; $ACF1 = 0.114$), and the estimated intervention

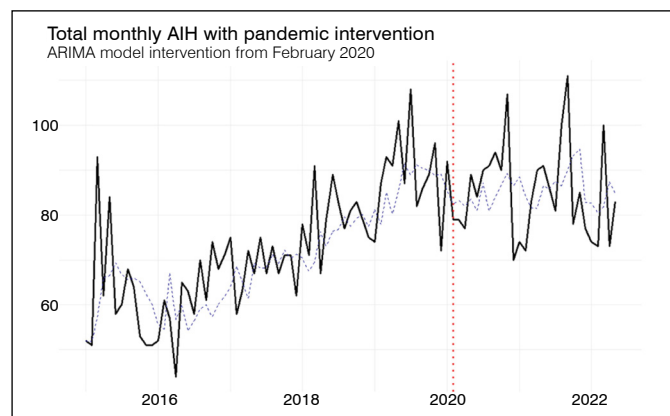
coefficient was 0.0330 ($p = 0.961$), indicating no significant effect. These results suggest that, despite the observed difference in medians, there was no sustained change in the trend of hospitalization over time. Figure 3 shows the variation in ALS and the difference between pre-pandemic and pandemic periods.

Regarding monthly MR, median values rose from 3.23 (IQR: 1.63–5.37) in the pre-pandemic period to 3.98 (IQR: 2.75–4.96) during the pandemic, but the difference was not statistically significant ($p = 0.344$). The ARIMA (0,0,0) model with intervention also did not detect a structural change associated with the onset of the pandemic. The estimated intervention coefficient was 0.3807 ($p = 0.433$). The lack of statistical significance supports the interpretation that the pandemic did not consistently impact the level of the mortality rate series. Residual analysis confirmed adequate model performance (Ljung-Box test: $Q = 20.58$; $df = 17$; $p = 0.195$), although the predictive accuracy was lower (MAPE = 54.88%), indicating greater variability and reduced forecasting precision for this indicator. Figure 4 illustrates the variation in MR over time and the comparison between pre-pandemic and pandemic periods. A comparative analysis between pre- and post-pandemic periods was also conducted to assess changes in the studied indicators after the onset of the pandemic. The mean monthly number of AIHs increased from 72.51 (14.01) in the pre-pandemic period to 79.71 (17.28) in the post-pandemic period, with a significant



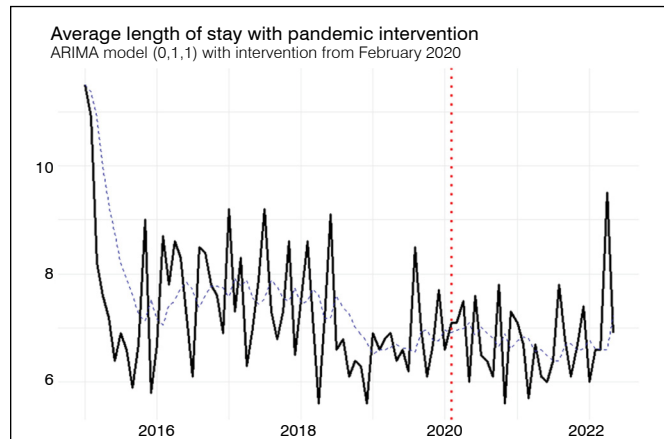
Source: Authors.

Figure 2. Variation in average monthly hospitalization cost over time (in thousands of BRL). Temporal trends with intervention point (red dotted line) referring to the beginning of the COVID-19 pandemic.



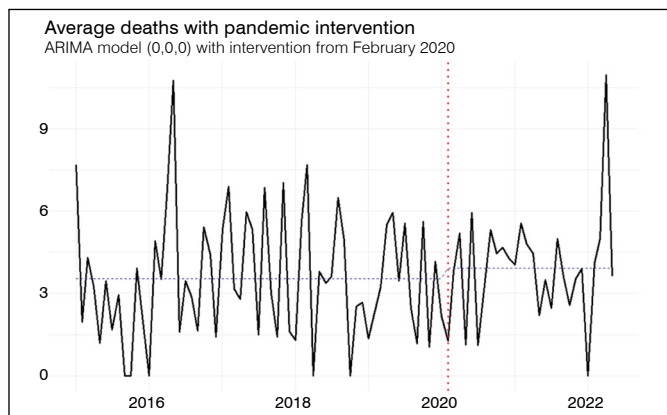
Source: Authors.

Figure 1. Monthly average number of authorized hospital admissions (AIH). Temporal trends with intervention point (red dotted line) referring to the beginning of the COVID-19 pandemic.



Source: Authors.

Figure 3. Average length of stay, in days. Temporal trends with intervention point (red dotted line) referring to the beginning of the COVID-19 pandemic.



Source: Authors.

Figure 4. Mean monthly in-hospital mortality rate. Temporal trends with intervention point (red dotted line) referring to the beginning of the COVID-19 pandemic.

difference ($p = 0.034$). The average monthly AHC also increased substantially, from BRL 7,670.90 (691.02) to BRL 9,046.05 (911.23), a highly significant difference ($p < 0.001$). Regarding ALS, there was a slight median reduction from 7.00 days (IQR: 6.60–8.25) to 6.80 days (IQR: 6.40–7.40), which was not statistically significant ($p = 0.388$). Similarly, the median monthly MR increased from 3.23 (IQR: 1.63–5.37) to 4.08 (IQR: 2.38–5.88), but this difference also did not reach statistical significance ($p = 0.254$).

DISCUSSION

Until 2013, orthopedic-oncologic procedures funded by the SUS did not include reconstruction or fixation; they were limited to the replacement of affected segments with non-conventional endoprostheses—the only compatible implants listed in SIGTAP/SUS at that time. Following a proposal by one of the authors of this article, the Brazilian Ministry of Health approved a change to the procedure coding system through Ordinance No. 2,947 of December 21, 2012, which was implemented the following year. This revision expanded the range of allowable implants to include conventional and specialized plates, rods, and external fixators, enabling the performance of reconstruction and fixation procedures in addition to replacements.

We found a national ALS of 7.13 days, with significant variation across Brazilian regions. In the United States, the ALS for patients undergoing resection with endoprosthetic replacement is approximately 8 days, whereas in the United Kingdom, it reaches around 15 days.^{5,6} Regional differences in ALS may reflect factors such as case complexity, rehabilitation protocols, and availability of postoperative care.

In our time series, the average monthly AHC was estimated at BRL 8,296.15, with wide regional variation. This value is substantially lower than in the United States, where the cost of a single non-conventional endoprosthesis can exceed USD 50,000.⁷ Several factors contribute to lower costs within SUS: (i) public funding through tax-based financing, which reduces out-of-pocket expenses for patients; (ii) government price regulation via SIGTAP-SUS, which sets reimbursement limits for procedures and hospitalizations; (iii) operational efficiency in public hospitals, aimed at maximizing patient volume and minimizing waste; (iv) lower labor costs compared to high-income countries; and (v) economies of scale, as SUS serves millions of users, enabling bulk purchasing at reduced prices. Costs related to multiple surgeries performed in a single session and postoperative care in intensive units were not included in this study's cost calculations.

ND analysis revealed uneven distribution across states, with higher MR in the South and lower MR in the Northeast. The national MR associated with these procedures in Brazil (4.86%) is comparable to rates reported in other countries, varying by case complexity, patient age, and quality of postoperative care.⁸ U.S. studies report MR rates as high as 9% for bone resection surgeries with endoprosthetic reconstruction.⁹

During the COVID-19 pandemic, global restrictions on healthcare resources significantly affected elective surgeries, reshaping orthopedic care. Initially, elective orthopedic procedures were suspended, later resuming under stricter safety protocols covering hospitalization through postoperative rehabilitation. In Italy, these surgeries were suspended starting February 23, 2020;¹⁰ the American College of Surgeons recommended halting all elective surgeries in March 2020 to reduce exposure and conserve hospital resources.^{11,12} The United Kingdom issued similar guidance on April 15, 2020, aiming to ease bed demand and support the pandemic response.¹³ As the health crisis evolved, new safety protocols enabled a gradual resumption of elective surgeries and outpatient services.

During the first two years of the COVID-19 pandemic in Brazil (2020–2021), a sharp decline was observed in the number of AIHs authorized for primary total knee arthroplasty, with reductions exceeding 50% in some regions.¹⁴ A similar trend was noted in total hip arthroplasty (THA); in 2020, the impact of the pandemic led to a 28.6% drop in primary THA procedures, with an even greater reduction (46.3%) in elective cases. In contrast, THAs carried out on an urgent basis—mostly related to fractures—remained stable during this period.¹⁵ For shoulder arthroplasties funded by SUS, a 6% decrease in authorized AIHs was observed between 2020 and 2021, with the Midwest and Northeast regions being the most affected, showing reductions of 45.5% and 16.5%, respectively.¹⁶ In most countries, only essential activities and COVID-19 treatment were prioritized.¹⁷ Bone tumors represent high-morbidity conditions that require timely and optimal multidisciplinary treatment, as delays or interruptions may pose life-threatening risks. In Brazil, the National Health Surveillance Agency (ANVISA), through Technical Note 06/2020, recommended prioritizing essential elective surgeries during the COVID-19 pandemic, particularly oncologic procedures due to their high risk of complications.¹⁸ Time series analysis showed that, during the pandemic, the previously observed upward trend in the monthly average number of AIHs continued. This may explain why, unlike other high-complexity orthopedic procedures funded by SUS, the trend of increasing AIHs for the procedures analyzed was maintained throughout the pandemic period.

Thaler et al. (2020)¹⁹ investigated the potential impact of the COVID-19 pandemic on the diagnostic workup and treatment of patients with musculoskeletal tumors through an online survey of members of the International Society of Limb Salvage and the European Musculo-Skeletal Oncology Society. They reported a substantial global reduction in procedures, with up to 20% of respondents indicating suspension or postponement of treatments, leading to longer waiting times and potentially worse clinical outcomes. Similarly, Onesti et al. (2022)²⁰ examined the impact of the pandemic on the diagnosis and treatment of patients with soft tissue and bone sarcomas or aggressive benign musculoskeletal diseases at a single referral center in Italy. They observed an average diagnostic delay of approximately 13 days during the first year of the pandemic compared to the pre-pandemic period.

Although significant differences were observed between the pre-pandemic and pandemic periods for both AHC and ALS, time series models with intervention indicated that only the AHC was significantly affected by the pandemic, showing a marked increase. This suggests a real rise in hospitalization complexity and costs, possibly due to more severe cases or changes in hospital

management during the pandemic. In contrast, the reduction in ALS appears to be a temporary fluctuation without a sustained trend. No significant differences or trends were identified for mortality. These findings indicate that the pandemic's impact was heterogeneous, more pronounced in indicators related to care complexity than in those linked to length of stay or short-term clinical outcomes. The limitations of this study are consistent with those of other retrospective reviews using databases. Most are related to under-reporting of cases, lack of information on the sociodemographic characteristics of the affected population, heterogeneity across Brazilian regions and states, and unavailability of specific data on underlying neoplasms, comorbidities, and causes of death. The data collected refers exclusively to the hospitalization period, making it impossible, for instance, to assess postoperative mortality. Additionally, the mortality model did not demonstrate an adequate

fit, which limits the interpretation of the time trend for this variable, despite the clear absence of differences across the pre-pandemic, pandemic, and post-pandemic periods.

CONCLUSION

We found no significant reduction in hospital admissions for bone tumor resection with prosthetic replacement or reconstruction and fixation during the COVID-19 pandemic. Time series analysis showed a continued upward trend in the average monthly hospital authorizations and AHC. These findings suggest that the pandemic may not have significantly affected the performance of such surgical procedures, possibly indicating that ANVISA's guidance to prioritize essential elective surgeries, especially oncologic ones, was followed by high-complexity oncology centers funded by the Brazilian public health system.

AUTHOR'S CONTRIBUTION: Each author contributed individually and significantly to the development of this article. AG: substantial contribution to the conception, design, writing and critical review of the intellectual content of the work and final approval of the version of the manuscript to be published; OPC, EPM, MCC, BGB and ESRM: critical review of the intellectual content of the work and final approval of the version of the manuscript to be published; FFR and AHS: data acquisition and analysis and writing of the work; KAM and NFL: acquisition, analysis and interpretation of work data; CRAJ and ESRB: interpretation of data and critical review of the intellectual content of the work.

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ARTHROSCOPIC LATARJET WITH CORTICAL BUTTONS: CLINICAL AND RADIOLOGICAL OUTCOMES

LATARJET ARTROSCÓPICO COM BOTÕES CORTICAIS: RESULTADOS CLÍNICOS E RADIOLÓGICOS

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ABSTRACT

Objective: To evaluate clinical and radiological outcomes of the arthroscopic Latarjet procedure with cortical buttons for traumatic anterior shoulder instability. **Methods:** Retrospective case series of medical reports and imaging studies of patients operated between April 2016 and September 2019 at a single hospital. Primary outcome was the Rowe score 24 months after surgery (MCID of 9.7 points). Secondary outcomes were the VAS, Rowe scores at other follow-up points, recurrence of instability, complications and tomographic evaluation of arthritis and graft healing, resorption and positioning. **Results:** 46 shoulders were evaluated. At 24 months, mean Rowe score increased from 34.4 ± 11.4 to 90.1 ± 12.2 ($p < 0.001$) and VAS from 6.1 ± 2.0 to 1.2 ± 1.9 ($p < 0.001$). Every patient achieved MCID. Over 90% of grafts were well positioned and approximately 85% of them healed. There was no redislocation and only one (2.2%) subluxation. There were complications in six patients (13%), and no reoperation was needed. **Conclusion:** At short-term, arthroscopic Latarjet procedure with cortical buttons provides good clinical outcomes, significant pain reduction and low recurrence rate. Graft healing and positioning were adequate. Complications were minor, with no reoperation needed. **Level of Evidence IV; Case Series.**

Keywords: Shoulder Dislocation; Joint Instability; Orthopedic procedures.

RESUMO

Objetivos: Avaliar desfechos clínicos e radiológicos do procedimento de Latarjet artroscópico com botões corticais para instabilidade anterior traumática do ombro. **Métodos:** Série de casos retrospectiva de pacientes operados entre abril de 2016 e setembro de 2019 em um único hospital. O desfecho primário foi o escore de Rowe 24 meses após a cirurgia (MCID de 9,7 pontos). Os desfechos secundários foram a EVA, escores de Rowe em outros períodos, recorrência da instabilidade, complicações e avaliação tomográfica de artrose e do enxerto (consolidação, reabsorção e posicionamento). **Resultados:** Foram avaliados 46 ombros. O desfecho primário aumentou de $34,4 \pm 11,4$ para $90,1 \pm 12,2$ ($p < 0,001$) e a EVA, de $6,1 \pm 2,0$ para $1,2 \pm 1,9$ ($p < 0,001$). Todos atingiram o MCID. Mais de 90% dos enxertos estavam bem posicionados e aproximadamente 85% consolidaram. Não houve re-luxação e apenas um caso (2,2%) de subluxação. Ocorreram seis complicações (13%), sem necessidade de reoperação. **Conclusão:** A curto prazo, o Latarjet artroscópico com botões corticais proporciona bons desfechos clínicos, redução da dor e pouca recidiva. A consolidação e o posicionamento do enxerto foram adequados, com poucas complicações (sem necessidade de reoperação). **Nível de Evidência IV; Série de Casos.**

Descritores: Luxação do Ombro; Instabilidade Articular; Procedimentos Ortopédicos.

Citation: Nascimento AT, Bastos RM, Assunção JH, Checchia CS, Gracitelli MEC, Silva FBA, Ferreira Neto AA, Malavolta EA. Arthroscopic Latarjet with cortical buttons: clinical and radiological outcomes. Acta Ortop Bras. [online]. 2025;33(3) Esp.: Page 1 of 5. Available from URL: <http://www.scielo.br/aob>.

INTRODUCTION

The treatment of recurrent traumatic anterior shoulder instability is preferably surgical.¹ In cases with increased risk for recurrence, Bankart repair alone is not ideal,² and coracoid transposition procedures

(like the Latarjet) lead to reliable results,³⁻⁵ with significant clinical improvement and few failures.^{6,7}

The limitations associated with the open Latarjet procedure have driven the development of arthroscopic techniques, initially

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

The study was conducted at Instituto de Ortopedia e Traumatologia, Hospital das Clínicas, Faculdade de Medicina, Universidade de São Paulo (HCFMUSP), R. Dr. Ovidio Pires de Campos, 333, Cerqueira Cesar, São Paulo, SP, Brazil. 05402-000.

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Article received on 01/28/2025 approved on 05/05/2025.



introduced by Lafosse et al. in 2007.⁸ Some authors^{9–11} have supported this approach, highlighting advantages such as improved accuracy of graft positioning, reduced risk of neurological injuries, better management of associated lesions, and minimized muscle damage. However, comparative research has not demonstrated a clear advantage of one technique over the other in terms of complication rates, functional outcomes, or radiographic results, leaving the choice of method largely dependent on the surgeon's preference.^{12–14}

Similarly, since Gendre et al.¹⁵ described coracoid process fixation with cortical-buttons (CBs) in 2016, some studies have endorsed this method to mitigate complications linked to screws,^{16,17} while maintaining similar biomechanical strength¹⁸ and clinical outcomes.^{17,19} Nonetheless, conflicting data on CBs indicate a potential increase in recurrent dislocation,^{17,20,21} and lower biomechanical stability.²² However, to date few studies have been published on the use of CBs in Latarjet procedures.^{11,19,20,23,24}

This study aimed to analyze clinical and radiologic outcomes after arthroscopic Latarjet with cortical-buttons for traumatic anterior shoulder instability. Our hypothesis is that results would be favorable, with few complications.

METHODS

This is an institutional ethical committee-approved (CAAE 54388821.5.1001.0068), single-center, retrospective case series study of medical records (after formal signed patient consent), evaluating clinical and radiological outcomes of patients undergoing arthroscopic Latarjet procedures with cortical buttons.

Data collection

Data from medical reports was retrospectively retrieved by the main author in 2023. Rowe scores and VAS had already been performed by a research assistant, unrelated to this study, when patients were followed at clinic: one week before surgery, and at 3, 6, 12 and 24 months after that. Likewise, pre- and postoperative (at 6 months) CT scans had already been performed.

Patients

Skeletally mature patients with traumatic anterior shoulder instability associated with any of the following criteria were indicated to surgery: Instability Severity Index Score (ISIS) ≥ 4 , anterior glenoid bone loss greater than 20%, off-track injury²⁵ or recurrence of instability after Bankart repair.

Patients were operated on at a single institution by a single surgeon, with 11 years of experience, between April 2016 and September 2019. Inclusion criteria in this retrospective study were: patients with pre- and postoperative clinical and imaging evaluations; a minimum follow-up of two years. Non-inclusion criteria were: multi- or bidirectional instability; one single episode of anterior shoulder dislocation; associated rotator cuff tears or fractures (other than the anterior glenoid rim or Hill-Sachs).

Standard of Care and Surgical Technique

Anesthesia, surgical technique and rehabilitation were performed in the same manner for every patient, as follows.

Intravenous general anesthesia was used after interscalene nerve block. Antibiotic prophylaxis with Cefazolin (2g every 8 hours for 24 hours) was performed.

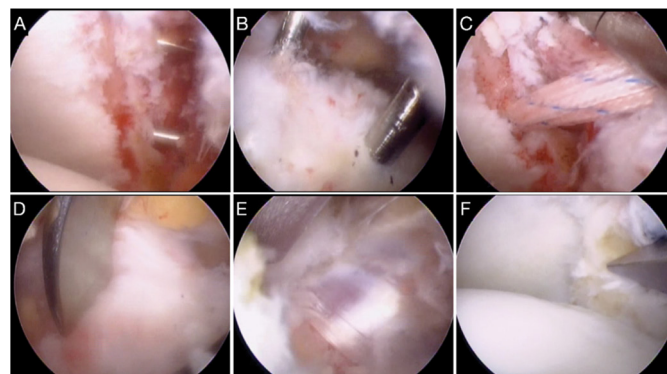
Patients were operated in a "relaxed beach chair" position. Intra-articular inspection was initially performed through the posterior portal. The anterior portal was made above the subscapularis tendon. The antero-inferior labrum, the middle glenohumeral ligament and the anterior capsule were resected to facilitate later graft passage. The anterior glenoid neck was debrided and flattened

with shavers. The coracoacromial ligament was released from the coracoid. Viewing from the *J portal* (performed with an *outside-in* technique at tip of the coracoid), the pectoralis minor muscle was detached and the lower surface of the coracoid was flattened. Any adhesion between the axillary nerve and the conjoint tendon was released. The subscapularis was longitudinally split between its superior two-thirds and its inferior one-third. Next, four guide wires were passed (two through the glenoid and two through the coracoid). At the glenoid, guide wires were placed using an anterior cruciate knee ligament reconstruction guide around the shoulder, with its anterior tip placed through the anterolateral portal (positioned at the antero-inferior glenoid neck, 5 mm medial from the articular surface) and its posterior end through the posterior portal. Perforation was performed from posterior to anterior. The same was repeated for the second glenoid guide wire, 2 cm more proximally (Figure 1A). A portal superior to the coracoid base (*H portal*) was created, and two guide wires were passed (approximately 2 cm apart) through the coracoid without any guide (Figure 1B). Using a 4 mm diameter cannulated drill, the first guide-wire (at the inferior glenoid neck) a tunnel was perforated, through which a prolene thread was passed from posterior to anterior, bringing along with it a CB (ToggleLoc™, Biomet - loaded with a number-two high resistant braid). It was passed through the subscapularis split and then temporarily retrieved through the anterolateral portal. The coracoid was tunneled through the most distal guide wire, and the same CB was transported through the coracoid and outside the *H portal*. The same process was repeated through the other two guide wires (Figure 1C). With both buttons placed over the coracoid, osteotomy was performed with a chisel (Figure 1D) and the braids were pulled from the posterior portal. This would bring the coracoid graft, through the subscapularis split, onto the antero-inferior glenoid neck (Figure 1E). Finally, the braids of both CBs were tensioned and sutured over a single posterior CB (Figure 1F). The CBs used had self-locking mechanisms, granting greater graft compression.

Patients wore a sling for 21 days. Passive shoulder range of motion (ROM) started at 14 days, while active ROM, at 21 days. Isometric strengthening started at 30 days and active-resistance exercises, at 45 days. Sports requiring upper limbs and manual labor were allowed after 4 to 6 months, after complete recovery of ROM and strength.

Methods of Assessment

The primary outcome was the ROWE score at 24 months, for which the MCID value of 9.7 was used.²⁶ Other dependent variables were:



Source: Author.

Figure 1. Right shoulder. Intraoperative view from the anterolateral portal. A: Guide wires passed through the glenoid. B: Guide wires passed through the coracoid process. C: Cortical buttons and wires passing through the glenoid tunnels. D: Osteotomy of the coracoid process. E: Conjoint tendon passed through the subscapularis split. F: Final aspect after graft fixation.

(1) ROWE score at other periods; (2) VAS for pain; (3) recurrence of dislocation and/or subluxation; (4) graft healing, reabsorption, and vertical and horizontal positioning at CT; (3) complications: infection, neurologic lesion, graft migration and fracture, and glenohumeral arthritis.

Independent variables were: (1) intrinsic to patients: age, sex, dominance, smoking, previous Bankart repair, sports activity and ISIS; (2) related to the injury: glenoid bone loss, Hill Sachs interval, and glenoid tracking pattern.

The main author retrospectively analyzed the CTs, as follows: glenoid bone loss was measured using the *best-fit circle* method;²⁷ humeral bone loss by the *Hill-Sachs interval*;²⁵ shoulders were classified as *on-* or *off-track*;²⁵ graft healing, resorption and positioning, as well as glenohumeral arthritis, were also analyzed.

Statistical Analysis

Continuous variables were assessed for normality using the Kolmogorov-Smirnov test, and homogeneity, the Levene test. Continuous variables are presented as mean, standard deviation, median and interquartile range (IIQ), as continuous data (except "age") had non-parametric distribution. Categorical variables were displayed in absolute values (and %). For functional results comparison (Rowe and VAS scores) over different evaluation periods, the Friedman test was used, and the Wilcoxon test for post-hoc analysis. The SPSS 21.0 was used, with a significance level of 5%.

RESULTS

During the studied period, 48 patients underwent surgery. Two cases were not included: a rotator cuff tear and a primary dislocation. The series consisted then of 46 shoulders (45 patients).

The mean age at surgery was 32.1 ± 9.3 years. Most patients were male, operated the dominant shoulder, and performed recreational sports regularly. Around 28% had a previous single Bankart repair (Table 1).

Average glenoid bone loss was $15.4 \pm 10.3\%$, and Hill-Sachs interval was 15.9 ± 6.1 mm. Nineteen (41.3%) shoulders were *off-track*. Average ISIS score was 5.3 ± 1.6 (Table 2).

Outcomes achieved statistically significant improvements. Mean Rowe score increased from 34.4 ± 11.4 to 90.1 ± 12.2 at 24 months ($p < 0.001$). Mean VAS went from 6.1 ± 2.0 to 1.2 ± 1.9 in the same period ($p < 0.001$) (Table 3) (Figures 2 and 3). Every patient achieved MCID.

More than 90% of grafts were well positioned horizontally and vertically, and approximately 85% had healed (Figures 4 and 5). Glenohumeral arthritis, previously observed in two patients (4.3%), was observed postoperatively in four (8.7%) (all Samilson and Prieto stage I) (Table 4).

Table 1. Baseline Characteristics of Patient-Related Variables.

	n	%
Male	39	84.8
Dominant side affected	31	67.4
Tobacco use		
Smoker	2	4.3
Former smoker	6	13.0
Epilepsy	1	2.2
Sports activity	37	80.4
Competitive	9	19.6
Collision	14	30.4
Contact	10	21.7
Non-contact	13	28.3
Prior Bankart repair	13	28.3

Table 2. Preoperative Bone Loss and ISIS Score.

	Average	SD	Median	IIQ
Glenoid width (mm)	28.5	2.4	28.5	4.0
Glenoid defect (mm)	4.3	2.9	5.3	7.0
Glenoid % loss	15.4	10.3	19.6	23.0
Hill-Sachs interval	15.9	6.1	16.2	7.0
ISIS score	5.3	1.6	5.0	1.0

Table 3. Pre and Postoperative Functional Assessment.

	Average	SD	Median	IIQ	P value
Rowe Score					
Pre-operative	34.4	11.4	40.0	15.0	<0.001*
3 months	82.2	16.2	87.5	10.0	
6 months	88.2	14.2	90.0	8.0	
12 months	89.6	14.0	92.5	5.0	
24 months	90.1	12.2	92.5	5.0	
Visual Analogue Score (pain)					
Pre-operative	6.1	2.0	6.0	2.0	<0.001**
3 months	2.5	1.8	3.0	3.0	
6 months	1.3	1.4	1.0	2.0	
12 months	1.3	1.8	1.0	2	

General comparisons were performed with the Friedman test. Post hoc analyses, with the Wilcoxon test. SD: standard deviation; IIQ: interquartile range; *: post-hoc analysis: difference between all follow-up times, except 12 and 24 months; **: post-hoc analysis: difference between all follow-up times, except 6 and 12 months, 6 and 24 months, and 12 and 24 months.



Source: Author.

Figure 2. This boxplot shows the distribution of Rowe Scale scores at different evaluation periods. The box represents the interquartile range (IQR), the line inside the box indicates the median, and the whiskers extend to the minimum and maximum non-outlier values. Outliers are shown as individual points.

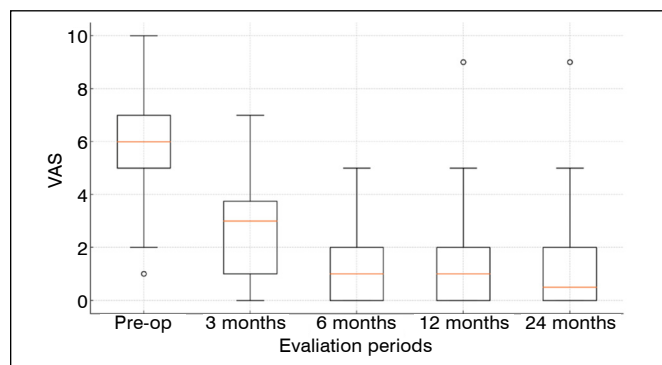


Figure 3. This boxplot presents the distribution of Visual Analog Scale (VAS) scores across different evaluation periods. The box illustrates the interquartile range (IQR), with the median marked by a line inside the box. Whiskers represent the range, and outliers are plotted as individual points.

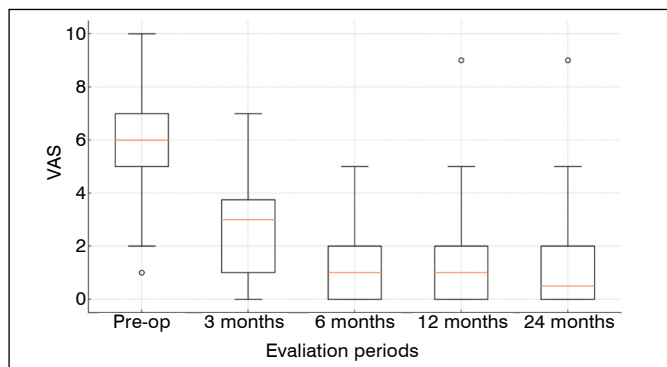
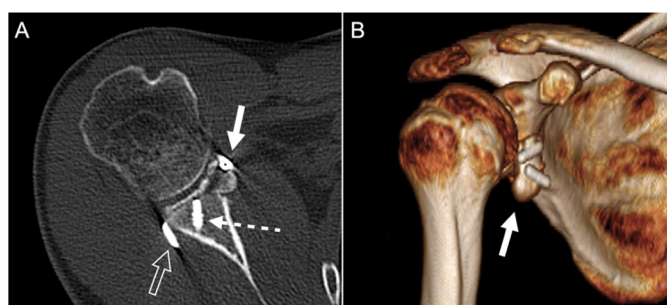


Figure 4. Left shoulder. Radiographs at 24 months postoperative depicting adequate graft healing and no radiographic complication. A: Grashey AP view. B: Scapular profile view. C: Axillary view.



Source: Author.

Figure 5. Right shoulder. Computed tomography at 24 months after surgery depicting adequate graft positioning (white arrow). A: Axial view; Hollow arrow points to the large posterior cortical button; Dashed arrow points to a metallic anchor used in the Bankart repair (previous failed surgery). B: Tridimensional reconstruction.

Table 4. Postoperative Tomographic Evaluation.

	n	%
Glenohumeral arthritis		
Pre-operative	2	4.3
Post-operative	4	8.7
Graft resorption	4	8.7
Graft vertical positioning		
At the equator	4	8.7
Below the equator	42	91.3
Horizontal positioning		
Lateralized > 5mm	2	4.3
Well positioned	44	95.7
Healing	39	84.8

There was one subluxation and one positive anterior apprehension test (2.2%), both in the same patient, and no redislocation. We observed six complications (six patients; 13%), including two superficial postoperative infections (4.3%) which were successfully treated with oral antibiotics (Table 5). Complications did not impact clinical outcomes.

DISCUSSION

Our results show that traumatic anterior shoulder instability can be successfully treated by the arthroscopic Latarjet procedure with cortical buttons (CBs), which yields good clinical outcomes, significant pain improvement and low recurrence rate. At 24 months, every patient achieved MCID. Mean Rowe score was 90.1, in accordance with other authors.^{9,11,28} Boileau et al.⁹

Table 5. Recurrences and Complications.

	n	%
Recurrences		
Dislocation	0	0
Subluxation	1	2.2
Complications		
Superficial infection	2	4.3
Graft migration	2	4.3
Axillary neuropraxia	1	2.2
Intraoperative graft fracture	1	2.2

in a series of 136 patients with CBs, reported an average of 90 points at 24 months. Girard et al.¹¹ with a minimum follow-up of 12 months, achieved 94 points, while Song et al.²⁸ average follow-up of three years, 95 points.

We observed significant improvement in pain (VAS improved from 6.1 to 1.2), similar to Song et al.²⁸, (5.3 to 1.2 points). Hardy et al.²⁰ assessed pain only at last follow-up, averaging 1.3 point. Others did not assess pain.^{9,11}

Our recurrence rate was 2.2%. This is comparable to Boileau et al.⁹ (2.9%), Girard et al.¹¹ (0%) and Song et al.²⁸ (1.8%). Meanwhile, Hardy et al.²⁰ reported a considerably higher rate (8.3%), statistically higher than those undergoing screw fixation (2.5%; $p=0.02$).

The graft was well positioned in most of our cases, both vertically and horizontally, similar to other authors using CBs.^{9,28} Healing occurred in 84.8%, lower than Boileau et al.⁹ (95%) and Song et al.²⁸ (97%). Graft resorption, however, was considerably lower in our series (8.7%) than in Song et al.²⁸ (18.5%). We believe variations in healing and resorption rates may result from CB type (with or without self-locking mechanisms), bone bed debridement, and intraobserver variability. However, it does not seem to influence clinical results at 24 months. We also observed an increase in glenohumeral arthropathy frequency from 2.2% to 4.3%, which was not evaluated by other authors who used CBs.

Infection occurred in two cases (4.3%), successfully treated with oral antibiotics alone. Song et al.²⁸ reported 1.9% of infections; other authors did not describe it.^{9,11,20} We believe this complication is not due to surgical approach or fixation method, but rather to longer surgical times and/or other population-related factors. Neurological injury occurred in one case (2.2%), lower than Song et al.²⁸ (3.7%) and higher than Boileau et al.⁹ (0%) and Girard et al.¹¹ (0%). In all studies, neurological changes were only sensitive and resolved spontaneously. Intraoperative graft fracture happened in one case (2.2%) and distal graft migration during follow-up occurred in two cases (4.3%). This is similar to Girard et al.¹¹ (4.2%). All other authors^{9,20,28} did not describe graft fracture or migration. None of our patients required reoperation, similar to Hardy et al.²⁰ and less than Song et al.²⁸ (2%).

Our study has limitations, as follows. Foremost is its retrospective design. The sample size, even if similar to other series, is too small for secondary analyses. The score used (Rowe) is not as sensitive as other scores, such as the WOSI²⁹. The postoperative follow-up of two years, even if similar to other studies, is probably insufficient to detect recurrence and progression of arthritis. Isokinetic assessment of patients was not performed, which has been shown to be altered after the Latarjet procedure.³⁰ Finally, imaging analysis was conducted solely by the main author, lacking intra- and inter-observer analysis. Despite these limitations, we believe innovative graft fixation techniques, such as cortical buttons, warrant further research due to frequent screw-related complications.⁶ Our study contributes to knowledge in this area. Randomized trials with larger samples are needed to assess the method's advantages and disadvantages.

CONCLUSION

At short-term, arthroscopic Latarjet procedure with cortical buttons provides good clinical outcomes for the treatment of traumatic anterior shoulder instability. There was significant improvement to

Rowe scores ($p < 0.001$), significant pain (VAS) reduction ($P < 0.001$) and a low recurrence rate ($n = 1$; 2.2%). Coracoid graft healing and positioning were adequate. Complications were minor (no clinical consequence) and no reoperation was needed.

AUTHOR'S CONTRIBUTION: Each author has contributed individually and significantly in the making of this article. TN: paper conception, data collection, and text drafting. CC: revision, translation, final approval, and submission. JA: conception, data analysis, and design. MG: conception and revision. FBAS: conception and design. RB: data collection and text drafting. AFN: revision and final approval. EM: conception, design, revision, and final approval.

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PREVALENCE OF INJURIES IN PROFESSIONAL FOOTVOLLEY ATHLETES

PREVALÊNCIA DE LESÕES EM ATLETAS PROFISSIONAIS DE FUTEVÔLEI

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ABSTRACT

Objective: Footvolley is a sport that have been gaining popularity, however, the literature on injuries in this modality is very scarce. Thus, this study aimed to describe the most common locations and types of injuries in professional footvolley athletes and compare the prevalence between male (M) and female (F). **Methods:** Observational, cross-sectional study, including the highest-ranked professional athletes in Brazil in the year 2023. The interviews took place during the national professional footvolley championship stages and included questions about sample characteristics, training history and routine, and injuries suffered throughout their career. **Results:** A total of 56 athletes, 36 F (26±5 years; 9±4 years of practice), and 20 M (28±6 years; 7±3 years of practice). Of this total, 95% reported some injury caused by playing footvolley, with knee injuries being the most prevalent (M/F=48%; M=44%; F=55%; $p>0.05$), and muscle pain (myalgia) being the most prevalent type (M/F=38%; M=39%; F=35%; $p>0.05$). M presented significant differences about F regarding the site of the injury (foot: M=6%; F=25%; $p=0.035$) and type of injury (intense nonspecific pain: M=28%; F=5%; $p=0.040$). **Conclusion:** Elite footvolley athletes in Brazil presented a high prevalence of injuries, with the most common injuries being in the knees. **Level of Evidence IV; Case Series.**

Keywords: Sports; Prevalence; Professional Athletes.

RESUMO

Objetivo: O futevôlei é um esporte que vem ganhando popularidade, porém a literatura sobre lesões nessa modalidade é bastante escassa. Assim, o objetivo deste estudo foi descrever as localizações e os tipos de lesões mais comuns em atletas profissionais de futevôlei e comparar a prevalência entre homens (H) e mulheres (M). **Métodos:** Estudo observacional, transversal, incluindo atletas profissionais mais bem classificados no Brasil no ano de 2023. As entrevistas ocorreram durante as etapas do campeonato nacional profissional de futevôlei e incluíram perguntas sobre características da amostra, histórico e rotina de treinamento, e lesões sofridas ao longo da carreira. **Resultados:** Participaram 56 atletas, sendo 36 M (26±5 anos; 9±4 anos de prática) e 20 M (28±6 anos; 7±3 anos de treinamento). Desse total, 95% relataram alguma lesão causada pela prática do futevôlei, sendo as lesões no joelho as mais prevalentes (H/M=48%; H=44%; M=55%; $p>0,05$) e a dor muscular (mialgia) o tipo mais prevalente (H/M=38%; H=39%; M=35%; $p>0,05$). Diferenças significativas foram verificadas nas comparações entre H e M quanto ao local da lesão (pé: H=6%; M=25%; $p=0,035$) e ao tipo de lesão (dor intensa inespecífica: H=28%; M=5%; $p=0,040$). **Conclusão:** Atletas de futevôlei de elite no Brasil apresentaram alta prevalência de lesões, sendo as lesões mais comuns nos joelhos. **Nível de Evidência IV; Série de Casos.**

Descritores: Esportes; Prevalência; Atletas Profissionais.

Citation: Diniz MED, NevesLM. Prevalence of injuries in professional footvolley athletes. Acta Ortop Bras. [online]. 2025;33(3) Esp.: Page 1 of 5. Available from URL: <http://www.scielo.br/aob>.

INTRODUCTION

Footvolley is a sport that originated on the beaches of Rio de Janeiro, Brazil, during the military dictatorship in the 1960s. As a result of the prohibition on engaging in sports that lacked a defined area and did not involve the use of a net, football players started utilizing volleyball spaces for their practice sessions.¹ Footvolley gained popularity in the subsequent years, and its popularity was further increased during the COVID-19 pandemic. This was primarily

because footvolley involves minimal physical contact between players, has a limited number of participants, and is played outdoors. These factors made footvolley a sport with a safety protocol during the pandemic.²

As footvolley has grown in popularity, specialized spaces dedicated to the sport have emerged. Various urban centers in Brazil have started to establish spaces for footvolley.³ This dissemination has contributed to the advancement of footvolley movements and

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

The study was conducted at Santo Amaro University, Rua Isabel Schmidt, 349, Santo Amaro, São Paulo, SP, Brazil, 04743-030.

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Article received on 09/18/2024 approved on 04/08/2025.



techniques.⁴ However, it has also led to an increase in injuries, as both amateur practitioners and professional athletes exert oneself to keep up with the sport's evolution and attempt more complex moves, including jumps, spins, and new attacks.

Although footvolley has gained popularity and seen advancements, there is a lack of scientific research on the occurrence of injuries related to its practice.⁵ The International Olympic Committee, which is the primary regulative institution for sports, prioritizes the protection of athletes' health.⁶ In addition, the World Health Organization acknowledges the health advantages of populations that engage in regular physical activity.⁷ Therefore, conducting research on the frequency of sports-related injuries is an essential step in suggesting preventive strategies for sports injuries,⁸ which can be advantageous for elite athletes as well as casual and non-professional footvolley players. Notably, other sports played on sand spaces, known as beach sports, have provided data on the frequency of injuries, as demonstrated in a study conducted during the Asian Beach Games, which involved athletes from over 40 countries. According to Al-shaqsi et al.,⁹ a significant number of injuries were found among professional athletes in beach handball (21%), beach soccer (15%), and beach volleyball (13%). As far as we know, there is only one study on footvolley that was conducted in 2015.⁵ This study found that 39% of the participants evaluated had footvolley injuries, with a higher occurrence of injuries in men.

Considering what has been described, our study aimed to assess the prevalence of injuries in professional footvolley athletes in Brazil, taking into account the lack of available information, and the significance of obtaining descriptive data as a crucial initial step in developing effective injury prevention strategies.⁹ Furthermore, we aimed to assess the incidence of injuries in both males and females and elucidate the primary anatomical site where these injuries commonly occurred.

MATERIAL AND METHOD

Study design

This study was conducted in São Paulo, Brazil, using a retrospective observational cross-sectional design. The study period spanned from August of 2023 to August of 2024. This study was approved by Local ethical committee (protocol number 6.131.376)

Sample

We reached out to athletes who were participating in professional footvolley championships in São Paulo city (Brazil), both in person before their matches and online through WhatsApp and Instagram. Following their initial interest in participating, the athletes were subsequently approached to complete the questionnaire administered by Google Forms during national competitions.

The selection of these athletes refers to the professional ranking of the Open Nacional de Footvolley championship and the ranking of the Brazilian Footvolley League, according to the position of the athletes until the day of data collection. In short, the sample consists of athletes ranked among the top 50 in each of the aforementioned rankings. We highlight that at the time of data collection for this research, the Brazilian Footvolley Confederation had championships suspended, as in the last election there was a legal challenge, which justifies the choice of these rankings mentioned above.

Survey of injury

Retrospective injury assessment was performed based on the International Olympic Committee guidelines for recording and reporting epidemiological data on injuries.¹⁰ In summary, a questionnaire with 22 questions, with questions about the characteristics of the sample (name, age, weight, height, length of time in the sport in years), aspects of training and competitions (Training volume, number of training sessions per week, being divided between footvolley and specific training to improve performance other than on the sand, average number of championships per month and carrying out mobility and/or strengthening before entering the court in championships) and occurrence of injuries (injuries that the athlete suffered during practicing the sport that took the athlete away from the sport for at least one day, with options for body parts to select and the most serious types of injury, that is, the one that kept the athlete away from the sport for the longest time, once again considering the location and type of injury; moment of injury, time away from footvolley after diagnosis and reason); Finally, questions about the athlete's perception of the greatest influence on the occurrence of the injury.

Statistical analysis

The data is displayed in absolute frequency (n) and relative frequency (%), as well as the mean $\pm$ standard deviation (SD). The data's normality and equality of variance were evaluated using the Shapiro-Wilk and Levene tests, respectively. The study participants were categorized into two groups according to their biological sex, specifically males and females. A chi-square test was employed to compare groups (male and female) for each category variable. The Mann-Whitney test was employed to compare groups when dealing with continuous variables.

RESULTS

The investigation comprised a total of 56 athletes. Table 1 displays the sample characteristics. The study had 36 male and 20 female participants. The athletes in question had an average age of 27.2 ± 5.6 years, a body weight of 70.9 ± 10.0 kg, and a BMI of 23.3 ± 2.0 kg/m².

Table 1. Sample characteristics.

Variable	All (n=56)		Men (n=36)	Women (n=20)	P (CI 95%)
	Mean $\pm$ DP	Min - Max	Mean $\pm$ DP	Mean $\pm$ DP	
Age (years)	27.2 $\pm$ 5.6	18 - 44	26.6 $\pm$ 5.4	28.4 $\pm$ 6.0	n.s
Weight (kg)	70.9 $\pm$ 10.0	50 - 95	76.1 $\pm$ 7.1	61.4 $\pm$ 6.9*	<0.001 (10.7 - 18.6)
Height (cm)	174 $\pm$ 9	150 - 193	180 $\pm$ 1	160 $\pm$ 6*	<0.001 (0.11 - 0.18)
BMI	23.3 $\pm$ 2.0	19 - 28	23.7 $\pm$ 1.8	22.6 $\pm$ 2.1*	0.033 (0.1 - 2.3)
Practice time (years)	8.5 $\pm$ 3.9	4 - 15	9.0 $\pm$ 4.1	7.7 $\pm$ 3.3	n.s
Days you train on court per week (days)	4.0 $\pm$ 1.2	3 - 7	4.1 $\pm$ 1.2	3.7 $\pm$ 1.3	n.s
On-court training periods per week	5.6 $\pm$ 2.9	4 - 12	6.0 $\pm$ 2.7	4.9 $\pm$ 3.2	n.s
Days you train off the court per week (days)	3.4 $\pm$ 1.5	0 - 7	3.2 $\pm$ 1.5	3.8 $\pm$ 1.4	n.s
Periods you train outside on the court per week	2.3 $\pm$ 1.1	0 - 7	1.5 $\pm$ 0.6	1.3 $\pm$ 0.6	n.s
Professional championships per month	2.4 $\pm$ 1.0	1 - 4	2.8 $\pm$ 0.8	1.6 $\pm$ 0.9	<0.001 (0.7 - 1.7)
I've already had an injury from playing footvolley	95%	--	95%	95%	--
Time away from the worst injury you had (days)	100 $\pm$ 81	2 - 210	94.3 $\pm$ 78.8	111 $\pm$ 87	n.s

Legend: SD = standard deviation; Min= minimum; Max = maximum; BMI = body mass index. CI = Confidence interval.

Regarding the practice of the modality, the average duration was 8.5 ± 3.9 years, with training sessions conducted 4.0 ± 1.2 days per week. Approximately 95% of the participants in the sample reported having had injuries while playing footvolley. The duration of absence from playing footvolley due to the most severe injury was 100 ± 81 days. Upon analyzing the data from the table, it is evident in the last column that there is a statistically significant difference ($p < 0.05$) in weight, height, BMI, and number of championships played. These values are lower for females in comparison to males.

Table 2 displays the locations where athletes reported experiencing injuries while participating in footvolley. Upon analyzing the overall outcomes, it was found that out of the 17 distinct areas, 14 were identified as sites of injuries. The knee was the most prevalent location, with 27 athletes (48%) reporting injuries in that area. This was followed by the hip, with 18 athletes (32%) experiencing injuries, and the lumbar region, with 17 athletes (30%) reporting injuries. When examining injuries in men, the knee is the most frequently affected area, with 16 athletes (44%) experiencing injuries in this region. The lumbar region is the second most common area of injury, with 12 athletes (33%) affected. Within the female population, the knee is the most prevalent outcome, observed in 11 athletes (55%), closely followed by the hip, which is observed in 8 athletes (40%). In Table 3 we present the types of injuries. In relation to all athletes, we can observe that muscle pain (myalgia) is the most prevalent injury (21 athletes – 38%), followed by sprain (20 athletes – 36%). When considering male injuries, muscle pain (myalgia) was the most prevalent (14 athletes - 39%) followed by sprain (11 athletes - 31%).

Table 2. Location of injuries suffered throughout their lives playing footvolley.

Region	All (n=56)	Men (n=36)	Women (n=20)	Qui-square
Shoulder – n (%)	10 (18%)	7 (19%)	3 (15%)	n.s.
Arm – n (%)	1 (2%)	1 (3%)	0 (0%)	n.s.
Forearm – n (%)	0 (0%)	0 (0%)	0 (0%)	--
Elbow – n (%)	4 (7%)	2 (6%)	2 (10%)	n.s.
Hand – n (%)	2 (4%)	1 (3%)	1 (5%)	n.s.
Hand – n (%)	0 (0%)	0 (0%)	0 (0%)	--
Chest – n (%)	0 (0%)	0 (0%)	0 (0%)	--
Abdomen – n (%)	1 (1%)	1 (3%)	0 (0%)	n.s.
Lumbar region – n (%)	17 (30%)	12 (33%)	5 (25%)	n.s.
Cervical region – n (%)	13 (23%)	9 (25%)	4 (20%)	n.s.
Hip – n (%)	18 (32%)	10 (28%)	8 (40%)	n.s.
Thigh (anterior) – n (%)	11 (20%)	8 (22%)	3 (15%)	n.s.
Posterior thigh – n (%)	12 (21%)	9 (25%)	3 (15%)	n.s.
Knee – n (%)	27 (48%)	16 (44%)	11 (55%)	n.s.
Calf – n (%)	8 (14%)	4 (11%)	4 (20%)	n.s.
Ankle – n (%)	14 (25%)	8 (22%)	6 (30%)	n.s.
Foot – n (%)	7 (13%)	2 (6%)	5 (25%)	0.035

Legends: n = number of athletes ; % = percentual of athletes.

Table 3. Type of injuries suffered throughout their lives playing footvolley.

Type	All (n=52)	Men (n=34)	Women (n=20)	Qui-square
Muscle tear (muscle strain) – n (%)	13 (23%)	7 (19%)	6 (30%)	n.s.
Ligament/meniscus tear – n (%)	12 (21%)	7 (19%)	5 (25%)	n.s.
Sprain – n (%)	20 (36%)	11 (31%)	9 (45%)	n.s.
Tendinitis – n (%)	16 (29%)	9 (25%)	7 (35%)	n.s.
Synovitis – n (%)	0 (0%)	0 (0%)	0 (0%)	--
Bursitis – n (%)	3 (5%)	1 (3%)	2 (10%)	n.s.
Periostitis – n (%)	10 (18%)	6 (17%)	4 (20%)	n.s.
Fracture – n (%)	1 (2%)	0 (0%)	1 (5%)	n.s.
Muscle pain (myalgia) – n (%)	21 (38%)	14 (39%)	7 (35%)	n.s.
Severe non-specific pain – n (%)	11 (20%)	10 (28%)	1 (5%)	0.040
Nonspecific chronic pain – n (%)	10 (18%)	5 (14%)	5 (25%)	n.s.

Legends: n = number of athletes ; % = percentual of athletes.

In female professional athletes, the highest prevalence was sprain (9 athletes – 45%), followed by tendonitis (7 athletes – 35%) or muscle pain (myalgia) (7 athletes – 35%). In comparing the number of injuries by type of injuries, male vs female presented statistical differences ($p = 0.035$) on site foot.

In Table 4 we present data on the most serious injury that athletes have suffered throughout their lives playing footvolley, considered by the greatest distance from the courts or those that bothered them until data collection. A total of 52 athletes who reported an injury while practicing footvolley, 48 reported a serious injury, 32 male and 16 female. The comparison of the number of injuries by the site of injury, considering male vs female showed no statistical differences ($p > 0.05$).

As reported for the most common injuries (Table 2), the knee is the most serious site of injury for both sexes (16 athletes – 33%), followed by the hip (10 athletes – 21%). For men ($n = 9$; 28%) the knee was the site of the most serious injury, as well as for female ($n = 7$; 44%). Finally, male athletes presented the hip region as the second region with the most injuries (06 athletes – 19%), as did female (4 athletes – 25%). The comparison of the location of the most serious injury ever suffered while playing footvolley, considering male vs female showed no statistical differences ($p > 0.05$).

Finally, in Table 5 we present the most serious types of injuries. Injuries due to ligament/meniscus tears were the most reported (total: $n = 10$, 21%; men: $n = 6$, 19%; female: $n = 4$, 25%), followed by

Table 4. Location of the most serious injury ever suffered while playing footvolley.

Region	All (n=48)	Men (n=32)	Women (n=16)	Qui-square
Shoulder – n (%)	2 (4%)	2 (6%)	0 (0%)	--
Arm – n (%)	0 (0%)	0 (0%)	0 (0%)	--
Forearm – n (%)	0 (0%)	0 (0%)	0 (0%)	--
Elbow – n (%)	0 (0%)	0 (0%)	0 (0%)	--
Hand – n (%)	1 (2%)	1 (3%)	0 (0%)	--
Hand – n (%)	0 (0%)	0 (0%)	0 (0%)	--
Chest – n (%)	0 (0%)	0 (0%)	0 (0%)	--
Abdomen – n (%)	0 (0%)	0 (0%)	0 (0%)	--
Lumbar region – n (%)	3 (6%)	2 (6%)	1 (6%)	n.s.
Cervical region – n (%)	1 (2%)	1 (3%)	0 (0%)	--
Hip – n (%)	10 (21%)	6 (19%)	4 (25%)	n.s.
Thigh (anterior) – n (%)	5 (10%)	4 (12%)	1 (6%)	n.s.
Posterior thigh – n (%)	2 (4%)	2 (6%)	0 (0%)	--
Knee – n (%)	16 (33%)	9 (28%)	7 (44%)	n.s.
Calf – n (%)	0 (0%)	0 (0%)	0 (0%)	--
Ankle – n (%)	6 (13%)	4 (13%)	2 (13%)	n.s.
Foot – n (%)	2 (4%)	1 (3%)	1 (6%)	n.s.

Legends: n = number of athletes ; % = percentual of athletes.

Table 5. Type of most serious injuries suffered throughout their lives playing footvolley.

Type	All (n=48)	Men (n=32)	Women (n=16)	Qui-square
Muscle tear/strain – n (%)	7 (15%)	6 (19%)	1 (6%)	n.s.
Ligament/meniscus tear – n (%)	10 (21%)	6 (19%)	4 (25%)	n.s.
Sprain – n (%)	3 (6%)	2 (6%)	1 (6%)	n.s.
Tendinitis – n (%)	4 (8%)	2 (6%)	2 (12%)	n.s.
Synovitis – n (%)	0 (0%)	0 (0%)	0 (0%)	--
Bursitis – n (%)	0 (0%)	0 (0%)	0 (0%)	--
Periostitis – n (%)	0 (0%)	0 (0%)	0 (0%)	--
Fracture – n (%)	1 (2%)	0 (0%)	1 (6%)	n.s.
Muscle pain (myalgia) – n (%)	3 (6%)	2 (6%)	1 (6%)	n.s.
Severe non-specific pain – n (%)	6 (13%)	5 (16%)	1 (6%)	n.s.
Nonspecific chronic pain – n (%)	7 (15%)	3 (9%)	4 (25%)	n.s.

Legends: n = number of athletes ; % = percentual of athletes.

muscle tear, muscle strain (total: n=7, 15%; men: n=6, 19%; women: n=1, 6.3%). In comparing the number of type of most serious injuries suffered throughout their lives playing footvolley, considering male vs female was verified no statistical differences ($p>0.05$).

DISCUSSION

The present study aimed to assess the prevalence of injuries in both male and female professional footvolley athletes in Brazil, and elucidate the primary anatomical site where these injuries commonly occurred. A total of 14 different areas were injured, with the knee being the most common site with a prevalence of 48%, followed by the hip with a prevalence of 32%, and the lumbar region with a prevalence of 30%. In a comparison of males and females, we identified differences in the location of injuries suffered throughout their lives playing footvolley (foot – male 6% vs female 25% $p=0.035$) and type of injuries suffered throughout their lives playing footvolley (Severe non-specific pain – male 28% vs female 5% $p=0.04$).

In comparison to the 2015 research on footvolley athletes, the percentage of total athletes who reported previous injuries was 41% and now 86%, indicating a variation in the occurrence of injuries in footvolley. In addition, even though the Asian Beach Games study did not include the footvolley modality, our observed prevalence of injuries was higher than seen in beach volleyball players (13%) and beach soccer athletes (24%).⁸

When comparing our data with a study conducted by De Menezes et al.¹¹ on the most common injuries in men's beach volleyball, we found that the knee and lumbar region were the areas with the highest number of injuries. Regarding the Asian Beach Games research, the knee and lumbar region were the most often injured anatomical locations in beach volleyball athletes, accounting for 21% of injuries each. In contrast, beach soccer had the foot as the primary source of injury, accounting for 37% of injuries.⁸ According to research conducted by Alves and colleagues, the lumbar region (56%) and the spine (32%) are the most afflicted locations in footvolley. Specifically, the knee has a frequency of 26% and the lumbar region has a prevalence of 24%.⁵

When comparing injuries between male and females, a significant disparity in answers is observed regarding non-specific severe pain. Specifically, 28% of male athletes presented non-specific severe pain, but just 5% of female athletes did so. This outcome can be somewhat elucidated by the observation that women possess a superior capacity to differentiate pain feelings in comparison to males.¹² The study conducted during the Asian Beach Games revealed that sprain is the predominant injury among beach volleyball participants, accounting for 50% of the cases. In beach soccer, strain was the most prevalent injury, accounting for 21% of the cases, followed by sprain at 19%.⁸

It is crucial to emphasize that, concerning the most severe injuries, we inquired the athletes about the precise moment when these injuries happened and obtained the following outcomes: 41% of the participants were engaged in a tournament, while 22% were involved in footvolley training. Additionally, 23% were actively playing footvolley, and 14% were doing specialized training sessions outside of the sand. A study conducted on professional football athletes from the eight main teams that participated in the Campeonato Paulista Series A2 in 2010 revealed a significant incidence of injuries during the championship. Approximately 61% of the players experienced at least one injury during this period.¹³

The athlete's most severe injuries were found to be influenced by several factors. These include physical exhaustion resulting from excessive training, competitions, or games (45% of reports), inadequate treatment of previous injuries (16%), ground conditions and climate (11%), insufficient heating (9%), and mental exhaustion (8%). The higher incidence of injuries observed during championships, coupled with the significant impact of physical fatigue, underscores the need for a comprehensive study to raise awareness among professional athletes regarding the extent of strain they face due to the increasing number of championships and, consequently, more rigorous game preparations. It is crucial to engage with expert health and sports specialists to tailor the whole preparing time for the championship, considering the specific requirements of the sport and any recent developments.¹⁴

This study is not free of limitations. Initially, we employed self-reported data. This type of data may have biases in responses due to the athletes' recollections. An optimal scenario would have a cohort design that includes a comprehensive registry of all athlete injuries spanning many years. Despite this constraint, it is crucial to emphasize the challenges associated with implementing the cohort design among athletes, particularly in sports with less popularity, such as footvolley. Additionally, the small sample size are important limitations. Furthermore, the limited sample size is a significant restriction. This may have resulted in an overestimation of the impact. Subsequent investigations should validate these conclusions by the implementation of more extensive studies.

CONCLUSION

Our study revealed that elite footvolley athletes in Brazil experienced injuries in 14 distinct anatomical regions, with the knee being the most prevalent site, followed by the hip and lower back. Upon comparing male and female athletes, we observed disparities in the occurrence of injuries sustained over their footvolley careers. Notably, female athletes exhibited a greater incidence of foot injuries compared to their male counterparts. Male athletes had a greater incidence of severe and non-specific pain in comparison to their female counterparts, in terms of the nature of the injuries sustained.

AUTHOR'S CONTRIBUTION: Each author contributed individually and significantly to the development of the manuscript. MEDD: Contributed with Conceptualization, Methodology, Investigation, Resources, Data Curation, Writing - Original Draft, Project administration; LMN: Contributed with Supervision of study, as in Conceptualization, Methodology, Validation, Formal analysis, Writing - Original Draft, Writing - Review & Editing.

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RETROSPECTIVE ANALYSIS OF THE IMPACT OF NEGATIVE PRESSURE WOUND THERAPY ON COMPLICATIONS OF DELAYED COVERAGE OF IIIB EXPOSED TIBIAL FRACTURES

ANÁLISE RETROSPECTIVA DO IMPACTO DA TERAPIA DE PRESSÃO NEGATIVA NAS COMPLICAÇÕES DA COBERTURA TARDIA DE FRATURAS EXPOSTAS IIIB DA TÍBIA

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ABSTRACT

Objective: To evaluate whether NPWT in delayed coverage of Gustilo-Anderson Type IIIB open tibial fractures reduces the complication rate, including deep infection, nonunion, and amputation. **Methods:** Retrospective case series including patients with Gustilo-Anderson Type IIIB open tibial shaft fractures treated between January 2014 and December 2017 with NPWT. The outcome measures were incidence of deep infection, nonunion, and amputation. Analysis of time to coverage (within 7 days vs. after 7 days) and type of soft tissue coverage. **Results:** 26 patients with open tibial shaft fractures, predominantly male (96.2%), mean age 33.4 ± 13.9 years. Seven patients (26.9%) received coverage within 7 days; 19 patients (73.1%) received delayed coverage. The flap types were Myocutaneous (42.3%), microsurgical (34.6%), fasciocutaneous (23.1%). The overall infection rate was 50%, no significant difference between early (57.1%) and delayed (47.4%) coverage groups ($p > 0.999$). No amputations in the early coverage group; 2 (10.5%) in the delayed coverage group. Nonunion rates were 42.9% (early) and 36.8% (delayed). Overall complication rate: 85.7% (early) vs. 57.9% (delayed) ($p = 0.357$). **Conclusion:** NPWT may exert a protective effect in cases of delayed coverage by isolating the wound and promoting healing. **Level of Evidence III; Retrospective study.**

Keywords: Negative-Pressure Wound Therapy; Fractures, Ununited; Amputation.

RESUMO

Objetivo: Avaliar se a NPWT na cobertura tardia de fraturas abertas da tíbia tipo IIIB de Gustilo-Anderson reduz a taxa de complicações, incluindo infecção profunda, não união e amputação. **Métodos:** Série de casos retrospectiva incluindo pacientes com fraturas expostas da diáfise da tíbia tipo IIIB de Gustilo-Anderson tratados entre janeiro de 2014 e dezembro de 2017 com NPWT. As medidas de resultado foram a incidência de infecção profunda, não união e amputação. **Análise do tempo para cobertura** (dentro de 7 dias vs. após 7 dias) e **tipo de cobertura de tecidos moles**. **Resultados:** 26 pacientes com fraturas expostas da diáfise da tíbia, predominantemente do sexo masculino (96,2%), com idade média de $33,4 \pm 13,9$ anos. Sete pacientes (26,9%) receberam cobertura em até 7 dias; 19 pacientes (73,1%) receberam cobertura tardia. Os tipos de retalho foram miocutâneo (42,3%), microcirúrgico (34,6%) e fasciocutâneo (23,1%). A taxa global de infecção foi de 50%, sem diferença significativa entre os grupos de cobertura precoce (57,1%) e tardia (47,4%) ($p > 0,999$). Não houve amputações no grupo de cobertura precoce; 2 (10,5%) no grupo de cobertura tardia. As taxas de não união foram de 42,9% (precoce) e 36,8% (tardia). Taxa global de complicações: 85,7% (precoce) vs. 57,9% (tardia) ($p = 0,357$). **Conclusões:** A NPWT pode proporcionar um efeito protetor nos casos de cobertura tardia, isolando a ferida e promovendo a cicatrização. **Nível de Evidência III; Estudo retrospectivo.**

Descritores: Tratamento de Ferimentos com Pressão Negativa; Fraturas não Consolidadas; Amputação.

Citation: Gonzalez TC, Ribaric I, Gomes YM, André MM, Zua FQD, Gonçalves MAM, Ivo M, Leonhardt MC, Silva JS, Kojima KE. Retrospective analysis of the impact of negative pressure wound therapy on complications of delayed coverage of IIIB exposed tibial fractures. Acta Ortop Bras. [online]. 2025;33(3) Esp.: 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 Universidade de São Paulo, Faculdade de Medicina, Hospital das Clínicas (HCFMUSP), Grupo de Trauma, Instituto de Ortopedia e Traumatologia, São Paulo, SP, Brazil.

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Article received on 09/12/2024 approved on 02/17/2025.



INTRODUCTION

Open tibial fractures are the most common type of open long bone fractures, typically resulting from a high energy trauma. These injuries are associated with significant muscle necrosis, high contamination and bone fragmentation leading to high morbidity and post-operative complications.^{1,2}

The Gustilo-Anderson classification system is widely used to categorize open fractures based on the extent of soft tissue and bone damage, as well as the type and degree of contamination. Type III fractures involve multifragmentary fractures with extensive soft tissue damage; Type IIIB specifically includes cases with extensive periosteal stripping and exposed bone at the end of the procedure.³ Open fracture, comminuted fracture, infection and location of fracture in the tibia are among the most relevant risk factors contributing to fracture nonunion.⁴

Infection is the most devastating complication following an open tibial fracture due to its detrimental impact on clinical outcomes, burden to the healthcare system, chronic pain and psychological distress.⁵ Early soft tissue coverage is a critical factor in reducing the risk of infection, with earlier coverage correlating with lower infection rates.⁶

However, timely coverage is not always feasible, especially in cases of delayed in a severely contaminated wound which requires multiple debridement and many times the appropriately trained reconstructive surgeon is not available.⁷ Traditionally, wet-gauze saline dressings were applied to prevent wound exposure to nosocomial environments.⁸ However, since its approval by the Food and Drug Administration, negative pressure wound therapy (NPWT) has increasingly been used as an alternative dressing technique. Although some studies have compared the outcomes of NPWT with conventional dressings, the superiority of NPWT in preventing complications has not been conclusively established.⁹⁻¹¹

This study aims to evaluate whether the use of NPWT in delayed coverage of open tibial fractures classified as Gustilo-Anderson Type IIIB can reduce the complication rate.

MATERIAL AND METHODS

This retrospective case series aimed to assess whether NPWT in delayed coverage of Gustilo-Anderson Type IIIB open tibial fractures decreases complications. The study included patients treated at a level one urban university trauma center between January 2014 and December 2017. The study was approved by the Research and Ethics Committee (approval number 10061019.0000.0068), and written informed consent was obtained from all participants. The patient data were collected from the medical record and available radiographs and included age, sex, comorbidities, trauma mechanism, AO/OTA classification,¹² type of fixation, type of definitive coverage, time between the injury and the definitive coverage and complications (infection, amputation and nonunion).

The inclusion criteria were patients over 18 years with open tibial shaft fracture Gustilo type IIIB who had been treated with NPWT, no other major injuries, minimum of 6 months of follow-up, and signed informed consent.

The exclusion criteria included open tibial shaft fracture IIIB treated with dressings other than the NPWT, type IIIB fractures in other bones, and polytrauma patients.

Initial treatment of open tibial fractures followed standard protocols, with thorough irrigation and debridement of all necrotic tissue.^{7,11} All fractures were fixed with an external fixator as part of a staged treatment approach. NPWT was applied using a polyurethane ether sponge with a pore size of 400–600 μm , covering the entire wound and sealed with an adhesive dressing. The system operated at 125 mmHg of continuous negative pressure. Definitive coverage was

performed once the wound was clean, free of necrotic tissue, and a microsurgeon was available.

Complications were recorded, including deep infection as defined by Metsemakers et al.¹³ amputation and nonunion.

Qualitative patient characteristics were described using absolute and relative frequencies, while quantitative characteristics were summarized using mean, standard deviation, median, and quartiles. Outcomes were analyzed according to qualitative characteristics using Fisher's exact tests or likelihood ratio tests, and quantitative characteristics were compared using Student's t-tests or Mann-Whitney tests.¹⁴ Statistical analyses were conducted using IBM SPSS for Windows, version 22.0, and data were tabulated using Microsoft Excel 2013. A 5% significance level was used for all tests.¹⁴

RESULTS

During the observation period (2014–2017), 41 patients with Gustilo-Anderson Type IIIB severe open fractures were treated, with 26 (63.4%) presenting with open tibial shaft fractures. Among these patients, 25 (96.2%) were male, with a mean age of 33.4 ± 13.9 years. Nine patients (34.6%) had comorbidities (Table 1).

The most frequent mechanism of trauma was motorbike accident (53.8%) followed by pedestrian injury (38.5%).

The most prevalent AO/OTA fracture type was type A (46.2%), followed by the type B (30.8%) and type C (23.1%). All fractures

Table 1. Patients' demographics and outcomes.

Variable	Description (n = 26)
Age	
Mean SD	33.4 $\pm$ 13.9
Median (p25; p75)	30 (22.8; 39.3)
Sex, n (%)	
Female	1 (3.8)
Male	25 (96.2)
Comorbidities, n (%)	
Smoking	2 (7.7)
Diabetes	1 (3.8)
Alcoholism	2 (7.7)
Illegal drugs	4 (15.4)
Mechanism of injury	
Motorbike accident	14 (53.8)
Runover by car	10 (38.5)
Car accident	1 (3.8)
Crush injury	1 (3.8)
Fracture AO classification, n (%)	
Type A	12 (46.2)
Type B	8 (30.8)
Type C	6 (23.1)
Soft tissue coverage, n (%)	
Fasciocutaneous flap	6 (23.1)
Myocutaneous flap	11 (42.3)
Microsurgical flap	9 (34.6)
Definitive fixation, n (%)	
Intramedullary nail	17 (65.4)
External fixation	9 (34.6)
Time to coverage, n (%)	
Within 7 days	7 (26.9)
Over 7 days	19 (73.1)
Complications, n (%)	
Deep infection	13 (50)
Nonunion	10 (38.5)
Amputation	2 (7.7)

were initially stabilized with an external fixator; 65.4% of fractures were subsequently fixed with an intramedullary nail, while 34.6% underwent a secondary external fixation.

All patients received intravenous antibiotics within 3 hours of injury and underwent irrigation and debridement within 12 hours. Seven patients (26.9%) received soft tissue coverage within 7 days, while 19 patients (73.1%) had delayed coverage beyond 7 days. Myocutaneous flaps were used for coverage in 11 patients (42.3%), microsurgical flaps in 9 (34.6%), and fasciocutaneous flaps in 6 (23.1%).

A total of 13 patients (50%) developed deep infections: 4 (57.1%) in the early coverage group and 9 (47.4%) in the delayed coverage group, with no statistically significant difference ($p > 0.999$). The infection rate showed no significant relationship with the type of fixation or the type of coverage.

No amputations occurred in the early coverage group, whereas 2 patients (10.5%) in the delayed coverage group required amputations. The nonunion rate was 42.9% in the early coverage group and 36.8% in the delayed coverage group. The overall complication rate was 85.7% in the early coverage group and 57.9% in the delayed coverage group ($p = 0.357$) (Table 2). Statistical analysis did not reveal any significant correlation between complications and demographic data (Table 3).

Table 2. Description of postoperative infection according to the characteristics assessed and results of statistical tests.

Variables	Deep infection		P
	No	Yes	
Age (years)			
Mean $\pm$ SD	30.8 $\pm$ 13.7	35.9 $\pm$ 14.2	0.355**
Sex, n (%)			
Female	1 (100)	0 (0)	>0.999
Male	12 (48)	13 (52)	
Smoking			
No	12 (50)	12 (50)	>0.999
Yes	1 (50)	1 (50)	
Diabetes			
No	13 (52)	12 (48)	>0.999
Yes	0 (0)	1 (50)	
Alcoholism			
No	12 (50)	12 (50)	>0.999
Yes	1 (50)	1 (50)	
Illegal drugs			
No	11 (50)	11 (50)	>0.999
Yes	2 (50)	2 (50)	
Mechanism of injury			
Motorbike accident	9 (64.3)	5 (35.7)	0.228#
Runover by car	4 (40)	6 (60)	
Car accident	0 (0)	1 (100)	
Crush injury	0 (0)	1 (100)	
Fracture AO classification, n (%)			
Type A	7 (58.3)	5 (41.7)	0.602#
Type B	4 (50)	4 (50)	
Type C	2 (33.3)	4 (66.7)	
Soft tissue coverage, n (%)			
Fasciocutaneous flap	4 (66.7)	2 (33.3)	0.108#
Myocutaneous flap	7 (63.6)	4 (77.8)	
Microsurgical flap	2 (22.2)	7 (77.8)	
Definitive fixation, n (%)			
Intramedullary nail	10 (58.8)	7 (41.2)	0.411
External fixation	3 (33.3)	6 (66.7)	
Time to coverage, n (%)			
Within 7 days	3 (42.9)	4 (47.1)	>0.999*
Over 7 days	10 (52.6)	9 (47.4)	

Chi square test; * Fisher exact test; # likelihood ratio test; **unpaired Student t test.

Table 3. Description of all post operative complications (infection, amputation and nonunion) according to the characteristics assessed and results of statistical tests.

Variables	All complications		p
	No	Yes	
Age (years)			
Mean $\pm$ SD	32.7 $\pm$ 15.3	33.7 $\pm$ 13.6	0.860**
Sex, n (%)			
Female	1 (100)	0 (0)	0.346
Male	8 (32)	17 (68)	
Smoking			
No	9 (36)	15 (62.5)	0.529
Yes	0 (0)	2 (100)	
Diabetes			
No	9 (36)	156 (64)	>0.999
Yes	0 (0)	1 (100)	
Alcoholism			
No	9 (37.5)	15 (62.6)	0.529
Yes	0 (0)	2 (100)	
Illegal drugs			
No	8 (36.4)	14 (63.3)	>0.999
Yes	1 (25)	3 (75)	
Mechanism of injury			
Motorbike accident	7 (50)	7 (50)	0.248#
Runover by car	2 (20)	8 (80)	
Car accident	0 (0)	1 (100)	
Crush injury	0 (0)	1 (100)	
Fracture AO classification, n (%)			
Type A	4 (33.3)	8 (66.7)	0.979#
Type B	3 (37.5)	5 (62.5)	
Type C	2 (33.3)	4 (66.7)	
Soft tissue coverage, n (%)			
Fasciocutaneous flap	3 (50)	3 (50)	0.530#
Myocutaneous flap	4 (36.4)	7 (63.6)	
Microsurgical flap	2 (22.2)	7 (77.8)	
Definitive fixation, n (%)			
Intramedullary nail	7 (41.2)	10 (58.5)	0.418
External fixation	2 (22.2)	7 (77.8)	
Time to coverage, n (%)			
Within 7 days	1 (14.3)	6 (85.7)	0.357*
Over 7 days	8 (42.1)	11 (57.9)	

Chi square test; * Fisher exact test; # likelihood ratio test; **unpaired Student t test.

DISCUSSION

Open tibial shaft fractures are the most common open long bone fractures, accounting for 11% of all open fractures.¹⁵ These injuries are often caused by high-energy trauma, leading to a high incidence of severe fractures, such as Gustilo-Anderson Type IIIA and IIIB. Chua et al. reported that 52.6% of these fractures are classified as Gustilo-Anderson Type IIIA and IIIB, with Type IIIB accounting for approximately 20% of all Type III fractures, or about 10% of all open tibial shaft fractures.¹⁶

To minimize the risk of infection in Gustilo-Anderson Type IIIB fractures, which are associated with significant soft tissue loss, periosteal stripping, and exposed bone, early antibiotic administration, thorough irrigation and debridement, skeletal fixation, and soft tissue management are critical.¹⁷ Godina advocated for early soft tissue reconstruction to reduce complications.¹⁸ However, early coverage is not always feasible due to factors such as severe contamination, difficulty in defining debridement margins, and the unavailability of a trained reconstructive surgeon. NPWT can serve as adjunctive therapy to protect the wound in such cases.¹⁹

The total number of patients requiring staged treatment for Type IIIB open tibial fractures is relatively low. Mathieu et al.²⁰ reported 5.4 per year, Cullen et al.²¹ 9.4 per year, Bhattacharyya et al.²² 9.5 per year and Gopal et al.²³ 9.3 per year. Our study observed an average of 6.5 cases per year, totaling 26 patients, similar to the published articles. This small sample size limits the statistical power of the study and the applicability of its conclusions.

The demographics of our patient cohort align with other studies, consisting primarily of young male adults involved in road traffic accidents with relatively simple fractures (Table 1).²⁴ The use of flaps reflects the severity of soft tissue injuries, with 42% requiring myocutaneous flaps and 35% requiring microsurgical flaps. In our study, 26.9% of patients received wound coverage within 7 days, while 73.1% had delayed coverage.

Comparisons with the literature are challenging due to the variability in reported infection rates, which range from as low as 1.5% in Godina¹⁸ study, to 19% with Kumaar,²⁵ to around 30% with Cullen²¹ and Singh,²⁶ to as high as 50% to 60%, respectively by Bhattacharyya²² and Mathieu.²⁰ This variation likely reflects the heterogeneity of Gustilo-Anderson Type IIIB injuries, which can range from minor to extensive lesions. Although it is generally expected that delayed coverage increases the complication rate, our study found similar infection rates in both early (47.1%)²⁴ and delayed coverage groups (47.4%).²⁵ The use of NPWT may have mitigated the risk of infection in delayed cases by

isolating the wound, removing secretions and infectious material, and promoting neovascularization.¹⁹

The nonunion rate was 38.5%, with 2 amputations (7.7%), showing no significant difference between the early and delayed coverage groups. Thus, NPWT may offer a protective effect in cases of delayed coverage, reducing the risk of nonunion and amputation.

This study has some limitations. The small sample size may affect the statistical power of the association and results. However, as mentioned before, the number of type IIIB open tibia shaft fracture with need for flap is low. The retrospective nature of the study has the disadvantage of this type of design. And, besides the NPWT other factors may play a role in the development of infection, like revision surgery, multiple debridement, type of antibiotics, time to surgery, etc. We recommend conducting a prospective randomized multicenter study with a larger number of patients in each group, and control of the confound variables to get more accurate statistical results.

CONCLUSION

The use of NPWT in Gustilo-Anderson Type IIIB open tibial fractures may help prevent an increase in complications such as deep infection, nonunion, and amputation, even in cases of delayed coverage. Given the severity of these injuries, the complication rate remains high, but NPWT may help maintain the complication rate in cases where coverage is delayed.

AUTHOR'S CONTRIBUTION: Each author contributed individually and significantly to the development of the manuscript. TG, IR, MA, and FZ contributed to data collection and analysis. MG, MI, and ML performed the surgeries and patient follow-up. KK and JS analyzed the statistical data. KK performed the literature review, revised the manuscript, and contributed to the study's conceptual development.

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CONGENITAL ANOMALIES OF THE UPPER LIMBS IN A UNIVERSITY CENTER: A CROSS-SECTIONAL STUDY

ANOMALIAS CONGÊNTAS DOS MEMBROS SUPERIORES EM UM CENTRO UNIVERSITÁRIO: ESTUDO TRANSVERSAL

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ABSTRACT

Objective: To identify the prevalence and characteristics of CAULs treated at a university center, aiming to improve epidemiological understanding and management of these conditions. **Methods:** Study carried out at the Hand Surgery and Microsurgery Service of Hospital São Paulo, UNIFESP, between January 2014 and February 2023. The sample included 296 patients diagnosed with CAULs, whose data were obtained from medical records. Information on sex, type of anomaly, age at first consultation, laterality, time until surgery, number of procedures and consultations were collected. Descriptive statistical analyses and association tests were performed, considering a significance level of 0.05. **Results:** It was observed that 61.15% of the patients were from São Paulo, with a higher prevalence of syndactyly (20.3%), followed by preaxial polydactyly (17.9%) and camptodactyly (11.5%). The majority (35.1%) presented bilateral involvement. Conservative treatment was used in 50% of the cases, while surgical intervention, often the only one (34.46%), was necessary in the others. **Conclusion:** This study provides an overview of CAULs, with findings that reinforce the predominance of anomalies such as syndactyly and the importance of individualized treatment strategies. **Level of Evidence II; Retrospective Study.**

Keywords: Clinical Epidemiology; Upper extremity; Congenital abnormalities; Hand Deformities.

RESUMO

Objetivo: Identificar a prevalência e características das ACMS atendidas em um centro universitário, visando melhorar a compreensão epidemiológica e o manejo destas. **Métodos:** Estudo realizado no Serviço de Cirurgia da Mão e Microcirurgia do Hospital São Paulo da UNIFESP, entre janeiro de 2014 e fevereiro de 2023. A amostra incluiu 296 pacientes diagnosticados com ACMS, cujos dados foram obtidos dos prontuários médicos. Foram coletadas informações sobre sexo, tipo de anomalia, idade na primeira consulta, lateralidade, tempo até cirurgia, número de procedimentos e de consultas. Análises estatísticas descritivas e testes de associação foram realizados, considerando um nível de significância de 0,05. **Resultados:** Observou-se que 61,15% dos pacientes eram naturais de São Paulo, com maior prevalência de sindactília (20,3%), seguida de polidactília pré-axial (17,9%) e camptodactília (11,5%). A maioria (35,1%) apresentou acometimento bilateral. O tratamento conservador foi utilizado em 50% dos casos, enquanto a intervenção cirúrgica, frequentemente única (34,46%), foi necessária nos demais. **Conclusão:** Este estudo fornece um panorama das ACMS, com achados que reforçam a predominância de anomalias como a sindactília e a importância de estratégias de tratamento individualizadas. **Nível de Evidência II; Estudo Retrospectivo^F.**

Descritores: Epidemiologia Clínica; Extremidade Superior; Anormalidades Congênitas; Deformidades da Mão.

Citation: Gomes DJL, Sabongi RG, Moraes VY, Nakachima LR, Belloti JC, Faloppa F. Congenital anomalies of the upper limbs in a university center: a cross-sectional study. Acta Ortop Bras. [online]. 2025;33(3) Esp.: Page 1 of 4. Available from URL: <http://www.scielo.br/aob>.

INTRODUCTION

Congenital anomalies (CA) are developmental disorders that occur during intrauterine life, affecting the development of the body. They represent a worldwide concern of public health interest, having a significant impact on infant morbidity and mortality.¹ Two clinical causes of congenital anomalies can be observed in the upper limbs: 1) alterations caused during the formation/differentiation process; or 2) alterations induced in the central nervous system.² In Brazil, they are responsible for a considerable percentage of

morbidity and mortality in children under one year of age.³ These alterations can be detected during pregnancy or after birth and can be functional (neuromotor), structural (physical deformity) or metabolic (e.g. inborn error of metabolism, phenylketonuria).⁴ The causes of CA can be genetic, environmental and/or multifactorial. Most occur spontaneously or are attributed to genetic factors, while few are associated with teratogens.^{4,5} CAs affect 2 to 3% of live births, and approximately 10% of these children have upper limb abnormalities.⁶⁻⁸

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

The study was conducted at Congenital Anomalies Outpatient Clinic of the Hand Surgery and Microsurgery Service at the Universidade Federal de São Paulo (EPM-UNIFESP), R. Botucatu, 740, Vila Clementino, São Paulo, SP, Brazil. 04023-062.

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Article received on 12/08/2024 approved on 04/03/2025.



Understanding the epidemiology of congenital anomalies of the upper limb (CAUL) is necessary for conducting comparative studies, allowing for the monitoring of changes in the occurrence profile over time, facilitating the development of treatment guidelines.⁹⁻¹¹ However, knowledge about the presentation and management of these anomalies is still limited in the Brazilian context.¹²

Understanding the profile of patients treated at specialized services for CAUL can have a significant effect on the planning of public policies, monitoring and research in the area. This information contributes to the identification of associated factors, implementation of more effective preventive measures, access to services and, consequently, improvement of health care.

The purpose of this study is to identify the most frequent CAUL and treatment aspects, providing information that can be used to establish strategies that allow for the provision of better care to these patients.

METHOD

Study design

This was a single-center, cross-sectional study conducted at the Hand Surgery Department of a university center. This study was approved by the Research Ethics Committee of our institution (number: 5,036,478).

Sample

We selected, in a convenience sample, all patients treated at the CAUL outpatient clinic between January 2014 and February 2023.

Inclusion criteria

Individuals of both sexes, regardless of age, diagnosed with CAUL were selected.

Exclusion criteria

Patients diagnosed with acquired disabilities, deformities caused by tumors, and CA in parts of the body other than the upper limb.

Data collection

By accessing patient records through the Electronic Medical Record. Information was collected on gender, CAUL diagnoses, age at first consultation, laterality, time since first surgical procedure, number of surgical procedures performed, and number of consultations; We obtained the data as available in the medical records, and, in their absence, they were considered as lost data.

Collection instrument

After individual evaluation of the medical records and removal of duplicates, the information was collected and recorded in a spreadsheet in the Microsoft Excel program, version 16.0, developed by Microsoft (Redmond, Washington, United States).

Statistical analysis

A database was created and, for the analysis of the collected data, descriptive statistics (mean, standard deviation, absolute and relative frequency) were used to characterize the sample studied. Statistical tests were used to assess the association between the variables of interest (sex, most prevalent CA, age at first consultation, location, time until surgical procedure, number of surgical procedures performed and number of consultations).

The results obtained were presented descriptively, in tables and comparative graphs formulated in Excel. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 26.0 software developed by International Business Machines Corporation (IBM) (New York, United States) and Minitab Statistical Software version 21.2 developed by Microsoft (Redmond, Washington, United States). A significance level of 0.05 (5%) was

set for this study. The mean (μ), median (Md), standard deviation (SD), first quartile (Q1), third quartile (Q3), minimum and maximum values, and confidence interval (CI) were calculated for the number of surgeries, number of consultations, and time until surgery in days. The Chi-Square or Fisher's Exact Test was used to verify the existence of significant associations between the nominal variables of the study, and the Student's t-test or Mann-Whitney test was used to verify the association between the continuous variables according to the study groups. Associations with a p-value lower than 0.05 and 95% confidence intervals.

RESULTS

Sample characteristics

During the study period, 296 patients with CAUL were treated, 208 surgeries were performed, with an average of 0.7; and 1892 consultations were reached, an average of 6.39 consultations per patient, with a minimum of 1 consultation and a maximum of 39 consultations for the same patient. In addition, the time between the first consultation and the surgical procedure was quite variable, ranging from 6 days to 2024 days, with 75% of the sample having undergone the surgical procedure within 188 days after the first consultation.

Gender: 134 occurred in female individuals (45.3%) and 162 in male individuals (54.7%). When comparing the sexes, it was observed that the number of men was significantly higher than the number of women ($p = 0.017$).

Place of Birth and Origin: There was a concentration of patients from the city of São Paulo - SP, with 61.15% of the patients being native and 50.68% coming from this location. (Tables 1 and 2).

- Type of Anomaly: Syndactyly emerged as the most prevalent CAUL in the study, accounting for 20.3% of cases. Preaxial polydactyly and camptodactyly followed closely, accounting for 17.9% and 11.5% of cases, respectively (Table 3).

- Location: Most patients (35.1%) presented anomalies in both hands. Unilateral lesions were more frequent in the left hand (29.1%) than in the right (23.3%). In 12.5% of cases, the lesions affected other regions of the upper limb. (Table 4).

- Treatment: Heterogeneity in treatment was observed, with half of the patients being treated conservatively and the other half undergoing surgical procedures. Among the surgical groups, 34.28% underwent a single surgery, while 15.54% required multiple interventions. The comparison between the groups revealed a statistically significant difference in relation to the conservatively treated group ($p < 0.001$). (Table 5)

Table 1. Place of birth.

Place of Birth	AF	RF	p
São Paulo - SP	181	61.15%	Reference
Diadema - SP	12	4.05%	0.001*
Taboão da Serra - SP	10	3.38%	0.001*
Others	93	31.3%	0.001*
TOTAL	296	100%	

AF = absolute frequency, RF = relative frequency. *Statistically significant difference compared to the most frequent place of birth.

Table 2. Provenience.

City of Provenience	AF	RF	p
São Paulo - SP	150	50.68%	Reference
Diadema - SP	8	2.7%	0.001*
Embu das Artes - SP	8	2.7%	0.001*
Others	130	43.92%	0.001*
TOTAL	296	100%	

AF = absolute frequency, RF = relative frequency. *Statistically significant difference compared to the most frequent place of birth.

Table 3. Diagnostic.

Congenital Anomaly	AF	RF	p
Syndactily	60	20.3%	0.006*
Preaxial polydactily	53	17.9%	< 0.001*
Camptodactily	34	11.5%	< 0.001*
Congenital trigger finger	30	10.1%	< 0.001*
Postaxial polydactily	30	10.1%	< 0.001*
Others CA	89	30.1%	Reference
TOTAL	296	100%	

AF = absolute frequency, RF = relative frequency. *Statistically significant difference compared to the most frequent place of birth.

Table 4. Location.

Location of the anomaly	AF	RF	p
Both hands	104	35.1%	Reference
Left hand	86	29.1%	0.113
Right hand	69	23.3%	0.002*
Other locations	37	12.5%	<0.001*
TOTAL	296	100%	

AF = absolute frequency, RF = relative frequency. *Statistically significant difference compared to the most frequent place of birth.

Table 5. Number of surgeries performed.

Number of surgeries	AF	RF	P
None	148	50%	Reference
One	102	34.46%	< 0.001*
Two	36	12.16%	< 0.001*
Three	6	2.03%	< 0.001*
Four	4	1.35%	< 0.001*
TOTAL	296	100%	

AF = absolute frequency, RF = relative frequency. *Statistically significant difference compared to the most frequent place of birth.

DISCUSSION

In Brazil, access to specialized outpatient services is provided through regionalized networks and a hierarchy of care, in order to allow users of the Unified Health System (SUS) to access the necessary health services. The fundamental component in the integration of health levels is the referral system (origin, usually Primary Health Care) and counter-referral (specialized service), in which a flow of referrals is carried out between services, considering their different levels of complexity.^{13,14}

Congenital and developmental anomalies of the upper limbs are relatively rare. The incidence is 0.2%.¹⁵ Although CAUL affect relatively few children, the impact on their carriers is usually quite significant. Treatment is complex, with corrective and palliative

options that pursue the overall goals of improving the functionality and appearance of affected individuals.¹⁵

The results of this study corroborate several findings in the literature. The predominance of males, for example, is consistent with observations from previous studies conducted in different geographic contexts.^{10-12,16-20} Despite the higher incidence of CAUL in males, there is little physiological, biological, or endocrinological evidence to explain the phenomenon. One justification raised is that there appears to be a lower frequency of spontaneous abortions of male fetuses with AC, in addition to the action of hormonal factors, which would justify the higher frequency in live-born boys, although this is not true for all types of anomalies.²¹ The high concentration of patients from the capital and metropolitan region of São Paulo highlights the need to expand the supply of centers specialized in CAUL in other regions of Brazil. Centralizing care may hinder access for patients from more remote areas, negatively impacting early diagnosis and appropriate treatment. The higher frequency of syndactily is in line with findings from studies in the United States.¹⁸ However, this finding contrasts with the predominance of polydactily observed in two national studies,^{12,20} in addition to an Australian study,¹¹ suggesting a possible influence of regional variations in the distribution of CAUL. Likewise, the high rate of congenital trigger in Swedish¹⁰ and Japanese¹⁹ studies contrasts with the lower frequency observed in this study, indicating the need to investigate possible genetic or environmental factors that may influence these differences.

The variability in the time between the first consultation and the performance of the surgical procedure, as well as the high rate of patients who did not undergo surgery, point to the complexity of managing these conditions and the need to individualize the treatment, considering not only the type of anomaly, but also the needs and expectations of each patient.¹⁰

Some limitations should be considered: the cross-sectional nature of the study restricts the ability to establish causal relationships between the factors analyzed and the development of CAUL; the retrospective collection of data from medical records may have introduced selection and information biases, limiting the generalization of the results.

Prospective studies with longitudinal patient monitoring are essential to deepen our understanding of the natural history of CAUL, assess long-term treatment outcomes and identify risk factors more accurately.

CONCLUSION

This study revealed a comprehensive overview of CAUL over a nine-year period. The prevalence and characteristics of CAUL found largely corroborate findings from previous research, reinforcing the importance of some conditions, such as syndactily and polydactily.

AUTHOR'S CONTRIBUTION: Each author contributed individually and significantly to the development of this article. DJLG: contributions to data collection and manipulation; and writing of the article; RGS: coordinated the project, from its elaboration, participation in data collection and writing of the article; VYM: contributions to data manipulation and critical review of the written work. LRN: collection and statistical manipulation of the data. JCB: contributions to project elaboration, data collection and critical review of the written work; FF: contributions to project elaboration and critical review of the written work.

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INTRAOPERATIVE COMPUTED TOMOGRAPHY: AN ADVANCED APPROACH FOR VISUALIZATION OF FIXATION MATERIAL IN DISTAL RADIUS FRACTURES

TOMOGRAFIA COMPUTADORIZADA INTRA-OPERATÓRIA: UMA ABORDAGEM AVANÇADA PARA VISUALIZAÇÃO DO MATERIAL DE SÍNTESE EM FRATURAS DE RÁDIO DISTAL

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ABSTRACT

Objective: To compare the efficacy of 2D fluoroscopy with intraoperative computed tomography (CT) in detecting intra-articular screws that extend beyond the dorsal cortex in distal radius fractures. **Methods:** Prospective study of 10 patients undergoing osteosynthesis of distal radius fractures, evaluating the accuracy of 2D fluoroscopy and intraoperative CT. **Results:** 2D fluoroscopy did not identify inadequate positioning, while intraoperative CT detected 20% of intra-articular screws and 60% of screws going beyond the dorsal cortex. **Conclusion:** Intraoperative CT is more effective in detecting inadequate positioning of the synthesis material and may prevent future complications. **Level of Evidence III; Prospective^d comparative study^e.**

Keywords: Distal Radius Fracture; Fluoroscopy; Osteosynthesis, Fracture.

RESUMO

Objetivo: Comparar a eficácia da fluoroscopia 2D com a tomografia computadorizada (TC) intraoperatória na detecção de parafusos intra-articulares e que ultrapassam a cortical dorsal em fraturas de rádio distal. **Métodos:** Estudo prospectivo com 10 pacientes submetidos à osteossíntese de fraturas de rádio distal, avaliando a precisão da fluoroscopia 2D e da TC intraoperatória. **Resultados:** A fluoroscopia 2D não identificou posicionamentos inadequados, enquanto a TC intraoperatória detectou 20% de parafusos intra-articulares e 60% de parafusos ultrapassando a cortical dorsal. **Conclusão:** A TC intraoperatória é mais eficaz na detecção de posicionamentos inadequados do material de síntese, podendo prevenir complicações futuras. **Nível de Evidência III; Estudo^d prospectivo comparativo^e.**

Descritores: Fratura Distal do Rádio; Fluoroscopia; Osteossíntese.

Citation: Pires PH, Gajo MM, Kuffner M, Calumby GF, Couto CC. Intraoperative computed tomography: an advanced approach for visualization of fixation material in distal radius fractures. Acta Ortop Bras. [online]. 2025;33(3) Esp.: Page 1 of 4. Available from URL: <http://www.scielo.br/aob>.

INTRODUCTION

Fracture of the distal radius is the most common fracture of the upper limb in adults, accounting for 1/6 of all fractures treated in the emergency room. Its anatomical reduction, especially in terms of preserving the intra-articular of the intra-articular surface, is considered essential for maintaining the functionality of the limb. Considering this factor, the use of volar locking plates has been chosen as the best method of osteosynthesis for this type of fracture, especially in the presence of a dorsal fragment with an intra-articular trace and in cases of high comminution.^{1,2} However, the use of locking plates on the volar aspect of the distal radius is associated with a greater risk of the screws penetrating the radiocarpal joint and being positioned beyond the dorsal cortex of the radius. Specifically in

comminuted fractures with intra-articular involvement, the synthesis material is positioned more distally, guaranteeing the reduction and stability of the fracture due to its subchondral location.³ Currently, intraoperative fluoroscopy is used to check this positioning, but due to the biconcave articular surface of the distal radius, it is not always effective.¹ Even with the use of this synthesis material, the average post-operative complication rate for distal radius fractures is 16.5%, related to conditions such as osteoarthritis and extensor tendon rupture. Considering the intra-articular protrusion of screws as a causal factor for complications such as osteoarthritis, the use of intraoperative computed tomography (CT) has been considered as an alternative for more reliable detection of the ideal positioning of the synthesis material.³ The aim of this study is to compare the

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

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Article received on 06/01/2024 approved on 08/14/2024.



use of 2D fluoroscopy with the use of intraoperative computed tomography, in order to detect which imaging method guarantees the most accurate detection of malpositioning of the synthesis material. Specifically with regard to intra-articular positioning and dorsal protrusion of screws, the aim is to assess which imaging method detects these alterations better, in order to avoid future complications related to chondral injury and extensor tendon injury.

MATERIAL AND METHOD

This study included patients undergoing surgical treatment for distal radius fractures at Hospital X from January to December 2023. This prospective comparative diagnostic study was approved by the Institutional Review Board/Ethics Committee (CAAE 75178723.4.0000.5125). All participants provided written informed consent prior to enrollment. Patients undergoing osteosynthesis with locked plates and screws were included. Patients treated with Kirschner wires and those with previous signs of radiocarpal joint degeneration were excluded. After selecting the patients, they underwent osteosynthesis of their respective fractures according to prior preoperative planning. The techniques used in the surgery and the method of checking the reduction and positioning of the synthesis material were not altered to suit the study. In other words, during the intraoperative period, the presence of an intra-articular screw was delimited by the 2D fluoroscopic view, using the usual AP and Profile views, as well as the additional skyline view and oblique view with a 30° elevation of the forearm. After completion of the reduction and placement of the synthesis material, the approached wrist was submitted to computed tomography while still in the intraoperative period (Figure 1). The images were analyzed immediately by the attending surgeon to determine the presence of intra-articular material or material extending beyond the dorsal cortex that had not previously been detected by conventional fluoroscopy. Depending on the results obtained with the new imaging method, the surgical procedure was completed or the positioning of the synthetic material was adjusted. The results of the CT scan did not change the definition of which synthesis material would be used or the technique used to implant this material, only the spatial orientation of the screws in relation to the radiocarpal articular surface and the dorsal cortex. Post-operative follow-up of the selected patients was carried out according to the usual pattern of the attending surgeon, weekly for the first two post-operative weeks and then at one and three months after surgery.



Figure 1. Study flowchart.

RESULTS

During the study period, 10 patients who underwent surgical treatment for distal radius fractures at Hospital X were included. The average age was 64 years, with a predominance of females (66%). The most common mechanism of trauma was falling from

height, and the most common fracture was type C1, according to the AO classification (Table 1). With regard to the side affected, 58% of the fractures occurred on the right side, which was the dominant side. All the patients were treated surgically with locking plates, and 70% of the procedures were carried out less than a week after the fracture. When analyzing the images obtained with conventional two-dimensional fluoroscopy, it was observed that this method did not identify cases of improper positioning, whether intra-articular or exceeding the dorsal cortical, representing 0% in both cases. In contrast, intraoperative CT performed after the final radiographic images presented a 20% identification rate for improper intra-articular positioning (2 out of 10 patients) and a 60% detection rate for screws exceeding the dorsal cortical of the radius (6 out of 10 patients). The higher percentages obtained with this method suggest that CT has superior capability in identifying improper positioning of the fixation material, especially those involving the dorsal cortical of the radius. Among the cases where intra-articular material was verified, 50% occurred in patients with fractures classified as AO type C. Regarding the identification of material exceeding the dorsal cortical, 66% were verified in fractures classified as AO type C (Table 2).

Table 1. Patients' epidemiologic data.

Patients	Age (Years)	Side	Fracture classification (AO)
1-	39	D	C1
2-	57	D	C3
3-	65	D	B2
4-	76	D	A3
5-	77	E	C1
6-	65	E	B3
7-	46	D	A3
8-	63	D	C1
9-	56	E	C1
10-	29	D	C1

Table 2. Obtained results with different image methods.

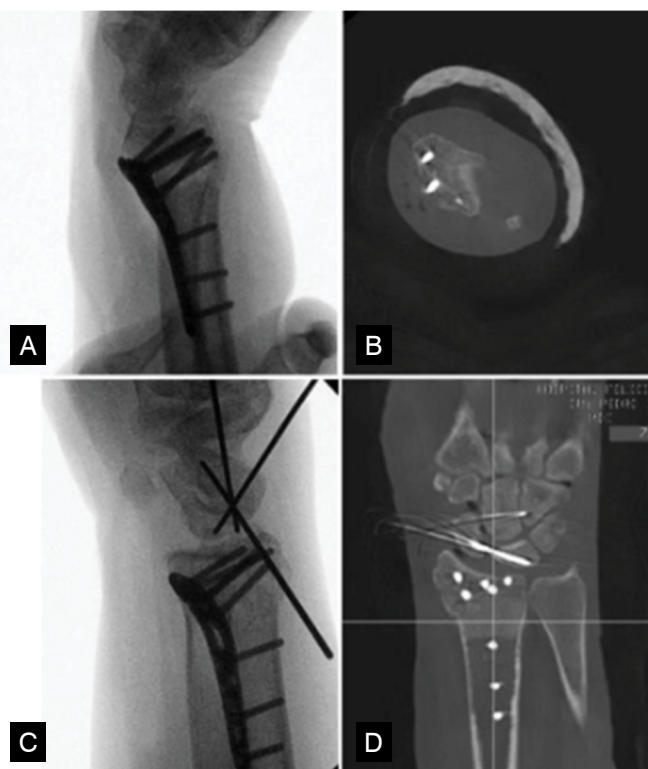
Patients	Age (Years)	Fracture classification (AO)	Intraoperative 2D fluoroscopy		Intraoperative CT	
			IA	DC	IA	DC
1-	39	C1	N	N	N	Y
2-	57	C3	N	N	N	Y
3-	65	B2	N	N	N	Y
4-	76	A3	N	N	Y	N
5-	77	C1	N	N	N	Y
6-	65	B3	N	N	N	N
7-	46	A3	N	N	N	Y
8-	63	C1	N	N	Y	N
9-	56	C1	N	N	N	Y
10-	29	C1	N	N	N	N

Subtitle: IA – intra articular material. DC – material positioned beyond the dorsal cortical. N – No mispositioned material. Y – detected mispositioned material.

DISCUSSION

Despite representing a major advance in the treatment of distal radius fractures, the use of the volar locking plate as a synthesis material brings with it the need for reliable imaging methods in order to establish the best positioning of the implant and avoid future complications. Especially in fractures consisting of small subchondral fragments, dorsal fragments or large comminution, the positioning of the screws in order to achieve adequate reduction has to be carried out in risk areas, resulting in a greater likelihood

of them entering the radiocarpal intra-articular space and exceeding the limits of the dorsal cortex of the radius. There are studies in the literature that advocate the use of unicortical locking screws in the most distal portion of the radius, however, especially in fractures that present comminution of the dorsal cortex, there is still room for debate as to whether the use of shorter screws determines the same effectiveness for fracture stability.⁴ Considering these factors, there is currently a search for the most appropriate imaging method for detecting inadequacies in the synthesis material in question. The use of traditional 2D fluoroscopy views has long been the most widely long been the most widely used imaging method to confirm the positioning of the plate and screws in the distal radius. However, due to the irregular anatomy of the and dorsal surface of the radius, these images give the false impression that the material is not going beyond the determined limits.³ In order to improve this visualization, several additional views have been proposed, the most widely used currently being the Dorsal Tangential View (DTV).⁵ When evaluating 30 fractures of the distal radius, Ganesh et al.⁵ observed that the DTV identified 26.7% of prominent screws in addition to those identified by conventional views. However, post-operative CT scans performed on the same patients identified that 2.86% of the screws remained prominent, even after intra-operative assessment with an additional fluoroscopic view. An interesting aspect of the study was that 80% of the screws not detected by DTV were positioned in the topography of the second extensor compartment. With the same aim of evaluating the efficacy of conventional fluoroscopy, Özbek et al.⁴ compared the use of traditional views with the skyline view in 52 patients with distal radius fractures. In the post-operative evaluation with CT, it was found that the group who underwent the special fluoroscopic view had significantly fewer ($p < 0.05$) prominent screws in the dorsal cortex when compared to the group who underwent the conventional views. Even though this advantage was demonstrated, the use of the skyline view still proved to be flawed since 26.9% of the patients had prominent screws identified by CT scan, most of which were located on the ulnar side of Lister's tubercle.⁴ The proposed use of intraoperative CT scans analyzed in this study seeks to ensure the most effective detection of prominent screws in the dorsal cortex of the radius or screws invading the intra-articular space (Figure 2). Dorsal prominence of the synthesis material is believed to be associated with irritation and rupture of the extensor tendons, a complication seen in up to 50% of patients undergoing surgical treatment for distal radius fractures.⁶ According to the cadaveric study by Austin et al.⁶ the 2-millimeter dorsal prominence of the synthesis material can cause tendon irritation, especially when in the ulnar column of the radius. In the study by Cha SM et al. the follow-up of 314 patients with island fracture of Lister's tubercle, it was concluded that other factors such as the formation of bone callus in the region of Lister's tubercle may also be involved in the rupture of the extensor pollicis longus after surgical treatment of a distal radius fracture.⁷ Despite the small sample size, the results of this study are compatible with those found in the literature. The detection of prominent material in the dorsal cortex in 60% of the fractures previously assessed by conventional fluoroscopy indicates that intraoperative CT is a more effective imaging method for the object in question. With a similar conclusion and a larger sample size, Schnetzke et al. after subjecting 307 distal radius fractures to intraoperative CT identified a 17.6% rate of abnormalities not detected by conventional fluoroscopy.⁸ Considering that in all of these procedures the surgeon considered the positioning of the synthesis material to be optimal after analyzing the 2D image, the revision procedures carried out after the abnormality was identified by CT would not have been carried out if it hadn't been for the use of a more effective imaging exam during the intraoperative period. According to Selles et al. the use of



Source: Author. A and B: 2D and 3D fluoroscopy of the same patient, showing a screw passing through the dorsal cortex by CT. C and D: 2D and 3D fluoroscopy of the same patient, showing detection of intra-articular screw by CT.

Figure 2. Intraoperative images obtained during the study.

intraoperative of intraoperative CT did not show statistically significant superiority in terms of fracture reduction, but it did indicate the need for intraoperative revision of synthesis material positioning in 11% of patients.⁹ In keeping with the results presented, several studies comparing the use of 3D and 2D imaging in the intraoperative period have achieved synthesis material abnormality detection rates of 17.6% to 32.4% with the use of CT.^{2,8,10,11} In all of these studies, the detection of screws both in the radiocarpal joint and extending beyond the dorsal cortex of the radius resulted in the procedure being revised at the same surgical time, avoiding the need for future re-approachment. According to Mehling et al. the more complex the fracture the more complex the fracture approached, the higher the revision rate after using intraoperative CT, as was observed in their study with a revision rate of 32.4% and detection of 58.8% of the screws in the radiocarpal joint. In this way, the use of intraoperative CT provided a lower risk when extremely distal positioning of screws was necessary, thus making it possible to immediately correct the positioning of the synthesis material.¹¹ The debate on the use of intraoperative CT involves its main disadvantages, such as increased radiation and surgical time. In their retrospective comparative study, Halvachizadeh et al.² evaluated 187 patients and detected a radiation exposure of 6.9mGy in the group undergoing intraoperative CT and 2.8mGy in the group undergoing conventional fluoroscopy. In the prospective study by Mehling et al.¹¹ the radiation dose per area was calculated at around 3.2 cGycm², which represented an increase of 55.6% in radiation when compared to the use of conventional fluoroscopy alone. Despite the significant increase in patient radiation, the doses observed are lower than the dose emitted during a Computed Tomography session outside the surgical environment (0.2mSv). The various studies found in the literature are based these data and conclude that the cost-benefit is valid, since the use of

intraoperative CT prevents the use of postoperative CT and the submission of the patient to additional imaging exams to monitor the synthesis material. In the another relevant finding was that the entire radioactive dose to which the patients were subjected, including conventional fluoroscopy, intraoperative and postoperative CT, reached a maximum of 0.25mSv, which is classified as a low-risk dose by the International Commission on Radiological Protection.^{2,9-11} With regard to the increase in surgical time, obtaining and processing intraoperative CT takes an average of six minutes, depending on the familiarity of the with the instrument.^{2,8,11} Considering that it may be necessary to review the procedure after obtaining the image, the total surgical time can increase by up to 28 minutes, or 37% more than the usual time.¹⁰ As the service and the team adapt to the use of intraoperative CT, the time added to the procedure decreases. the total surgical time is the surgeon's experience and not the type of imaging method used.² The cost of adding this new imaging method as the method of choice for intraoperative distal radius fracture conferencing should also be considered. The cost of acquiring and maintaining these devices is around twice that of traditional fluoroscopy. However, when evaluating the cost-benefit ratio, it should be borne in mind that the use of intraoperative CT prevents the need for future revision surgeries and the need for postoperative CT scans, thus reducing the likelihood of additional costs for the patient.¹¹ Hüfner et al. propose that despite the high cost, if used with high frequency and culminating in an intraoperative revision rate of over 5%, the addition of CT to the intraoperative conference protocol would bring economic benefit to orthopaedic services.¹² The results presented both

in this study and in the literature review show that the use of intraoperative CT in the treatment of distal radius fractures ensures better visualization not only of the fracture but also of the positioning of the synthesis material. Its inclusion as the imaging method of choice results in higher revision rates within a timely surgical timeframe and with little radioactive risk for the patient and team. Especially in cases of comminuted fractures with very distal or dorsal fragments, CT becomes an extremely useful tool in detecting intra-articular or prominent screws, thus avoiding future re-approachment and possibly interfering with the rate of post-operative complications.⁸ This study has some limitations, the main one being the small number of patients included. Even with a small sample, the results mirrored those found in the literature, although the absence of true positives made it impossible to calculate variables such as sensitivity and specificity. It should also be considered that the descriptive analysis does not allow us to gauge that the differences presented have statistical significance, but rather suggests that the hypotheses raised are probable.

CONCLUSION

Intraoperative computed tomography identified abnormalities in the positioning of the synthesis material in 60% of cases. In line with the literature reviewed, the conclusion is supported that there is significant support for the application of this imaging method in order to improve the surgical treatment of distal radius fractures, especially in cases characterized by distal and dorsal comminution. Future studies should further investigate the clinical benefits and challenges associated with this technique.

AUTHOR'S CONTRIBUTION: Each author made significant individual contributions to the development of this manuscript: MMG and GFC: Conception and design of the study, acquisition and interpretation of data, writing of the manuscript and critical review of the intellectual content. Actively participated in the discussion of the results, review and approval of the final version of the paper. Responsible for ensuring the integrity and accuracy of all parts of the work. PHP: Performed the surgeries, analyzed the data, participated in writing the manuscript and critically reviewed the intellectual content. Contributed to the discussion of the results and final approval of the manuscript. Responsible for ensuring the integrity and accuracy of all parts of the work. MK and CCC: Statistical analysis, revision of the manuscript and participation in the discussion of the results. Contributed to the revision and final approval of the work. Responsible for ensuring the integrity and accuracy of all parts of the work.

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RETURN TO WORK AFTER CARPAL TUNNEL RELEASE SURGERY

RETORNO AO TRABALHO APÓS CIRURGIA DE SÍNDROME DO TÚNEL DO CARPO

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ABSTRACT

Objective: To clarify whether work-related factors influence the return to work after CTS surgery. **Methods:** Descriptive observational study that included 56 patients who underwent CTS surgery. The variables studied were profession, employment status, time off work after surgery, reason for returning to work, stress level, leave granted by the National Institute of Social Security (INSS), change in job function, and level of work effort. **Results:** The average time to return to work was 39.8 days (SD: 22.3). Self-employed individuals returned to work 6.5 days (SD: 22.3) earlier than salaried employees with a formal contract, who returned in 43.8 days (SD: 23.9; $p=0.49$). Most patients were on leave granted by the INSS, with an average of 47.8 days (SD: 23; $p=0.003$). Patients who had surgery on their left upper limb returned to work one week earlier than those who had surgery on their right ($p=0.025$). **Conclusion:** Coverage by INSS are associated with a delay of approximately two weeks in return to work compared to patients without this coverage. **Level of Evidence II; Retrospective Study.**

Keywords: Return to Work; Carpal Tunnel Syndrome; Social Security.

RESUMO

Objetivo: Esclarecer se fatores relacionados ao trabalho influenciam o retorno ao trabalho após cirurgia para síndrome do túnel do carpo (STC). **Métodos:** Estudo observacional descritivo que incluiu 56 pacientes submetidos à cirurgia para STC. As variáveis estudadas foram profissão, situação empregatícia, tempo de afastamento do trabalho após a cirurgia, motivo para o retorno, nível de estresse, licença concedida pelo Instituto Nacional do Seguro Social (INSS), mudança na função ocupacional e nível de esforço no trabalho. **Resultados:** O tempo médio para retorno ao trabalho foi de 39,8 dias (DP: 22,3). Trabalhadores autônomos retornaram ao trabalho 6,5 dias (DP: 22,3) antes dos empregados formais, que retornaram em 43,8 dias (DP: 23,9; $p=0,49$). A maioria dos pacientes estava de licença concedida pelo INSS, com uma média de 47,8 dias (DP: 23; $p=0,003$). Pacientes que realizaram a cirurgia no membro superior esquerdo retornaram ao trabalho uma semana antes daqueles operados no membro direito ($p=0,025$). **Conclusão:** Pacientes com cobertura pelo INSS estão associados a um atraso de aproximadamente duas semanas no retorno ao trabalho em comparação com pacientes sem essa cobertura. **Nível de Evidência II; Estudo Retrospectivo.**

Descritores: Retorno ao Trabalho; Síndrome do Túnel do Carpo; Previdência Social.

Citation: Pontes RGPC, Cardeal AC, Santos MA, Rezende LGRA, Mazzer N, Engel EE. Return to work after Carpal Tunnel Release surgery. Acta Ortop Bras. [online]. 2025;33(3) Esp.: Page 1 of 4. Available from URL: <http://www.scielo.br/aob>.

INTRODUCTION

Carpal Tunnel Syndrome (CTS) is the most common compressive syndrome in the upper limb, characterized by the compression of the median nerve in the carpal tunnel.¹ In severe cases, motor function and grip strength are affected, leading to work absenteeism and reduced productivity. Over the past 5 years in Brazil, 2,855 sick leaves and 1,081 retirements were granted for individuals with CTS.² CTS is widely associated with occupations involving repetitive movements and extreme wrist positioning, being common among manual Workers.³ Surgery has reported success rates between 71% and 90%,^{4,5} and the lack of clear guidelines to guide return to work after CTS surgery represents a significant challenge, as the length of absenteeism can have a substantial impact on the economy and patient

well-being. A British study revealed that return-to-work guidelines after CTS surgery vary considerably depending on the type of work performed, creating inconsistencies in postoperative management.⁶ The return to work of Brazilian patients has an important particularity: the influence of the National Institute of Social Security (INSS). However, the relationship between these factors has not yet been explored in the literature. This study aims to identify the factors related to the time of return to work after surgical treatment of CTS in Brazilian patients, considering the particularities of the social security system, and thus fill a gap in the medical literature, providing information to help surgeons guide a safe return to work.

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

The study was conducted at Hospital das Clínicas of the Ribeirão Preto, Medical School, Universidade de São Paulo (HCFMRP-USP), and the Hospital Estadual de Serrana, R. Ten. Catão Roxo, 3900, Vila Monte Alegre, Ribeirão Preto, SP, Brazil. 14015-010. Correspondence: Renata Gabriela Pereira Cunha Pontes. Rua Cantanhede, Jardim Eldorado, São Luis, Maranhão, MA, Brazil. 65066-620. renatagpcunha@gmail.com

Article received on 12/02/2024 approved on 04/08/2025.



MATERIALS AND METHODS

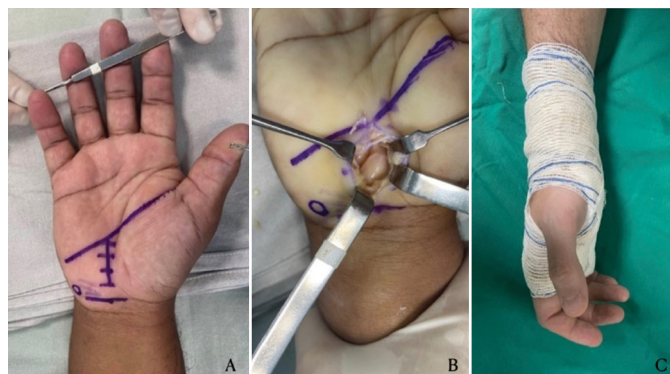
Descriptive observational study using electronic medical record data complemented by online questionnaires completed by patients. The study population included patients who underwent CTS surgery at the Hospital das Clínicas of the Ribeirão Preto Medical School, University of São Paulo, and at the State Hospital of Serrana from January 2015 to October 2022.

Employed patients at the time of surgery were included. Responses from patients who did not properly sign the Informed Consent Form (ICF) were excluded. Medical record data included epidemiological information (age, gender, ethnicity, comorbidities), disease-related data (laterality, clinical examination results at the first evaluation, severity of electromyography at diagnosis, presence of thenar atrophy), and surgical information (postoperative complications). Data not available in the medical records was collected through a questionnaire sent via WhatsApp® to all patients who met the inclusion criteria. The variables collected through the questionnaire included: type of job, employment relationship, time away from work after surgery, cause of early or late return (open response), perceived stress level at work, perceived stress level at home, receipt of INSS leave, and need for job change. Patients also characterized their job as light or heavy manual work.

The questionnaire presented open responses.

The research project and instrument were approved by the Research Ethics Committee of HCFMRP-USP under CAEE: 45539421.3.0000.5440.

All patients underwent the same surgical technique, involving open carpal tunnel release through a mini-incision under local anesthesia and sedation. Complete release of the transverse carpal ligament was performed. Patients were discharged on the same day of surgery with a soft splint. (Figure 1).



Source: Photo archive of the Hand Surgery Residence at FMRP-USP.

Figure 1. (A) Surgical planning, highlighting the incision site. (B) Identification of the nerve post-neurolysis. (C) Application of a soft splint for postoperative support.

In this study, of the 445 surgeries performed, several groups were excluded from receiving the questionnaire: 6 patients had passed away, 4 were unemployed, 71 were retired, and 108 were housewives. Consequently, the questionnaire was sent to 256 patients, resulting in 75 responses. Further exclusions were made based on incomplete or incorrect data: 4 patients were excluded due to questionnaire errors, 7 had not yet returned to work, 2 were waiting for surgery on the contralateral side, and 6 housewives had incorrect information on record. As a result, 56 patients were deemed eligible for analysis.

RESULTS

Most patients were female (87.9%), with 69.6% being white, 21.5% mixed-race, and 8.9% black (Table 1). This racial distribution was consistent with the general population according to the 2010 census.

Table 1. Epidemiological variables and return to work.

Variable	Mean return to work (days)	SD	p-value
Self-declared race			
White	36.5	23.4	0.1
Mixed	51.3	19.6	
Black	39.8	15.1	
Gender			
Female	40.7	22.5	0.8
Male	37.4	25.5	

The average age was 44 years, ranging from 27 to 64 years, following the international trend of CTS affecting primarily individuals between 40 and 60 years old.^{3,7,8}

Regarding the affected hand, 48.2% of patients presented with symptoms in the right hand, 23.2% in the left hand, and 28.6% in both hands. The majority of patients (74%) had electromyography findings consistent with moderate to severe CTS, likely reflecting the fact that the study was conducted in specialized Hand Surgery referral centers, which generally receive more advanced cases due to the time required for referral processes. Additionally, part of the study period coincided with the COVID-19 pandemic, during which elective outpatient services were suspended, potentially delaying diagnosis and treatment.

The Phalen test was the most frequently positive (69.6%), followed by the Durkan test (64.2%) and Tinel test (60%). None of the clinical examination data, including the presence of thenar atrophy, showed an association with return to work time.

The average return to work was 39.8 days, ranging from 3 to 90 days. More than half of the patients (55.4%) returned to work between 15 and 30 days after surgery (Figure 2). The main reasons for returning to work were financial necessity, reported by patients responsible for supporting their families, as well as the desire to work and perceived improvement after surgery (Table 2).

The perception of a successful surgical outcome was associated with an earlier return to work. In this group, the average time was shorter (36.3 days, SD: 20.7) compared to those who rated their hand as the same (47.5 days, SD: 27.5) or worse (55 days, SD: 22.9) than before surgery ($p=0.08$).

Regarding INSS leave, 57.1% of patients used this benefit, with an average of 47.8 days (SD: 23.8) compared to 29.1 days (SD: 14.8) for patients not on leave ($p=0.003$). The multivariate analysis corroborated the bivariate analysis data. Patients on INSS leave returned on average 16.7 days later than those not covered by the benefit, ranging from 5.9 to 27.4 days more ($p=0.002$).

Patients who considered their stress level high at home tended to return to work earlier, while those who reported high stress at work took longer to return (Tables 3 and 4).

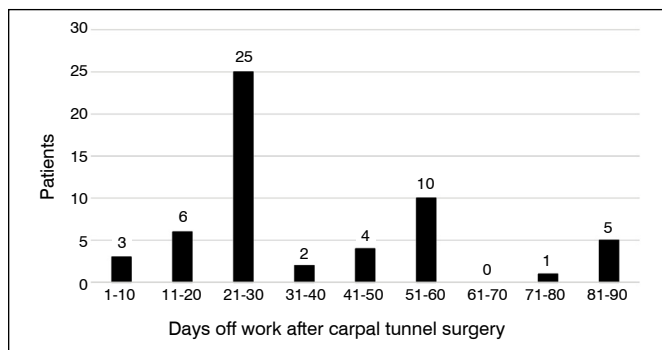


Figure 2. Patient distribution by time to return to work (in days).

Table 2. Reason for return to work after CTS surgery.

Reasons given by patients for returning to work due to financial necessity	Reasons given by patients for returning to work due to pleasure in working or improvement in condition
"I have children to support."	"I like working."
"Single mother of three children."	"The desire to work."
"I need to work, I am alone, not retired."	"I love what I do."
"The severity of the problem and the pain it caused did not motivate me to return. I resigned from the company because the recovery would take many months and I would still have to operate on the other hand... However, I got another job where there is no heavy labor, and due to that, I have less difficulty and pain."	"I returned to work because I was doing well."
"Necessity, without work there is no money."	"The quick improvement."
"Financial problems... children to take care of, etc...."	"My hand was normal, and because I need to help at work."
"My bills are coming, and the only source of income I have is work."	"After the surgery, my hand was much better."

Table 3. Impact of Home Stress Levels on Return-to-Work Time.

Stress level at home	N	%	Mean days to return to work	SD
Low	22	39.3%	43	27.5
Moderate	26	46.4%	38	18.6
High	8	14.3%	35	18.5

Table 4. Impact of Work Stress Levels on Return-to-Work Time.

Stress level at work	N	%	Mean days to return to work	SD
Low	10	17.9%	34	25.0
Moderate	21	37.5%	38	20.8
High	22	39.3%	42	21.8
No response	3	5.4%		

Regarding laterality, patients who underwent surgery on their non-dominant hand returned to work 2 weeks earlier than those with bilateral symptoms ($p=0.025$) (Table 5). Although we did not have sufficient data on hand dominance in the medical records for analysis, given that the global population is predominantly right-handed (90.7%),⁹ it is likely that patients who had surgery on their non-dominant hand experienced a quicker return to work.

DISCUSSION

The data revealed significant variability in return-to-work times, with some patients experiencing notably longer recovery periods than others. This variability underscores the influence of a wide range of factors, including individual patient characteristics and external factors such as access to INSS leave and social support, all of which play a crucial role in determining recovery time.

Traditional clinical factors, such as the presence of atrophy or results from specific clinical tests, did not show a significant association with delayed return to work. This suggests that purely clinical characteristics of CTS are not predictive of recovery time and return to work. A study with 50 workers in Israel found no association between positive clinical tests and longer return-to-work period.¹⁰ Patients who rated surgical outcomes positively tended to return to work earlier. This highlights the importance of communication between doctors and patients to set realistic expectations and build trust in the treatment. Dissatisfied patients with CTS surgery outcomes tend to either not return to work or return late, as described in a French cohort involving 935 patients.¹¹

Financial needs of patients were identified as a motivation for returning to work. Many patients were primary breadwinners and faced economic pressures to resume work. This finding reinforces the influence of socioeconomic factors on the return-to-work process, previously described in the literature.¹

Approximately 39.3% of patients returned to work after more than 30 days post-surgery, indicating a substantial period of absenteeism

Table 5. Multivariate analysis.

Variable	Unstandardized coefficient*	Confidence interval	p-value
Race			
White	-0.3	(-17.5; 16.8)	0.969
Mixed	5.7	(-14; 25.5)	0.570
Black (reference)			
CTS laterality			
Right CTS	-8.4	(-20.6; 3.7)	0.176
Left CTS	-15.6	(-29.2; -1.9)	0.025
Bilateral (reference)			
Work perception			
Light manual	-5.6	(-16.9; 5.6)	0.330
Heavy manual (reference)			
INSS leave			
Patient on leave	16.7	(5.9; 27.4)	0.002
Patient not on leave (reference)			
Surgical outcome perception			
Same as before surgery	9.2	(-6.3; 24.9)	0.245
Worse than before surgery	15.3	(-0.4; 31.1)	0.056
Better than before surgery (reference)			
Hypertension (HTN)			
Without HTN	10.5	(-0.06; 21.2)	0.051
With HTN (reference)			
Phalen's test in the first consultation			
Positive Phalen	3.9	(-7.2; 15.1)	0.489
Negative Phalen (reference)			
Household tasks during the leave			
Performed	-5.8	(-16; 4.2)	0.258
Did not perform (reference)			
Employment relationship			
Salaried with a formal contract	3.6	(-7.3; 14.6)	0.512
Salaried without a formal contract (reference)			

* Unstandardized coefficient: represents an average change compared to a standard value. Negative results: return to work before the reference. Positive results: return to work after the reference.

for a significant portion of the studied population. The average return-to-work period after CTS surgery was 39.8 days, with most patients returning between 15 and 30 days. Those who returned within 15 days generally performed jobs that did not require intense use of the hands. This 2-week earlier return for light manual workers was also found by De Kesel et al. in a study with 107 cases.¹² The use of INSS benefits by patients was strongly associated with a delayed return to work, which highlights the direct influence of social security policies. On the other hand, patients who did not

receive such benefits often had to return to work prematurely, even before full recovery. This dual scenario underscores the need for public policies that ensure financial support during postoperative recovery, without forcing early returns due to economic necessity. The relationship between stress levels at work and delayed return underscores the importance of managing work stress as a potential target for interventions that can expedite return to work. In the short term (up to 60 days), patients with high psychological demand jobs are less likely to return to work successfully compared to those with low work stress levels.¹³

The main limitation of this study, which may have impacted the results, was the limited response rate (29%) to the questionnaire by patients, who reported fear of scams when clicking on links sent

via WhatsApp. However, as the first Brazilian research studying return-to-work time after CTS surgery and the influence of INSS during this period, it offers important insights into patient recovery and the role of social security policies.

CONCLUSION

This research showed that coverage by INSS is associated with a delay of approximately 2 weeks in return to work compared to patients without this coverage. When surgery is performed on the non-dominant hand, patients tend to return to work more quickly. Psychosocial factors, such as positive perception of surgical outcomes, low work stress, and high home stress, as well as economic factors, showed a tendency for earlier return to work.

AUTHOR'S CONTRIBUTION: Each author contributed individually and significantly to the development of this article. RP contributed to data collection and analysis, manuscript writing, and performed the surgeries. AC contributed to data collection and performed the surgeries. MA participated in manuscript writing and revision. LR and NM revised the manuscript and performed the surgeries. EE revised the manuscript, contributed to the intellectual concept of the article, and supervised the professional master's program.

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THE EFFECTS OF ROCKER SOLE ON RUNNING KINEMATICS AND WEIGHT-BEARING COMPUTED TOMOGRAPHY: A 3D ANALYSIS STUDY

OS EFEITOS DO SOLADO ROCKER NA CINEMÁTICA DA CORRIDA E NA TOMOGRAFIA COMPUTADORIZADA COM CARGA: ESTUDO DE ANÁLISE 3D

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ABSTRACT

Rocker sole footwear can be indicated as a treatment for forefoot load distribution disorders, such as diabetic ulcers, metatarsalgia, and hallux rigidus, among others, with favorable clinical outcomes. Pressure analysis studies on rocker sole footwear highlight results that explain their clinical benefits for forefoot conditions. There is insufficient data in the literature to understand the changes in foot mobility and anatomy caused by rocker sole footwear. This study proposes a methodology using weight-bearing computed tomography (WBCT) to evaluate the anatomical alterations in the forefoot associated with rocker sole footwear. The goal is to investigate morphological changes in the forefoot that explain the clinically established kinetic and kinematic effects of such footwear. Biomechanical analysis potentially enhances the understanding of kinetic and kinematic findings without the bias of rocker sole position or magnitude changes. **Level of Evidence V; Expert Opinion.**

Keywords: Kinematics; CT Scan, X Ray; Metatarsalgia; Forefoot, Human.

RESUMO

Calçados com solado rocker podem ser indicados como tratamento para distúrbios de distribuição de carga no antepé, como úlceras diabéticas, metatarsalgia e hálux rígido, entre outros, com resultados favoráveis na evolução clínica. Estudos da avaliação de pressão sob o pé com o uso de calçado com solado rocker evidenciam resultados, que explicam a vantagem clínica do uso desses calçados para o antepé. Não há dados suficientes na literatura para compreendermos quais são as alterações na mobilidade e anatomia dos pés impostas pelos calçados com solados rocker. Propomos nesse artigo uma metodologia de mensuração com tomografia com carga (TCC), avaliar as alterações anatômicas do antepé associadas ao uso do calçado com solado rocker. O objetivo é investigar as alterações morfológicas no antepé que justifiquem os efeitos clínicos, cinéticos e cinemáticos, já estabelecidos na literatura. A análise biocinética potencialmente facilita a compreensão cinética e cinemática dos achados anatômicos, sem o viés da mudança da posição e da magnitude do rocker no solado. **Nível de Evidência V; Opinião do Especialista.**

Descritores: Cinemática; Tomografia Computadorizada; Metatarsalgia; Antepé Humano.

Citation: Sposeto RB, Godoy-Santos AL, DaCosta A, Metsavaht L, Leporace G, Ferkel E, Cesar Netto C. The effects of rocker sole on running kinematics and weight-bearing computed tomography: a 3D analysis study. Acta Ortop Bras. [online]. 2025;33(3) Esp.: Page 1 of 5. Available from URL: <http://www.scielo.br/aob>.

INTRODUCTION

Rocker sole footwear, referred to in the literature as “rocker bottom” or “rocker profile,”^{1,2} demonstrates mechanical advantages in redistributing forefoot load, reducing localized overload. As a result, this footwear is frequently used to treat diabetic foot, hallux rigidus, metatarsalgia, sesamoiditis, stress fractures in athletes, and other conditions.³⁻⁵

These shoes are widely used for treating foot and ankle pathologies, recreational activities, and sports, particularly running. Rocker soles introduce modifications, such as an increment in the plantar volume proximal to the metatarsal heads, which creates a pivot point during the stance phase, altering mechanical and biokinetics properties.

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

The study was conducted at Laboratório Prof. Manlio Mario Marco Napoli, Departamento de Ortopedia e Traumatologia, Hospital das Clínicas, Faculdade de Medicina, Universidade de São Paulo, R. Dr. Ovidio Pires de Campos, 333, Cerqueira Cesar, São Paulo, SP, Brazil. 05403-010.

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Article received on 12/14/2024 approved on 04/03/2025.



Despite their shared characteristic of sole rigidity, rocker footwear varies significantly in other features. The plantar volume may be angular or rounded, differing in magnitude and anterior or posterior placement along the sole.⁴ These variations affect their mechanical properties and the degree of load redistribution, reducing forefoot pressure.⁶

There are three rocker sole positions: forefoot, hindfoot (negative heel), and double. Forefoot rockers are recommended to decrease overload in this region, hindfoot rockers accommodate tibiotalar joint stiffness, and double rockers reduce midfoot overload.⁴

In forefoot rockers, the position and the magnitude can be quantified. The magnitude is described in degrees (for angular soles) or curvature radius (for rounded soles).^{1,7} The position is defined as a percentage, calculated by dividing the distance from the rocker apex to the sole's anterior edge by the total sole length.

Changes in rocker position and shape yield varied pressure redistribution outcomes. For forefoot conditions, most rockers are positioned between 50% and 60%, with angles ranging from 20° to 30°.^{1,4,7}

INDICATIONS

Rocker sole footwear is frequently employed as an offloading strategy in the treatment of diabetic foot, yielding favorable clinical outcomes in ulcer management.³⁻⁵

Due to its mechanical properties, likely related to restricting forefoot and tibiotalar joint movement in the sagittal plane, rocker footwear is also indicated for conservative management of forefoot conditions such as hallux rigidus, sesamoiditis, metatarsalgia, Morton's neuroma, stress fractures, metatarsophalangeal osteoarthritis, and rheumatoid forefoot deformities.^{8,9}

For hindfoot and ankle conditions, rocker soles accommodate movement limitations caused by tibiotalar osteoarthritis and improve gait patterns in patients with tibiotalar arthrodesis.⁷

ROCKER SOLE MECHANICS

The theoretical explanation for rocker sole functionality is based on the pivot created by the sole's plantar volume. This pivot forces gait progression as body weight transfers over it, decreasing the range of dorsiflexion of the metatarsophalangeal joints and reducing pressure on the metatarsal heads. Thus, the rocker effect primarily occurs during the terminal stance phase.^{10,11}

Numerous studies confirm reduced forefoot pressure during gait with rocker footwear. Fuller et al.³ reported a 21% reduction in peak pressure in asymptomatic individuals, while Brown et al.⁴ observed reductions in pressure under the first, second, and third metatarsal heads of 6.97%, 54.44%, and 25.87%, respectively, compared to conventional footwear.

The kinematics and kinetics of gait produce mixed results, showing few changes when comparing rocker soles with conventional shoes.^{2,11,12} Myers et al.¹¹ observed a two-step per minute increase with rockers but found no changes in step length, gait speed, or stance duration.

Boyer and Andriacchi² analyzed the running patterns of 19 healthy volunteers using conventional and rocker forefoot shoes. They found greater ankle dorsiflexion during initial contact and mid-stance, with lower running speeds in the rocker group but no significant kinetic or kinematic changes in the knees or hips.

Van Bogard et al.¹² studied the gait of 40 healthy individuals wearing conventional and rocker forefoot shoes. They noted statistically significant differences, including a more neutral pelvic position in the sagittal plane, increased hip extension during mid and terminal stance phases, greater knee flexion at initial contact, higher ankle dorsiflexion during initial stance, and increased plantarflexion during

push-off. No changes in walking speed were observed, though cadence increased, and step length decreased in the rocker group. Differences in rocker position and magnitude across studies may explain the variability in findings.¹³

Despite descriptions in the literature of the rocker sole's impact on reducing forefoot pressure and gait kinematics, there is no documentation of sagittal plane movement changes in the metatarsophalangeal joints or metatarsal head positioning. This information is important to anatomically justify changes in forefoot pressure and to be able to plan the positioning and magnitude of the rocker individually in specific cases.

Assessing sagittal plane joint positions under load is challenging with radiography due to metatarsal and phalangeal overlap.¹⁴⁻¹⁷ Radiographic evaluations lack precision due to their bidimensional nature, leading to interpretative errors.^{15,18}

Weight-bearing computed tomography (WBCT) provides the advantage of sectional imaging with submillimeter cuts, improving precision and enabling three-dimensional visualization of the metatarsophalangeal joints without overlap, while maintaining physiological load.¹⁶⁻²¹

The authors of this article proposed an ongoing prospective comparative study to evaluate differences in forefoot positioning among volunteers without foot deformities or complaints, using rocker sole footwear during simulated push-off. The objective is to identify and quantify changes in the positioning of the metatarsophalangeal joints during the use of rocker sole footwear, assessed through weight-bearing computed tomography (WBCT) in conjunction with biomechanical analysis. The study was approved by the ethics committee, number 7.021.305. The Informed Consent Form will be explained and applied to the participants.

TOMOGRAPHIC ASSESSMENT

We utilized the Cone Beam CT LineUP scanner, a cone-beam CT from CurveBeam® (Hatfield, PA, USA), with a field of view of 20 cm height and 20–35 cm diameter. The radiation dose per scan was 5 μ Sv.

The acquisition follows the standard protocol of the device for foot imaging. The protocol includes settings of 120 kVp, 5.0 mA, 43.2 mAs, a rotation time of 26 seconds, a CTDI vol of 2.717 mGy, and a dose-area product of 15.01 dGy*cm² with a 12-millisecond pulse. We set the increment at 0 mm, the collimation detector fixed at 5% as per factory calibration, a slice thickness of 0.31 mm $\pm$ 0.5 mm with a 0.3 mm interval between slices, and a field of view adjusted to 35 cm in diameter and 20.9 cm in height. No filters were applied during acquisition.

For the analysis of the tomography scans, we used the CubeVue© software version 3.7.0.3, developed by CurveBeam® (Hatfield, PA, USA). This program imports the DICOM images generated by the WBCT and provides a comprehensive analysis of the foot.

We positioned the volunteers to simulate the push-off phase of gait, ensuring that the evaluated foot was placed in 15° of ankle plantarflexion under load, while the contralateral foot remained in a plantigrade position, symmetrically distributing the load.

To maintain this position throughout the scan, we prepared an anterior support in contact with the leg simulating the push-off, combined with a 15° wedge placed under the hindfoot. The anterior support was adjustable vertically to accommodate the volunteer's height, ensuring consistent contact and position maintenance (Figure 1). The feet were positioned parallel to each other, with the second ray aligned to the gait axis.

Each foot was evaluated under three conditions:

- Barefoot (Barefoot Group - BG): The volunteer was assessed barefoot bilaterally.



Source: Images from the author's personal archive. A. Anterior portion of the leg in contact with the anterior positioner, facilitating the reference for the ankle plantar flexion. B. Maintenance of the simulated push-off position with the assistance of the posterior wedge. C. View of the anterior positioning support and the 15° elevated posterior wedge. D. Placement of markers for the biomechanical evaluation on the anterior portion of the lower limbs. E. Placement of markers for the biomechanical evaluation on the posterior portion of the lower limbs. F. Placement of markers for the biomechanical evaluation of the lower limbs in a lateral view.

Figure 1. Positioning in WBCT and markers for biomechanical evaluation of the lower limbs.

- Conventional Sole Footwear (Conventional Group - CG): The volunteer wore bilateral flat, flexible sole shoes.
- Rocker Sole Footwear (Rocker Group - RG): The volunteer wore bilateral rocker sole shoes.

Following this series of scans, the contralateral foot underwent the same protocol, totaling six scans per volunteer. The total radiation exposure of 0.5 mrem per individual was deemed safe, as reported by Kim et al.²²

The tomographic scan of the foot in a plantigrade position was obtained during the contralateral foot's push-off simulation, allowing for comparisons between plantigrade and push-off positions.

For the CG (Conventional Group), we used a shoe with a flat and flexible sole (Ever Way®, Marvin model). For the RG (Rocker Group), we used a shoe with a rounded rocker sole, an apex located at 60% of the sole's length, a curvature radius of 15.5 cm, a sole height of 30 mm, a 6 mm drop, and a rigid construction (HOKA®, Gaviota 5 model).

We assessed the second and third metatarsophalangeal joints (M2 and M3), as these form the intermediate column of the foot. This segment is more stable proximally in the tarsometatarsal joints, making it less susceptible to minor pronation and supination variations that could affect the positioning of the metatarsophalangeal joints during push-off.²³⁻²⁵ This stability ensures more reproducible measurements.

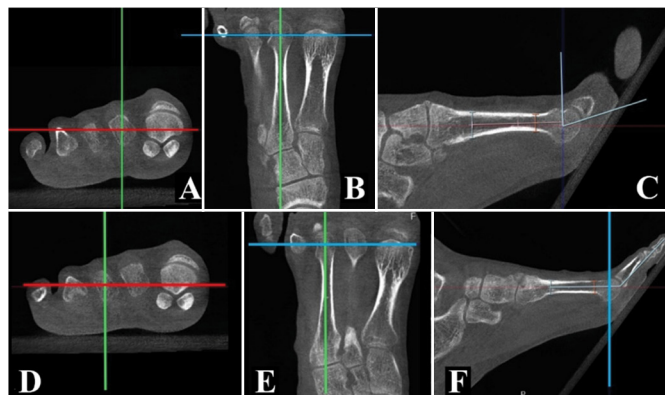
With the acquired images, we will perform the following measurements:

- Metatarsal Articular Coverage Angle (MACA): Measured in the sagittal plane perpendicular to the ground, passing through the center point of the metatarsal head. The angle is formed by a line perpendicular to the metatarsal's longitudinal axis at the head center

and a line connecting this point to the most plantar articular point of the proximal phalanx (Figure 2A, B, C).

- Metatarsophalangeal Joint Extension Angle (MJE): Measured in the sagittal plane perpendicular to the ground, passing through the metatarsal head center. The angle is formed by the metatarsal's longitudinal axis and a line connecting the most distal point of the distal phalanx to the intersection of the metatarsal axis at the head center (Figure 2D, E, F).

These tomographic measurements aim to assess the mobility of the metatarsophalangeal joint in isolation (MACA) and the angular result of the combined mobility of the metatarsophalangeal and interphalangeal joints (MJE).



Source: Images from the author's personal archive. A. Coronal plane, center of the 2nd metatarsal head located. The sagittal plane is perpendicular to the ground. B. Axial plane, center of the 2nd metatarsal head located. The sagittal plane is aligned with the metatarsal axis. C. Sagittal plane, measurement of the angle from the center of the metatarsal head with a line perpendicular to the axis and another line at the most plantar point of the proximal phalanx joint. D. Coronal plane, center of the 3rd metatarsal head located. The sagittal plane is perpendicular to the ground. E. Axial plane, center of the 3rd metatarsal head located. The sagittal plane is aligned with the metatarsal axis. F. Sagittal plane, measurement of the angle between the metatarsal axis and the line connecting the most distal point of the distal phalanx to the point where the metatarsal axis crosses the head.

Figure 2. Acquisition of tomographic measurements. Green line – representation of the sagittal plane. Red line – representation of the axial plane. Blue line – representation of the coronal plane.

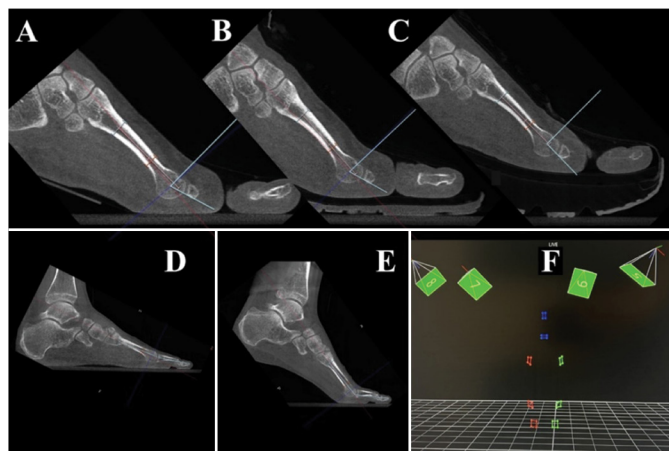
BIOMECHANICAL ASSESSMENT

Kinematic data are collected using a motion analysis system consisting of eight high-speed cameras (Vero 1.3, Vicon, Oxford, UK), sampling at 100 Hz for the walking test and 250 Hz for the running test. The data are filtered with a Butterworth low-pass filter, with a cutoff frequency defined by the residuals analysis of Winter. 3D angles are calculated according to Grood and Suntay.²⁶ All biomechanical data are processed using custom routines in Matlab 2015 software (MathWorks, Natick, USA).

A marker setup consisting of rigid plates, each with four markers, is positioned on the participants' thighs and legs (bilaterally). Rigid plates with four markers each are placed on the posterior region of the pelvis (between the posterior superior iliac spines) and on the posterior trunk (at the height of the 10th thoracic vertebra). Four reflective markers are also placed on the posterior part of the participants' shoes, bilaterally (Figures 1 and 3).

After placing the markers, a static capture is performed for each participant. For this, adhesive markers are applied bilaterally at the following anatomical reference points: the heads of the first and fifth metatarsals, between the heads of the second and third metatarsals, lateral malleolus, medial malleolus, fibular head, tibial tuberosity, medial femoral condyle, lateral femoral condyle, anterior superior iliac spines, xiphoid process, between the clavicles, and at the spinous process of the 7th cervical vertebra.

A pointer with two markers is used to identify these anatomical reference points, following the Calibrated Anatomical Systems



Source: Images from the author's personal archive. A. Metatarsal articular coverage angle: simulated push-off barefoot, measured at 68°. B. Metatarsal articular coverage angle: simulated push-off with conventional footwear, measured at 72.3°. C. Metatarsal articular coverage angle: simulated push-off with rocker footwear, measured at 90.6°. D. Metatarsophalangeal joint extension angle: barefoot plantigrade. E. Metatarsophalangeal joint extension angle: simulated push-off barefoot. F. Three-dimensional representation of trunk positioning in the lower limbs during biomechanical evaluation.

Figure 3. Examples of images obtained in weight-bearing tomographic and biomechanical evaluations.

Technique (CAST),²⁷ thus establishing the participants' orthostatic posture for calibration and obtaining anthropometric and inertial parameters. After static capture, a functional calibration capture is performed to calculate the hip and knee joint centers.^{28,29} After the calibrations, the running test is conducted with the first shoe, followed by the second shoe. The Foot Velocity Algorithm³⁰ is used to determine the stance and swing phases of each cycle. The Altman and Davis method³¹ is used to check the initial foot contact pattern with the ground. The running test is performed on a treadmill (Master Top 18, Inbramed, Porto Alegre, Brazil). The participant selects their preferred running speed for the test. Before the run, a warm-up of approximately 3 minutes of walking at 5.5 km/h is performed. Then, the speed is increased to the running pace, where the participant warms up for about 3 minutes, and a 1-minute running trial is then collected.

During the 3D kinematic assessment, male participants wear shorts or briefs, and female participants wear shorts and a sports top. Each participant performs the walking and running tests with two types of shoes: rocker shoes and conventional shoes, in this order. With this weight-bearing tomography protocol and biomechanical evaluation, we aim to investigate the functional mechanism of the clinical improvement observed with the use of rocker shoes. The literature suggests that there is less mobility in the metatarsophalangeal joints, as the volume of the rocker proximal to them induces early push-off. Our hypothesis is that WBCT will show that there is less mobility in the metatarsophalangeal joints with the rocker shoe compared to barefoot walking and conventional shoes.

SUMMARY

The use of rocker sole footwear as a treatment for forefoot load distribution disorders, such as diabetic ulcers, metatarsalgia, and hallux rigidus, among others,³⁻⁵ has shown favorable results in clinical progression.³² Studies evaluating pressure under the foot with rocker sole footwear highlight results that explain the clinical advantage of using these shoes for the forefoot.^{2-4,11}

There is insufficient data in the literature to fully understand the changes in foot mobility and anatomy imposed by rocker sole footwear. In this article, we propose a methodology using weight-bearing computed tomography (WBCT) to assess the anatomical changes in the forefoot associated with the use of rocker sole footwear, aiming to find a morphological explanation for the clinical, kinetic, and kinematic effects already established in the literature.

WBCT is an accurate imaging method^{17,21} that would allow us to assess the joint relationship of the five metatarsophalangeal joints, as well as the position of the metatarsals during the push-off phase in individuals wearing rocker sole footwear.

Biomechanical evaluation, performed alongside WBCT using the same sample and footwear, potentially facilitates the understanding of the kinetic and kinematic aspects of the anatomical findings, without the bias of changes in the position and magnitude of the rocker in the sole.

ACKNOWLEDGMENTS

We thank HOKA Brasil for donating the tennis and Biocinética São Paulo for donating the 3D motion analysis to carry out this study.

AUTHOR'S CONTRIBUTION: Each author made significant individual contributions to the development of this manuscript. RBS and AILGS: substantially contributed to the conception, design, data analysis and interpretation, writing, revision, and approval of the manuscript.; LM, GL, EF and CCN: substantially contributed to the acquisition and analysis of the data and the critical revision of the intellectual content.

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MUSCULOSKELETAL ALTERATIONS OF ORTHOPEDIC INTEREST IN MUCOPOLYSACCHARIDOSES

ALTERAÇÕES MUSCULOESQUELÉTICAS DE INTERESSE ORTOPÉDICO NAS MUCOPOLISSACARIDOSES

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ABSTRACT

Mucopolysaccharidoses (MPS) are lysosomal storage diseases characterized by the improper accumulation of glycosaminoglycans due to genetic deficiencies in specific enzymes. This accumulation leads to progressive cellular and tissue dysfunction, affecting multiple systems, particularly the musculoskeletal system, resulting in multiple dysostoses with deformities in the spine, thorax, and limbs. Clinically, MPS manifests as recurrent respiratory infections, sleep apnea, severe cardiac lesions, and hydrocephalus, among other symptoms. Bone and joint alterations markedly impair motor function and the quality of life of patients. However, early diagnosis can be achieved by identifying osteoarticular signs, which are crucial for the immediate initiation of treatment. Despite the well-pronounced skeletal manifestations, there is a lack of recognition among specialists, indicating the need for detailed reviews for medical professionals, especially orthopedists, radiologists, pediatricians, and geneticists. This study aims to highlight the orthopedic alterations of MPS, emphasizing their radiographic aspects, which are essential for suspicion, differential diagnosis, and correct identification, contributing to better management of these diseases. **Level of Evidence V; Review Article.**

Keywords: Mucopolysaccharidoses; Limb Deformities, Congenital; Functional Independence.

RESUMO

Mucopolissacaridoses (MPS) são doenças de armazenamento lisossômico caracterizadas pelo acúmulo inadequado de glicosaminoglicanos, devido à deficiência genética de enzimas específicas. Esse acúmulo provoca disfunção celular e tecidual progressiva, afetando múltiplos sistemas, especialmente o sistema osteoarticular, resultando em disostose múltipla com deformidades na coluna, tórax e membros. Clinicamente, as MPS manifestam-se por infecções respiratórias recorrentes, apnéia do sono, lesões cardíacas graves, hidrocefalia, entre outros sintomas. As alterações ósseas e articulares comprometem significativamente a funcionalidade motora e a qualidade de vida dos pacientes. No entanto, o diagnóstico precoce pode ser feito pela identificação de sinais osteoarticulares, condição fundamental para o início do tratamento imediato. Apesar das manifestações esqueléticas serem bem pronunciadas, há uma carência de reconhecimento entre especialistas, indicando a necessidade de revisões detalhadas para profissionais da área médica, especialmente ortopedistas, radiologistas, pediatras e geneticistas. Este estudo visa evidenciar as alterações ortopédicas das MPS, destacando seus aspectos radiográficos, essenciais para a suspeita, diagnóstico diferencial e identificação correta, contribuindo para um melhor manejo dessas doenças. **Nível de Evidência V; Artigo de Revisão.**

Descritores: Mucopolissacaridoses; Deformidades Congênitas dos Membros; Independência Funcional.

Citation: Matos MA, Lopes PS. Musculoskeletal alterations of orthopedic interest in mucopolysaccharidoses. Acta Ortop Bras. [online]. 2025;33(3) Esp.: Page 1 of 5. Available from URL: <http://www.scielo.br/aobp>.

INTRODUCTION

Mucopolysaccharidoses are lysosomal storage diseases characterized by the non-degradation and consequent improper storage of glycosaminoglycans in the lysosomes.¹ Degradation does not occur due to genetic defects that result in the lack of enzymes responsible for the catabolism of glycosaminoglycans.²

Each mucopolysaccharidosis is caused by a mutation that determines the missing enzyme and the mucopolysaccharide that will accumulate (Table 1).^{1,2} This lysosomal accumulation leads to gradual and progressive cellular and tissue dysfunction, characterized by multisystemic involvement and generally lethal for individuals affected by mucopolysaccharidoses.³

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

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Article received on 09/18/2024 approved on 02/17/2025.



Table 1. Classification of MPS, according to enzyme deficiency and accumulated substrate (GAG).

Type of MPS	Eponym	Enzyme deficiency	Substrate
MPS I	Scheie, Hurler–Scheie, Hurler syndromes	α -L-iduronidase	DS/HS
MPS II	Hunter syndrome	Iduronate-2-sulfatase	DS/HS
MPS III-A	Sanfilippo A syndrome	Heparan-N-sulfatase	HS
MPS III-B	Sanfilippo B syndrome	α -N-acetylglucosaminidase	HS
MPS III-C	Sanfilippo C syndrome	Acetyl-CoA- α -glucosaminide acetyltransferase	HS
MPS III-D	Sanfilippo D syndrome	N-acetylglucosamine 6-sulfatase	HS
MPS IV-A	Morquio A syndrome	Galactose-6-sulfatase	KS
MPS IV-B	Morquio B syndrome	β -galactosidase	KS
MPS VI	Maroteaux–Lamy syndrome	N-acetylgalactosamine 4-sulfatase	DS
MPS VII	Sly disease	β -glucuronidase	DS/HS
MPS IX	Natowicz disease	Hyaluronidase	HA

Source: Adapted from Muenzer J.¹ Caption: HA – Hyaluronic acid; coA – coenzyme A; DS – Dermatan sulfate; HS – Heparan sulfate; MPS – Mucopolysaccharidosis; KS – Keratan sulfate; α – alpha; β – beta.

Mucopolysaccharidoses (MPS) are rare and serious diseases that predominantly affect the lungs, cardiorespiratory system, central and peripheral nervous system, and in a very specifically way, the osteoarticular system.¹ The involvement of the musculoskeletal system in mucopolysaccharidoses is known as multiple dysostosis and results in alterations of the spine, chest, and limbs. Clinically, MPS is characterized by recurrent respiratory infections, snoring, sleep apnea, severe valvular heart lesions, hydrocephalus, spasticity, among other injuries.^{4,5}

The involvement of the bones and joints significantly contributes to the loss of motor functionality and the quality of life of patients, leading to even greater human suffering.⁶ However, early diagnosis can be achieved by recognizing the osteoarticular signs of the disease, which are, generally, constant and precocious, and may even exist before the first year of life.⁷ Recognizing skeletal signs of MPS is of particular importance, as many MPS now have a baseline treatment whose effectiveness depends directly on early medication initiation.^{7,8}

Despite the musculoskeletal signs being multiple and well pronounced, there is evidence that even specialists in skeletal dysplasias are not able to diagnose MPS by observing such signs.^{9,10} This points to the need for reviews that are capable of detailing and popularizing these bone alterations among general practitioners, but, especially, orthopedists, radiologists, pediatricians, and geneticists. For this reason, the present study aims to thoroughly review the orthopedic alterations of mucopolysaccharidoses, emphasizing their radiographic aspects.

PATHOLOGY

Glycosaminoglycans (GAGs) accumulate in both intracellular and extracellular compartments.¹¹ These compounds bind to proteins to form proteoglycans, which have a structural function. GAGs also have functions in various cellular processes, such as adhesion, transduction, and activation of specific inflammatory pathways.^{11,12} The accumulation of GAGs is involved in the apoptosis of chondrocytes and in the increase of TNF- α levels, which may be the main factors responsible for the musculoskeletal manifestations of the disease.^{11,12}

The involvement of bones, cartilage, synovial fluid, capsule, ligaments, tendons, and other periarticular tissues is a common finding in all types of mucopolysaccharidoses.¹²⁻¹⁴ Endochondral and pseudomembranous bone growth as well as bone remodeling processes are affected, leading to diaphyseal, metaphyseal, and epiphyseal changes.^{13,14}

The accumulation of GAGs in the periarticular tissues associated with epiphyseal changes leads to stiffness, contractures,

and increased joint volume, causing the so-called “dry arthritis,” where there is no associated inflammatory process.¹⁵ The deposition of GAGs in the flexor tendons, with thickening of the retinaculum and pulley, associated with flexion stiffness of the interphalangeal joints, is responsible for the characteristic claw hand of MPS.^{16,17} The thickening of the flexor retinaculum and tendon sheaths in the carpal tunnel leads to compression of the median nerve at the wrist (carpal tunnel syndrome).¹⁸

Radiographic Evaluation

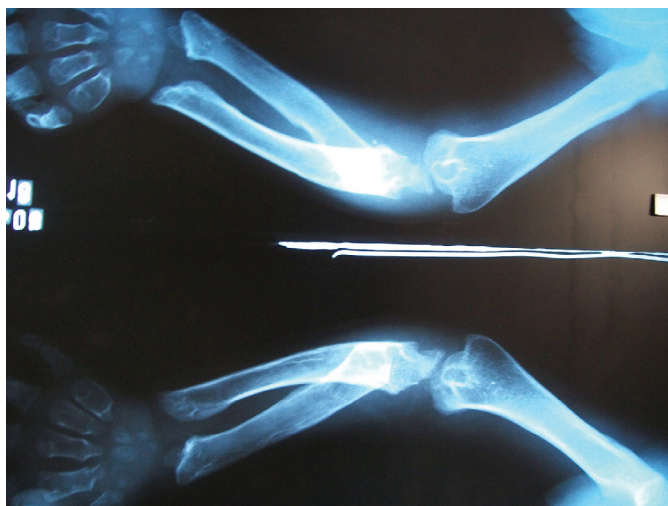
Clinical and laboratory diagnosis is the gold standard in cases of MPS, including enzymatic dosage and genetic sequencing using skeletal dysplasia panels.¹⁰ Conventional radiography is essential for suspicion, differential diagnosis, and most of the time, it is possible to identify radiographic characteristics that lead to the correct diagnosis.^{10,19} A complete skeletal radiographic evaluation should be performed as isolated images can lead to incorrect diagnoses.^{10,19} The best approach is to perform the standard screening for MPS, which includes AP and lateral skull radiographs, AP and lateral thoracolumbar spine, AP chest, AP pelvis, AP upper limb panoramic, AP lower limb panoramic, and AP left hand.^{19,20} In this study, the main radiographic aspects of the orthopedic alterations of mucopolysaccharidoses will be presented.

Long bone and limbs deformities

Upper limb

Dysfunction in the endochondral growth of long bones causes decreased length with a relative increase in width, resulting in overall shortening of the upper and lower limbs with subsequent short stature.^{13,14} There is metaphyseal widening that creates the appearance of periarticular edema which is called “dry arthritis”; the physis is irregular and hypoplastic with erratic and misdirected growth, originating diaphyseal tortuosity that results in deformities such as the so-called “Madelung-like” in the wrist (Figure 1). The alteration in remodeling and pseudomembranous growth associated with changes in endochondral growth causes thinning of the cortices, osteopenia, bone fragility, and contributes to the irregularities observed in the longitudinal axis of the diaphysis.^{13,14}

The shoulder joint presents hypoplasia of the proximal humeral epiphysis with a wide and shallow glenoid cavity. There is cortical thinning with medullary widening, and the proximal humerus is in varus with prominence of the greater tubercle exhibiting a medial notch that gives it the appearance of a “shepherd’s crook” deformity.²¹ The clavicle is thick and hypoplastic in its lateral portion, and the scapula is also relatively small and malformed.^{20,21} (Figure 2). The wrist has hypoplasia of the distal radius and ulna with widening of both metaphyses, which are inclined towards each other



Source: Author's.

Figure 1. Shortening of the radius and ulna with irregularities and abnormal curvature, associated with cortical thinning and medullary rarefaction (osteopenia), creating an inflated appearance; distal and proximal dysplasia of both bones is also noted, with widening and irregularities of the metaphyses, as well as convergent inclination of the distal metaphyses.



Source: Author's.

Figure 2. Shortened, widened, and irregular clavicle with increased curvature; dysplastic glenoid cavity; proximal humeral metaphyseal widening with abnormal notching in the medial region and varus deformity of the neck (shepherd's crook).

(Madelung-like deformity), giving the appearance of a "V"-shaped carpus. The carpal bones are irregular, small, with late ossification of the nuclei. The metacarpals are arranged in a fan shape and present proximal thinning sometimes with a small beak and distal widening.²¹ Like other long bones, the metacarpals are also shorter and wider, the physes are tortuous, and the epiphyses are hypoplastic, irregular and of late appearance. The phalanges have the characteristic appearance of a bullet, being wider proximally and tapered with a smooth rounding distally.²¹ (Figure 3).

Lower limb

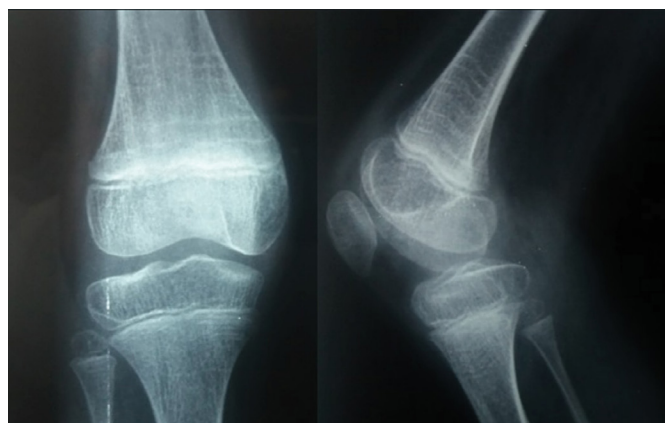
Hip dysplasia in MPS is usually very severe and can lead to subluxation, dislocation, late degenerative joint disease, or even femoral head osteonecrosis.^{19,20,22,23} Most patients present with increased cartilage associated with a shallow and poorly developed acetabulum in its lateral portion, which is also poorly ossified, producing

extrusion of the femoral head with increased acetabular and increased Riemers indices.^{19,20,22,23} The iliac wing has a fan-shaped and rounded appearance with lateral inclination and is tapered distally. The ossification of the femoral head is late, irregular, with the medial portion poorly developed and gradually fragmented, resembling Perthes disease.¹⁰ The proximal femur is in valgus with an enlarged neck, producing a Shenton line rupture. (Figure 4).



Source: Author's.

Figure 3. Radial and ulnar dysplasia with metaphyseal and epiphyseal irregularities, with ends inclined toward each other (Madelung-like deformity); carpal bones with delayed and irregular ossification; metacarpal bones shortened, widened, irregular, with thinned cortices and conical-shaped proximal ends (beak-shaped); malformed phalanges with widened bases and narrow, rounded apices (bullet-shaped).

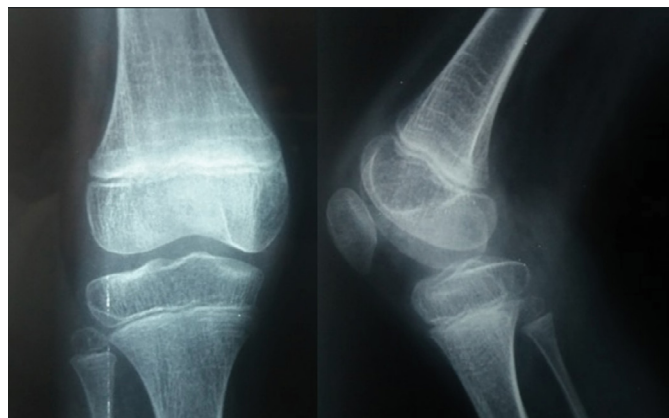


Source: Author's.

Figure 4. Radiological image of the hip showing flattened and malformed femoral head associated with femoral neck valgus. There are also acetabular dysplasia and head subluxation.

The tibia has hypoplasia of the lateral part of the epiphysis, producing the characteristic valgus knee, especially in MPS type IV, which usually develops after two years of age and progresses slowly, causing joint degeneration.^{19,23} The feet in MPS can vary between planovalgus patterns with twisted toes²⁴ or cavovarus with equinus; there is lateral hypoplasia of the distal tibial physis, and the fibula is curved towards the tibia, often with absence or hypoplasia of the distal ossification center.²⁴ Gradually, the feet become clinically equinus and acquire forefoot widening that makes it difficult to fit into shoes, while shortening and overlapping of the foot rays are also common.^{24,25} As previously described, the accumulation of

GAGs in tendons and tendon sheaths gradually produces flexion deformity of the toes, leading to similar claw deformity seen in the hand.²⁶ (Figures 5, 6 and 7).



Source: Author's.

Figure 5. Radiological image of the knee in PA and lateral views, showing hypoplasia of the lateral part of the tibial epiphysis – valgus knee.



Source: Author's.

Figure 6. Clinical characteristic of valgus knee (knock knee) and plano-valgus foot deformity with flexed toes – claw deformity.



Source: Author's.

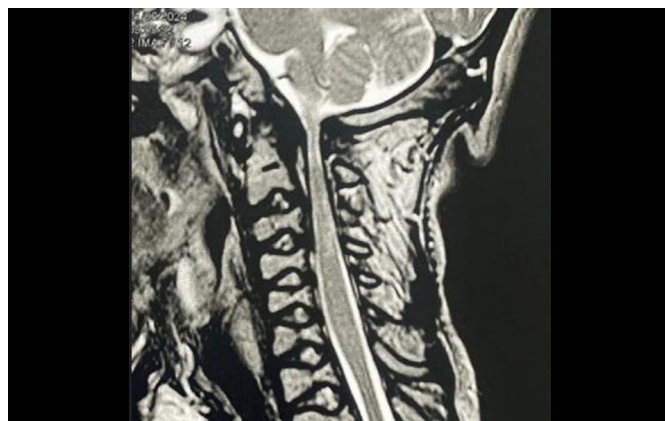
Figure 7. Clinical appearance of the hand in a claw-like posture with flexion of the distal and proximal interphalangeal joints, and the metacarpophalangeal joints.

Spine deformities

Cervical spine

The craniocervical junction stenosis is a common finding in MPS. This alteration occurs due to multiple factors that ultimately are responsible for stenosis, which can lead to spinal cord compression, myelopathy, and signs and symptoms of upper motor neuron compromise.^{19,27,28} The accumulation of GAGs in the ligaments and meninges produces tissue thickening, particularly in the peri-odontal region (thickened dura and hypertrophied ligamentum flavum). Other findings that contribute to stenosis are platybasia, hypoplasia of both odontoid and C₁ arch, disc protrusion, and basilar invagination.^{19,27,28}

Atlantoaxial instability, which is particularly found in MPS type IV, is another significant factor associated with craniocervical injury.^{19,27} In the case of other forms of MPS, tissue thickening causes cervical stiffness, which relatively protects against craniocervical instability. However, patients with MPS IV present C₁-C₂ hypermobility, making them especially susceptible to spinal cord injury. Baseline treatment with enzyme replacement therapy reduces the accumulation of GAGs, which is also a risk factor that should be monitored by cervical spine magnetic resonance imaging.^{27,29} (Figure 8)



Source: Author's.

Figure 8. MRI image of the cervical spine showing spinal cord compression and myelopathy.

Thoracolumbar spine

The vertebral spine is characterized by platyspondyly, anterior beaking of the vertebral body, with maintained or increased disc height. The beak is located anteroinferiorly in MPS I and centrally in MPS IV.^{19,30} The vertebrae also present a posterior notch in the body,³¹ and their overall shape resembles the profile image of a "betta fish". Acute thoracolumbar kyphosis is a common deformity that manifests as vertebral humping, often before the age of two. It affects around three vertebrae, with the apical vertebra having anterior wedging and being posteriorly displaced.^{19,30,31} Lumbar stenosis is rare but can occur due to discal retropulsion. Although scoliosis may be present, it is much rarer and, when present, it is always associated with kyphosis.^{19,30} (Figure 9)

FINAL CONSIDERATIONS

MPS are a group of skeletal dysplasias characterized by disproportionate short stature, usually rhizomelic. This condition comprises 15 types divided into seven phenotypes according to the specific enzyme deficiency. MPS present several osteoarticular alterations known as multiple dysostosis (disostosis multiplex). The main alterations include cervical instability and stenosis, platyspondyly and acute thoracolumbar kyphosis, claw hands and feet, valgus



Source: Author's.

Figure 9. In this figure, it is possible to see the typical shape of the vertebrae (beta fish) on the X-ray, as well as the retropulsion of the intervertebral discs causing stenosis of the spinal canal at the kyphosis apical vertebra.

knees, hip dysplasia, and long bone deformities. Many of these characteristics are not specific to MPS and are also present in other skeletal dysplasias, but knowledge of the details of osteoarticular radiology is essential to avoid delays and diagnostic errors that can allow the patient's evolution to irreversible and even lethal conditions. This report presents the main orthopedic and radiographic aspects in the limbs and spine of patients with mucopolysaccharidoses, emphasizing the role of these alterations in early diagnosis. The scarcity of similar studies certainly makes it difficult to correctly identify suspected patients since MPS are rare diseases with multiple differential diagnoses in the field of skeletal dysplasias, often leading to errors of evaluation. This article represents an important contribution to improving the suspicion, screening, and identification of MPS by pediatricians, geneticists, and rheumatologists who are usually unfamiliar with the details of orthopedic radiology.

AUTHOR'S CONTRIBUTION: Each author made an individual and significant contribution to the development of this article. MAAM: Substantial contribution to study conception, data interpretation, manuscript writing, and critical review of the intellectual content. PSL: Substantial contribution to study conception, discussion of results, manuscript writing, and critical review of the intellectual content.

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