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SUMMARY

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Original Article

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RELIABILITY OF A NEW BAROPODOMETRY PLATFORM DURING BAREFOOT WALKING IN HEALTHY ADULTS

CONFIABILIDADE DE UMA NOVA PLATAFORMA DE BAROPODOMETRIA EM AVALIAÇÃO DE ADULTOS HÍGIDOS

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ABSTRACT

Objective: To expand existing knowledge on gait parameters in a healthy population using a baropodometer and to ensure the reliability of the equipment. Methods: A cross-sectional study was conducted with fifty healthy adults aged 24 to 65 years. Parameters were collected from both sides over at least five valid steps. The Wilcoxon test was performed, and the Intraclass Correlation Coefficient (ICC) for static and dynamic measurements was obtained with 95% confidence and a p-value of 0.005. Results: The platform's reliability exceeded 0.7 for all parameters, both in static and dynamic analysis. All parameters showed a difference of less than 10% compared to the mean estimate across the five tests performed. Discussion: The platform's reliability showed moderate to high ICC values, indicating that, under similar hardware and software conditions, platforms from different manufacturers may produce comparable results. The ICC for PTI was lower than that of the other variables, possibly due to physiological differences in posture, which affect gait speed. Conclusion: The HS Tecnology manufacturer's baropodometer is a reliable tool for gait analysis in barefoot healthy individuals. ***Level of Evidence III; Cross-Sectional Study.***

Keywords: Gait Analysis; Foot; Reproducibility of Results.

RESUMO

Objetivo: Ampliar o conhecimento existente sobre os parâmetros da marcha em uma população saudável utilizando um baropodômetro e garantir a confiabilidade do equipamento. Métodos. Estudo transversal com análise cinquenta adultos saudáveis, com idades entre 24 e 65 anos. Os parâmetros foram coletados de ambos os lados, em pelo menos cinco passos válidos. Teste de Wilcoxon foi realizado e o Coeficiente de Correlação Intraclasse (ICC) para as medições estáticas e dinâmicas foi obtido com 95% de confiança e valor de p de 0,005. Resultados. A confiabilidade da plataforma foi superior a 0,7 em todos os parâmetros, tanto na análise estática quanto dinâmica. Todos os parâmetros apresentaram uma diferença inferior a 10% em relação à estimativa da média nos cinco testes realizados. Discussão. A confiabilidade da plataforma mostrou valores de ICC moderados a altos, indicando que, sob condições de hardware e software similares, plataformas de diferentes fabricantes podem gerar resultados comparáveis. O ICC do PTI foi menor que o das outras variáveis, possivelmente devido a diferenças fisiológicas na postura, que afetam a velocidade da marcha. Conclusão. O baropodometro de um fabricante Baroscan® (HS Tecnology, Brasil) é uma ferramenta confiável para análise da marcha em indivíduos saudáveis descalços. ***Nível de Evidência III; Estudo Transversal.***

Descritores: *Análise da Marcha; Pé; Reprodutibilidade dos Testes.*

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INTRODUCTION

Gait analysis is part of many clinical and research protocols, and in order to perform it accurately and objectively, it is necessary to use equipment capable of performing kinematic or force measurements.[1-6] During gait, body weight is transferred to the foot upon contact with the ground, starting at the heel and ending at the forefoot.[7-10] Measuring ground contact pressure, contact time, and support area distribution provides a variety of information about body position, balance, and the interference of external loads.[4] According to Rosário et al., the imbalance resulting from postural impairments can lead to functional overload, dysfunction, degeneration, or even clinical problems related to incapacitating pain.[4] The presence of high pressure peaks in certain regions of the foot has been widely studied as an important causal factor for various diseases and deformities, especially those located in the functional complex of the foot and ankle.[11-13]

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

The study was conducted at Universidade Federal de Minas Gerais, Hospital das Clinicas, Departamento de Dermatologia (HC-UFMG), Empresa Brasileira de Servicos Hospitalares (Ebserh), Av. Prof. Alfredo Balena, 110, Santa Efigenia, Belo Horizonte, Minas Gerais, MG, Brazil. 30130-100.
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The baropodometer is an advanced force platform used to measure plantar pressure in both static and dynamic positions during gait analysis.[14] To do this, dedicated hardware is required for proper data collection and compatible software to process this data and produce images similar to those of a podoscope.[14-20] This technique provides direct and indirect information about the patient's position when standing still, walking, or even running.[18] Baropodometric analysis is capable of assessing foot dysfunction and can map and record plantar pressure peaks and changes in body balance, enabling the analysis of anomalies.[20] During static assessment, pressure values, area, and center of pressure (COP) deviations can be obtained.[9-11] Dynamic gait analysis allows the collection of data on load distribution during walking, measurement of peak pressure, contact area, and contact time with each region of the foot in relation to the ground.[9-11] Thus, this tool is useful for detecting areas at risk of pain, calluses, or even foot deformities, as well as biomechanical anomalies of the foot, pelvis, and spine.[3,4,13] On the other hand, it is also frequently used in the manufacture of custom orthopedic insoles or footwear to accommodate deformities or modify pressure points for the treatment of pain, especially when located in the foot or ankle.[13]

The peak pressure variable (PP) is calculated using the vertical component of the ground reaction force (GRF). To this end, pressure sensors essentially act as force transducers, measuring the force acting on a surface of known area.[3,5-8,14]

There are advantages to using a baropodometer in clinical practice or for research purposes, as it enables non-invasive analysis of gait, posture, and body balance with high accuracy. However, the accuracy and repeatability of absolute values obtained through baropodometric assessment have been questioned in previous studies examining different pressure systems. These studies compared various devices and performed some hardware technology comparisons to confirm the reproducibility and reliability of the platforms, indicating that comparative studies are needed due to the variability of results obtained with different technologies.[2-4]

The platform technology depends largely on the manufacturer, which can result in a variety of hardware resolutions, sensor types, sampling rates, and detectable pressure ranges. These possible variations between manufacturers can impact the results of force or time measurements that plantar pressure exerts on the device, especially in research contexts. Researchers and clinicians may need to compare data collected from different platforms due to equipment cost, availability in each location, changes in technology over time, or even when used together in multicenter studies to combine data sets from separate studies or clinics.[3,5-8,14]

There are several companies worldwide that manufacture plantar pressure platforms, but only a few have had their equipment tested for accuracy and reliability. Some studies comparing hardware and software with similar specifications from different manufacturers have shown moderate to high correlations, with Intraclass Correlation Coefficients (ICC) greater than 0.7 in comparisons between evaluators.[4,5,7,8,15,18] Therefore, it is crucial to verify the reproducibility of similar hardware and software technologies, even when they come from different manufacturers around the world, to ensure that they provide consistent and accurate results. Ensuring reproducibility can significantly enhance the utility of baropodometers, particularly in developing regions where access to previously validated or high-quality equipment may be limited. By confirming the accuracy and consistency of these tools, researchers and clinicians in such fields can use them with greater confidence in their studies and practices.

Currently, some plantar pressure measurement systems on the market have validated their results as reliable and repeatable, such as platform-based systems (e.g., Novel Emed®, TekScan MatScan®, Medicapteurs S-Plate®, RS-Scan Footscan®, Poprint® and Podoprint®) (1,3,18,19) and systems based on insoles or footwear (e.g., Novel Pedar®, TekScan F-Scan®, RS-Scan Insole®, WalkinSense®, and IBV Biofoot®).[5-8,13] These plantar pressure measurement devices have also proven to be reliable tools for quantifying dynamic plantar pressures. However, most of these systems are manufactured in the United States and Europe, resulting in high acquisition and maintenance costs, especially in developing countries. Additionally, each system typically requires specific software for data processing, which may not be readily available in all regions of the world. Therefore, it is essential to evaluate the validity, reliability, and effectiveness of locally available pressure systems to ensure their suitability for clinical use and large-scale research.

The objective of this study is to evaluate the accuracy and repeatability of the national platform and expand existing knowledge about gait parameters in a healthy population.

MATERIALS AND METHODS

Participants

The study was approved by the Research Ethics Committee (CEP) of the Federal University of Minas Gerais (UFMG CAAE 27968619.9.0000.5149. After CEP approval, 50 healthy adults (25 men and 25 women) were invited to participate in the study. Participants were aged between 24 and 65, with body mass indices (BMIs) ranging from 18 to 37. All participants were physically active, had no comorbidities, pain, or limitations that could affect their walking ability, and signed the informed consent form.

Platform

The Baroscan® (HS Tecnology, Brazil) used in this study measures 680 x 510 x 10 mm and weighs 2.2 kg. It was equipped with 4096 resistive sensors, each measuring 10 x 10 mm, covering a total contact area of 500 x 500 mm. The platform is capable of measuring static and dynamic pressure between 0.4 and 100 N/cm^2, with a maximum sampling frequency of 200 Hz. The manufacturer calibrated the equipment within one year before data collection.

Warm-up Period and Data Collection

Participants were instructed to walk barefoot, at their own pace and speed, for five minutes on a five-meter-long walkway, with the baropodometric plate positioned in the first third of the walkway. After this warm-up period, data were collected from the left and right feet, with a minimum of five steps per foot. Only tests in which the foot made contact with the entire platform were considered valid. Five valid tests were recorded for each participant in the initial session and again after a two-week interval. All data were subjected to statistical analysis.

Statistical Analysis

Descriptive statistics were calculated for each plantar pressure parameter, including static and dynamic tests across the entire surface of the foot. The data were analyzed using SPSS statistical software (IBM®, Chicago IL). To assess reproducibility, the Wilcoxon test was performed, and the ICCs for both static and dynamic measurements were calculated with a 95% confidence interval and a significance level of $p < 0.005$.

RESULTS

The study participants consisted of 25 healthy men and 25 healthy women who agreed to participate. The average age was 48.9 years (ranging from 24 to 65 years). The average body mass index (BMI) of the subjects was 25.32 (ranging from 18.31 to 37.55).

During static analysis, the pressure values found in each variable were summarized (Table 1), and ICC values greater than 0.7 were obtained for all parameters, such as PP (0.705) and MP (0.748), with a 95% confidence interval and p<0.005 (Table 2).
The dynamic analysis is summarized in Tables 3 and 4, which present the pressure values found in this population for each test performed. The results also showed ICC values greater than 0.7 for all parameters: peak dynamic pressure (DPP) (0.828), mean dynamic pressure (DMP) (0.82), pressure time index (PTI) (0.797), and contact time (CT) (0.761) with a 95% confidence interval and p<0.005. (Table 5)
The reliability of the platform exceeded 0.7 in all parameters analyzed, both in static analysis (Table 2) and dynamic analysis (Table 5). All parameters showed a difference of less than 10% from the unbiased estimate of the mean within the five tests performed. The pressure values obtained in both assessments, including static and dynamic gait assessments on the two assessment days, are summarized in Tables 1, 3, and 4 for this population of healthy individuals.

DISCUSSION

Foot pressure measurements are part of many clinical and research protocols, and several companies currently manufacture and distribute foot pressure platforms worldwide. Platform technology is specific to each manufacturer, and suppliers can offer a wide variety of hardware resolutions, different types of sensors, sampling rates, and pressure detection ranges. For many researchers, especially in some developing countries, previously validated baropodometry devices may not be available for purchase, or their maintenance costs may be prohibitive. As technology continues to advance, even in developing countries, a growing number of new manufacturers are producing baropodometry equipment with specifications comparable to those of established, high-quality, internationally validated models. The availability of this new type of domestically produced equipment could expand its daily use in medical offices and broaden its application in clinical research. To this end, even under similar hardware and software specifications, researchers must ensure the validity and comparability of results between available equipment to enable meaningful comparisons in the literature.
Furthermore, this study was conducted in a healthy population, which increases the amount of information on gait analysis data and helps to understand the variability of non-pathological thresholds for static and dynamic gait. Therefore, the objective of this study was to evaluate the accuracy and repeatability of a nationally manufactured baropodometry platform (XXX), with hardware and software specifications similar to those of internationally validated models, using a healthy population. This assessment is crucial for understanding the variation in different technologies used in clinical and research settings, as well as for increasing knowledge about possible non-pathological variations in gait analysis.
The results demonstrate that the variables PP, MP, and TC presented ICC values greater than 0.8. These results are consistent with previous reports, which have shown high reliability for these variables across different brands and manufacturers.
In this study, the PTI variable values presented an ICC value of 0.797. Although this is the lowest ICC among the variables measured,

Table 1. Baropodometric gait parameters in healthy subjects during static analysis at the initial appointment (E1) and the second appointment two weeks later (E2) are presented as medians and quartiles. (n = 50).

Parameters	E1	E2
Peak of pressure kPa (D)	1.29 (1.06 - 1.56)	1.39 (1.15 - 1.66)
Peak of pressure kPa (E)	1.27 (1.01 - 1.64)	1.41 (1.06 - 1.66)
Mean pressure kPa (D)	0.36 (0.30 - 0.40)	0.39 (0.31 - 0.43)
Mean pressure kPa (E)	0.35 (0.28 - 0.41)	0.38 (0.32 - 0.44)
Contact area (cm2)	83.62 (67.14 - 94.15)	79.66 (68.36 - 93.99)

Table 2. Static analysis comparing ICC, IC, and p-value of mean parameters for intra-platform correlation at the first appointment with the second appointment after two weeks apart. (n = 50).

Static parameters	ICC	IC 95%	p-value
Peak of pressure (kPa)	0.705	(0.533; 0.821)	0.000
Mean pressure (kPa)	0.748	(0.595; 0.849)	0.000
Contact area (cm2)	0.801	(0.673; 0.882)	0.000

ICC- Intraclass correlation coefficient. CI – Confidence interval. *p-value* – statistical significance when p<0.05.

Table 5. Dynamic analysis comparing ICC, IC, and p-value of mean parameters for intra-platform correlation at the first appointment with the second appointment after two weeks apart. (n = 50).

Dynamic parameters	ICC
Peak of pressure (kPa)	0.828
Mean pressure (kPa)	0.82
Integral pressure time (kPa s/cm^2)	0.797
Time of contact (ms)	0.834

ICC – intraclass correlation coefficient. CI – Confidence interval. **p-value* – statistical significance when p<0.05.

Table 3. Baropodometric gait parameters in healthy subjects during dynamic analysis at the initial appointment (trials 1 to 5) are presented as median and quartiles (n = 50).

Parameters	1	2	3	4	5
Peak of pressure (kPa/cm^2)	3.34 (2.8 - 4.31)	3.48 (2.92 - 4.35)	3.49 (2.95 - 4.68)	3.54 (3.13 - 4.50)	3.5 (3.06 - 4.49)
Mean pressure (kPa/cm^2)	0.96 (0.81 - 1.05)	0.88 (0.8 - 0.97)	0.87 (0.79 - 0.99)	0.93 (0.79 - 0.98)	0.91 (0.79 - 0.98)
Integral pressure time (kPa s/cm^2)	0.27 (0.22 - 0.35)	0.27 (0.21 - 0.37)	0.27 (0.24 - 0.35)	0.29 (0.23 - 0.35)	0.27 (0.24 - 0.34)
Time of contact (ms)	597.5 (491.25 - 682.5)	530 (447.5 - 625)	507.5 (430 - 591.25)	480 (398.75 - 547.5)	472.5 (383.75 - 540)

Trials 1, 2, 3, 4, 5: median and quartiles of each plantar pressure analysis during initial appointment.

Table 4. Baropodometric gait parameters in healthy subjects during dynamic analysis at the second appointment two weeks later (trials 1 to 5) are presented as median and quartiles (n = 50).

Parameters	1	2	3	4	5
Peak of pressure (kPa/cm^2)	3.38 (2.85 - 3.95)	3.31 (2.85 - 4.10)	3.48 (3.02 - 4.03)	3.45 (3.02 - 4.56)	3.45 (2.92 - 4.37)
Mean pressure (kPa/cm^2)	0.87 (0.80 - 0.97)	0.93 (0.80 - 1.03)	0.91 (0.84 - 1.10)	0.96 (0.87 - 1.06	0.93 (0.86 - 1.06)
Integral pressure time (kPa s/cm^2)	0.27 (0.22 - 0.31)	0.26 (0.22 - 0.33)	0.27 (0.22 - 0.34)	0.29 (0.22 - 0.36)	0.29 (0.22 - 0.39)
Time of contact (ms)	550 (525 - 650)	570 (475 - 661.25)	532.5 (423.75 - 627.5)	497.5 (395 - 558.75)	490 (380 - 546.25)

Trials 1, 2, 3,4,5: median and quartiles of each plantar pressure analysis at second appointment.

it still indicates moderate reliability. This result is lower than that of PP, TC, and MP, which contrasts with previous studies that found higher ICCs for PTI. According to Murphy et al.[12], differences in pressure measurements can be attributed to small, unavoidable physiological changes that may occur during non-pathological walking, such as changes in speed, body position, and muscle activity, which can affect load distribution and ultimately interfere with some measured parameters. PTI describes the cumulative effect of pressure over time on a specific area of the foot, providing the total load exposure of an area of the sole with each step during walking. The moderate reliability of the PTI can be attributed to these physiological changes, as this variable is closely related to walking speed. Previous studies suggest that reducing the average number of attempts can decrease gait variability and enhance the accuracy of results. However, even with five attempts, some physiological changes during walking may be present, ranging from fluctuations in speed to minimal postural adjustments, which could eventually interfere with the results, as demonstrated in a study by Hafer et al.[7] Many studies have demonstrated comparable reliability within a session and between sessions of different pressure platforms or insoles, both in healthy subjects and in groups with specific pathologies, with ICC values greater than 0.7. Similar results were found in our study. Overall, the reliability results of the platform demonstrate moderate to high ICC values, indicating that plantar pressure measurements using this equipment are consistent. This suggests that, under similar *hardware* and *software* specifications, different platforms from various manufacturers could produce comparable results.

Additionally, it is crucial to collect data on healthy populations to facilitate future comparisons with populations that may have gait and balance disorders. Previous studies, such as that by Cordeiro et al.[19], have already demonstrated that even with pressures lower than 195 kPa, some pathologies can lead to the development of ulcers or deformities in the feet, thus highlighting the need to relate healthy populations to the various gait parameters obtained with this type of equipment.

CONCLUSION

Generally, baropodometers produced by domestic manufacturers are reliable tools, with ICC values above 0.7 in the parameters analyzed to assess plantar pressure distribution in both static and dynamic measurements in a healthy population.

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VANCOMYCIN- AND CHLORHEXIDINE DIGLUCONATE-IMPREGNATED DRESSING FOR THE PREVENTION OF ORTHOPEDIC SURGICAL SITE INFECTIONS: A PILOT STUDY USING A LOW-COST PROCEDURE

CURATIVO IMPREGNADO COM VANCOMICINA E DIGLUCONATO DE CLOREXIDINA NA PREVENÇÃO DE INFECÇÕES DE SÍTIO CIRÚRGICO ORTOPÉDICO: ESTUDO PILOTO UTILIZANDO PROCEDIMENTO DE BAIXO CUSTO

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ABSTRACT

Objective: This study introduces a novel approach by proposing a dressing impregnated with vancomycin and chlorhexidine for post-operative care, specifically targeting patients undergoing orthopedic surgeries. Methods: The research design involved a pilot study with a randomized control group, aiming to evaluate the efficacy and safety of vancomycin with a chlorhexidine dressing (Evidence Level I). Participants received vancomycin and CHG impregnated dressing or non-impregnated dressing during the period from March 2023 to October 2023 in trauma-related surgery in the lower limbs. The sample size was based on convenience, considering the pilot study; even though it was randomized and blinded, this study was not a clinical trial. Results: A total of 12 patients used an impregnated dressing, and nine used the same dressing without impregnation. Despite limitations, including the small sample size and single-center study location, our findings demonstrate the safety of the impregnated dressing in trauma surgeries, indicating potential applicability in broader surgical contexts. Conclusion: In conclusion, this study contributes to the discourse on preventive strategies for SSIs, presenting a pioneering approach with the use of vancomycin and chlorhexidine-impregnated dressings. Future research endeavors, incorporating larger-scale studies and addressing study limitations, are crucial for advancing the understanding and implementation of effective postoperative care strategies. ***Level of Evidence I; Case-control study.***

Keywords: Dressing; Antibiotics; Trauma; Vancomycin; Chlorhexidine.

RESUMO

Objetivo: Este estudo introduz uma nova abordagem ao propor um curativo impregnado com vancomicina e clorexidina para cuidados pós-operatórios, visando especificamente pacientes submetidos a cirurgias ortopédicas. Métodos: O desenho da pesquisa envolveu um estudo piloto com grupo controle randomizado, com o objetivo de avaliar a eficácia e segurança do curativo de vancomicina com clorexidina (nível de evidência I). Os participantes receberam curativo impregnado de vancomicina e CHG ou curativo não impregnado durante o período de março de 2023 a outubro de 2023 em cirurgia relacionada a trauma em membros inferiores. O tamanho da amostra foi baseado em conveniência considerando o estudo piloto, mesmo sendo randomizado e cego, este estudo não foi um ensaio clínico. Resultados: 12 pacientes utilizaram curativo impregnado e 9 utilizaram o mesmo curativo sem impregnação. Apesar das limitações, incluindo o pequeno tamanho da amostra e a localização do estudo em um único centro, nossos achados demonstram a segurança do curativo impregnado em cirurgias de trauma, indicando potencial aplicabilidade em contextos cirúrgicos mais amplos. Conclusão: Concluindo, este estudo contribui para o discurso sobre estratégias preventivas para ISC, apresentando abordagem pioneira com o curativo impregnado de vancomicina e clorexidina. Esforços de pesquisas futuras, incorporando estudos em maior escala e abordando as limitações dos estudos, são cruciais para avançar na compreensão e implementação de estratégias eficazes de cuidados pós-operatórios. ***Nível de Evidência I; Estudo de caso-controle.***

Descritores: *Curativo; Antibióticos; Trauma; Vancomicina; Clorexidina.*

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INTRODUCTION

Advancements in medical technology have expanded surgical options, enabling more specific procedures across various medical domains worldwide. Despite these advancements, the management of surgical incisions remains a significant concern, irrespective of the surgical category or location.[1] Over the past decades, there has been a growing emphasis on postoperative care, exemplified by the emergence of the Enhanced Recovery After Surgery (ERAS) protocol, which advocates interventions aimed at enhancing patient recovery and reducing postoperative complications.[2] However, recommendations regarding the selection of dressings for post-operative surgical incision care, despite surgical site infection (SSI) being a common nosocomial infection, are notably lacking.

SSI affects up to 23.6 per 100 surgical procedures, with considerable implications for patients and healthcare systems.[3] These infections are associated with increased morbidity, mortality, and treatment costs, resulting in an additional postoperative period of 7 to 11 days and an elevated risk of death by 2 to 11 times compared to postoperative patients without SSI. In the field of orthopedic surgery, SSIs are recognized as a crucial risk factor for complications and unfavorable outcomes.[4-7] The healthcare costs associated with these complications exceed $1.6 billion in the United States alone.[8]

Among the resources for preventing SSIs in orthopedics, various types of dressings can be employed to preserve the physiological wound healing process and prevent potential infections, improving early discharge. These dressings can be broadly classified into four categories: traditional or passive, skin substitutes, interactive materials, and bioactive dressings.[9] Bioactive dressings, in particular, play a significant role by providing active materials, such as antibiotics, to the wound site.[10] These materials can be impregnated in structures like nanofibers, wafers, foams, sponges, hydrogels, membranes, and films, each with advantages to enhance their biological activity.[11] Moreover, the widespread use of antibiotics has led to the emergence of resistant strains, and postoperative bioactive dressings emerge as a potential solution by minimizing systemic effects through local release, reducing the likelihood of microbial resistance.[12-17] Additionally, surgical site infections can occur post-discharge, where dressings offer the convenience and superior adherence to treatment.[18]

Different dressing structures have distinct advantages and disadvantages. Sponges provide thermal insulation, maintain a moist environment at the wound site, and exhibit high porosity; however, they are mechanically fragile.[19] On the other hand, hydrogels can store a significant amount of water within their 3D polymeric network, facilitating a moist environment for healing, but require a secondary dressing due to their mechanically fragile properties.[20] Hydrocolloids, as non-adherent and painless dressings, can be easily removed by saline or sterile water but may be cytotoxic, have an unpleasant odor, and maintain an acidic pH at the wound site. Films effectively block the flow of liquids and bacteria while allowing free passage of oxygen and water vapor.[21] Due to their flexible, lightweight, and low water absorption characteristics, films are suitable for treating delicate skin and superficial wounds with low exudation. However, they can be challenging to handle, adhere to the wound bed, and cause accumulation of exudate. Membranes are known to act as physical barriers, replicate the three-dimensional architecture of the native extracellular matrix, and ensure cell proliferation, gas exchange, and nutrient supply. They are a semipermeable biomaterial, similar to films, but with a higher water absorption capacity. However, their use is limited by the materials and solvents used in their production.[22]

In the context of various dressing types, a Cochrane review conducted in 2011 and subsequently updated (2022) examined different dressing strategies, including studies of wounds without dressings, but found insufficient evidence to draw a reliable conclusion about the superiority of any one dressing.[11] This was due to the inadequate quality of available evidence, with most studies being limited in size and considered susceptible to systematic errors. Therefore, the authors recommend further research to advance this field.

Among the drugs producing the desired antimicrobial effect in dressings, chlorhexidine gluconate (CHG), an antiseptic that has demonstrated efficacy in reducing the risk of catheter-associated blood infections, is noteworthy.[23] However, despite its promising use, there is still a gap in scientific knowledge regarding the use of dressings impregnated with CHG in preventing surgical site infections and reducing bacterial load.

Other drugs with similar effects include antibiotics, among which vancomycin stands out due to its widespread use in clinical therapies and its antimicrobial potential against resistant Gram-positive pathogens present in the early stages of infection. However, maintaining therapeutic systemic levels of this antibiotic can be challenging and lead to adverse effects such as nephrotoxicity. Local vancomycin release avoids systemic side effects, with topical use already showing promise in the treatment of osteomyelitis, for example. Thus, this research proposes a dressing impregnated with vancomycin and CHG for postoperative care of patients undergoing orthopedic surgeries to prevent surgical site infections by delivering antimicrobials directly to the affected site.

METHODS

Dressing development

The impregnated dressing was developed based on a 20% chlorhexidine digluconate solution, diluted with vancomycin. The solution contained 5% chlorhexidine and 125mg/L vancomycin. Following the formulation of the solution, a 300 gsm filter paper was immersed for a sufficient absorption period and subsequently subjected to freeze-drying, followed by ethylene oxide sterilization. Preliminary microbiological tests for the dressing were conducted using the Kirby-Bauer method.[24] For this, 6 mm diameter disks were created and placed on a Muller-Hinton agar plate previously inoculated with *Staphylococcus aureus* ATCC® 25923.[25] The resulting inhibition zone was compared with a disk made of the same material but without impregnation.[26] The impregnated dressings were assessed for efficacy over 7 days on human skin. Volunteers received the dressing in the form of 6 mm diameter disks, which were placed on healthy skin for a duration of 7 days. After this period, the disks were removed from the skin and placed on a Muller-Hinton plate previously inoculated with *S. aureus* ATCC® 25923. The inhibition zone was compared with a disk made of the same material but without impregnation.

Study design and sample size

This is a pilot study evaluating the use of vancomycin and CHG dressings for immediate wound coverage (post-operative) for seven days to prevent surgical site infections. It was a controlled and randomized study (non-impregnated dressing) involving a total of 23 participants who underwent elective and emergency fracture repair surgery at a University Hospital (CAAE 68749223.9.0000.0020). Participants received vancomycin and CHG impregnated dressing or non-impregnated dressing during the period of March 2023 to October 2023. The sample size was based on convenience, considering the pilot study; even though it was randomized and blinded, this study was not a clinical trial.

Ethical aspects

The study was submitted and approved by the Research Ethics Committee. Dressings impregnated with vancomycin and CHG were produced at the LEID (Laboratory of Emerging Infectious

Diseases) of the Pontifical Catholic University of Paraná. The proportions and properties of the dressings used in this study cannot be disclosed at this time, as they are protected by patent law (Law No. 9.279, May 14, 1996, Brazil). The control dressing consisted of the same material without impregnation. All participants must sign the Informed Consent Form, and interventions will only occur after the document has been signed.

Inclusion and exclusion criteria

The inclusion criteria are adult patients (18 years or older) who are already scheduled for the surgical procedure and provide informed consent to participate in the study. Exclusion criteria were patients allergic to vancomycin or CHG, with a known history of allergy to any of the drugs, recent infectious process, or immunocompromised.

Randomization

Randomization was done through sealed envelopes indicating the type of dressing to be used. The patient and the surgeon were blinded, with only the person responsible for the dressing production aware of the dressing type. The statistical analysis was blinded, and the groups were recognized after the final analysis.

Intervention and outcome

On the surgery day (day 0), the assigned dressing was applied to the surgical site intraoperatively after the sutures were placed. A photograph of the sutured surgical incision was taken with pre-calibrated rulers placed adjacent to the surgical site for subsequent 2D morphometric analysis. Gauze will then be placed over the dressing, followed by a bandage over the entire surgical area. Participants were instructed not to disturb the dressings for the first 24 h. The first dressing change occurred 24 hours after admission (day 1) in the hospital setting, during the hospitalization. The second change occurred 48 hours post-procedure (day 2), after discharge, and was to be performed by the patient, who was instructed accordingly.

The next assessment took place after seven days (day 7) post-surgery in an outpatient setting at the same hospital. 2D morphometric analysis of the wound was conducted, with pre-calibrated rulers placed adjacent to the surgical site for a new photograph. Additionally, the doctor executed the Bluebelle Wound Healing Questionnaire (WHQ) and collected sociodemographic data for qualitative analysis of the surgical wound and the healing process. Surgical site infection was the primary outcome and was evaluated until day 30. The definition of SSI was based on CDC (Center for Diseases Control) criteria, which included: 1) occurs within the first 30 days after surgery and involves only the skin and subcutaneous tissue; 2) purulent drainage from the superficial incision OR positive culture of secretion or tissue from the superficial incision, obtained aseptically (cultures collected by swab are not considered); 3) the superficial incision is intentionally opened by the surgeon in the presence of at least one of the following signs or symptoms: pain, increased sensitivity, local edema, hyperemia, or warmth, UNLESS the culture is negative. Safety was evaluated as adverse events associated with the dressing, including rash, pain, infection, bleeding, necrosis, and dehiscence. The follow-up was 30 days.

Statistical analysis

Student's t-test compared continuous variables and was expressed in absolute numbers or percentages. The categorical variables were analyzed by chi-square or Fisher test and expressed as absolute numbers or percentages. Statistical difference was considered when $p < 0.05$. SPSS v23 was used for statistical analysis (IBM, Armonk NY).

RESULTS

Microbiological tests demonstrated that the dressings exhibited significant antimicrobial activity against S. aureus, a pivotal bacterium in SSI (Figure 1). In the 7-day validation, the dressings maintained their activity. This test is crucial for defining the duration of dressing use, preventing unnecessary applications due to activity loss, and potentially extending the usage time for patients lacking optimal wound care conditions — a common scenario in developing countries. The 24-hour inhibition halo presented a median of 28+/-2.5 mm (n = 10). The inhibition halo was absent in all control dressings (n=10).

A total of 23 randomized patients were enrolled, with 2 excluded due to non-infectious compartment syndrome requiring re-intervention. Consequently, 21 patients were included for the application of dressing. Among the 21 included patients, 12 received the impregnated dressing (57.14%), and 9 received the control dressing (52.38%). The median age was 40 years (IQR 25-75% 28-44). Comorbidities were observed in 28.57% of patients, including three with systemic arterial hypertension and two with diabetes mellitus, one of whom had both comorbidities. Smoking, a risk factor for not healing, was present in 19.04% of patients. Regarding gender, 90.47% (19/21) were male. The data for group comparison are presented in Table 1. Considering the small number of patients in the pilot study, no statistical difference was observed between the groups. Only one case of SSI occurred, which was identified in the control group. Therefore, it is possible to consider that the impregnated dressing is equivalent to the control group, demonstrating its safe use. In Figure 2, the appearance of the dressing in the surgical area before it is covered with a transparent film can be observed.

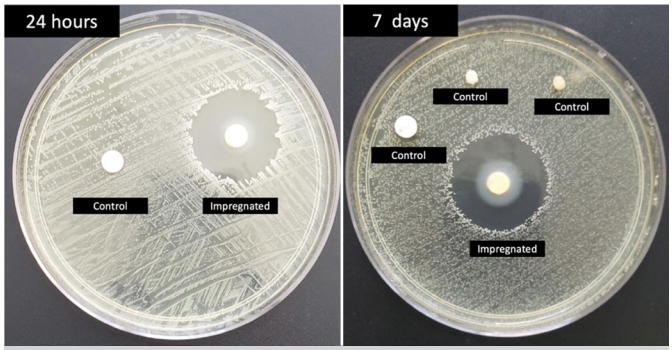

Figure 1. Disk testing of vancomycin-CHG impregnated dressing 24 h after impregnation and 7 days after continuous skin contact.

Table 1. Clinical and outcome data of patients under vancomycin-chlorhexidine impregnated dressing and the control group. SAH – Systemic arterial hypertension; DM – diabetes mellitus; SD – Standard deviation.

	Impregnated dressing (n=12)	%	Control (n=9)	%	Total	%	P value
Age (median/ IQR 25-75%)	40 (30-53)		39 (28-41)		40 (28-44)		0.222
Male sex	11	91.66	8	88.88	19	90.47	0.686
Comobidities			1	11.11	1	4.76	0.324
SAH	3	25	1	11.11	4	19.04	
DM	2	16.67	1	11.11	3	14.28	
Smoking	2	16.67	2	22.22	4	19.04	0.353
Trauma							0.523
Lower limbs	9	75	6	66.67	15	71.42	
Upper limbs	3	25	3	33.33	6	28.57	
Infection	0	0	1	11.11	1	4.76	0.429

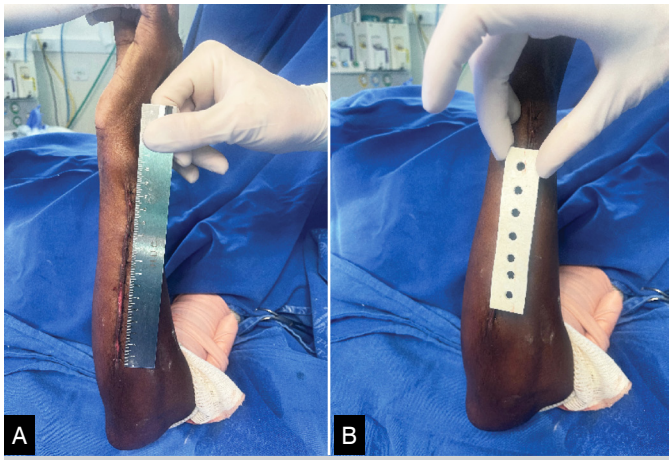

Figure 2. Surgical wound before (A) and after (B) vancomycin-CHG impregnated dressing.

DISCUSSION

Antimicrobial dressings are routinely applied in the care of post-operative incisions, and the development of these dressings has garnered significant attention to meet the growing demands for wound protection against Surgical Site Infections (SSIs) and wound healing promotion.[27] Aligned with the global purpose of developing dressings with these attributes, our study, albeit in a pilot phase, enriches this discussion by presenting a potential strategy in the form of a dressing impregnated with vancomycin and CHG. This specific antimicrobial combination has not undergone prior investigations, highlighting the pioneering nature of this research in SSI prevention. Regarding CHG, its efficacy in reducing MRSA contamination in surgical wounds has been previously demonstrated in a porcine model, showing significant antimicrobial activity and highlighting the potential of CHG dressings against MRSA.[28] Furthermore, meta-analyses support this by stating that dressings impregnated with CHG significantly reduce infections related to central venous catheters, with rare adverse effects.[29] As for vancomycin, studies such as Kalalinia et al. (2021) presented vancomycin-loaded hybrid nanofibers, demonstrating a significant absence of cytotoxicity and effective inhibition of bacterial growth, highlighting the safe and effective use of vancomycin in this topical application.[30] However, the effectiveness of the dressing proposed by our pilot study cannot be compared with those described at this time due to the small sample size.

Therefore, given the lack of consensus regarding postoperative wound care, leaving the choice of dressing to the individual discretion of the physician, coupled with the limitations and uncertainties raised by previous studies, the urgent need for advancing research in this domain is emphasized.[28] Given the increasing relevance of the topic, the lack of substantial data, and the pilot nature of this study, we foresee, in line with the envisioned approach in previous research, the conception and execution of a randomized, double-blind, large-scale study with homogeneous sampling addressing the new dual-action antimicrobial dressing impregnated with vancomycin and CHG in operative wounds, aiming to achieve both statistical and clinical significance. Despite the small number of patients in our study, which precluded a comparative evaluation of infection rates due to the low incidence of this type of trauma at this time, the new dressing proved to be safe in trauma surgeries, indicating promising applicability in other surgeries.

Regarding the study limitations, this is a pilot study rather than a large-scale clinical trial, which limits the ability to draw robust conclusions about the effectiveness of vancomycin and CHG dressings. Additionally, undisclosed properties of the dressings hinder replication in studies at other centers now. Conducted at a single University Hospital in Curitiba, PR, the study's findings may not be universally applicable. Therefore, future research addressing these limitations can enhance the overall assessment of the dressing's effectiveness in preventing Surgical Site Infections.

This study aimed to evaluate the efficacy and safety of operative wound dressings impregnated with vancomycin and CHG, representing an innovative approach to preventing SSI and highlighting the lack of prior research on this specific antimicrobial combination. We grounded our research in previous studies by considering the individual efficacy of CHG and vancomycin. However, the small number of patients did not allow for a comparative evaluation of the infection rate due to the low incidence of this type of trauma. Finally, based on the absence of adverse effects in the sample, our study demonstrated that this new dressing is safe for use in trauma surgeries, with potential applicability in other surgical procedures.

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EPIDEMIOLOGICAL PROFILE AND WAITING TIME FOR OSTEOSYNTHESIS OF TRANSTROCHANTERIC FRACTURES

PERFIL EPIDEMIOLÓGICO E TEMPO DE ESPERA NA OSTEOSSÍNTESE DE FRATURA TRANSTROCANTERIANA

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ABSTRACT

Objective: To evaluate the epidemiological profile and waiting time for osteosynthesis in patients admitted due to intertrochanteric fracture in a public hospital in the Federal District of Brazil. Methods: This observational, descriptive, and retrospective study involved patients over 18 years old with intertrochanteric fractures between June and December 2023. Demographic, clinical data, and information about waiting time for osteosynthesis were collected. Analyses were performed using descriptive statistics and logistic regression. Results: The majority of patients (61.4%) were female, with a mean age of 74 years. The average time between fracture and care was 3.4 days, and from fracture to osteosynthesis was 22.7 days. The mortality rate was 6.8%, with higher prevalence in elderly women with comorbidities. Conclusions: The study demonstrates that a prolonged time between fracture and osteosynthesis is associated with worse clinical outcomes, particularly in elderly patients with comorbidities. Optimizing the waiting time for surgery is essential to reduce morbidity and mortality and improve patient recovery. ***Level of Evidence IV; Observational, Descriptive, and Retrospective Study.***

Keywords: Femoral Fractures; Osteosynthesis, Fracture; Indicators of Morbidity and Mortality; Treatment Delay; Aged; Rehabilitation.

RESUMO

Objetivo: Avaliar o perfil epidemiológico e o tempo de espera para a osteossíntese de pacientes internados devido à fratura transtrocanteriana em um hospital público do Distrito Federal. Métodos: Estudo observacional, descritivo e retrospectivo realizado com pacientes maiores de 18 anos com fratura transtrocanteriana entre junho a dezembro de 2023. Foram coletados dados demográficos, clínicos e informações sobre o tempo de espera até a osteossíntese. As análises foram realizadas utilizando estatística descritiva e regressão logística. Resultados: A maioria dos pacientes (61,4%) eram do sexo feminino, com idade média de 74 anos. O tempo médio entre a fratura e o atendimento foi de 34 dias, e entre a fratura e a osteossíntese foi de 22,7 dias. Pacientes com comorbidades tiveram maior tempo de internação e complicações associadas. A taxa de mortalidade foi de 6,8%, com maior prevalência em mulheres idosas com comorbidades. Conclusões: O estudo demonstra que o tempo prolongado entre a fratura e a osteossíntese está associado a piores desfechos clínicos, especialmente em pacientes idosos com comorbidades. É fundamental otimizar o tempo de espera para cirurgia, visando à redução da morbimortalidade e melhor recuperação dos pacientes. ***Nível de Evidência IV; Estudo Observacional, Descritivo e Retrospectivo.***

Descritores: *Fraturas do Fêmur; Osteossíntese; Morbimortalidade; Atraso no Tratamento; Idoso; Reabilitação.*

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INTRODUCTION

A transtrochanteric fracture is a common type of fracture of the proximal femur, located between the greater trochanter and the lesser trochanter. This fracture is predominantly observed in the elderly, due to osteoporosis and the increased risk of falling in this age group.[1] The transtrochanteric fracture represents one of the main causes of morbidity and mortality in elderly patients and requires a specific therapeutic approach to ensure the best possible recovery.

In younger patients, these fractures may result from high-energy trauma, such as motor vehicle accidents.[2]

These fractures can vary in complexity, ranging from simple and stable to complex and unstable. The fracture pattern can be classified using the Evans classification system or the AO (*Arbeitsgemeinschaft für Osteosynthesefragen*) classification.[3]

The main risk factors are advanced age, osteoporosis, falls, and associated comorbidities.[4-7] Diagnosis is made through a combination

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The study was conducted at Hospital Regional de Taguatinga, located in the Federal District of Brazil.
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of medical history, physical examination, and imaging tests. X-rays are usually sufficient to confirm the fracture and assess its pattern. In complex cases or when other injuries are suspected, a computed tomography (CT) scan may be necessary.[8]

The treatment of transtrochanteric fractures can be conservative or surgical, depending on the type of fracture, the patient's clinical condition, and associated comorbidities. However, osteosynthesis is the treatment of choice in most cases due to its benefits in terms of recovery and early mobilization.[9]

Osteosynthesis, a surgical technique widely used in the treatment of bone fractures, plays a crucial role in the recovery of patients with transtrochanteric femur fractures.[1] The main objectives of surgical management through osteosynthesis are fracture stabilization, pain relief, and early restoration of patient mobility.[3] The choice of fixation method depends on several factors, including the fracture pattern, bone quality, and the patient's overall clinical condition.[4] The most commonly used techniques include intramedullary nails and plates with screws, each with specific advantages in the context of transtrochanteric fracture treatment.[5]

This procedure presents both risks and benefits that the specialist and the patient should consider. The benefits include stable fracture fixation, allowing better alignment of bone fragments and facilitating the healing process; early mobilization of the patient, which is crucial for the prevention of secondary complications such as venous thromboembolism and pneumonia; it helps to significantly reduce associated pain, improving patient comfort and allowing better adherence to the rehabilitation protocol; it restores the function of the affected limb, allowing the patient to resume their daily activities and maintain independence; and it presents better clinical results in terms of functional recovery and patient quality of life.[1-5]

The main risks are infection at the surgical site, which may be superficial or deep, requiring additional treatment or, in severe cases, removal of the implant; possibility of failure of the implant used for fixation, either due to breakage or loosening, which may require further surgery; risk of perioperative complications, including cardiovascular events, venous thromboembolism, and pulmonary complications; in some cases, the fracture may not heal properly (nonunion) or may heal in an improper position (malunion), affecting function and requiring additional treatment; there is a risk of damage to soft tissues, blood vessels, and nerves adjacent to the fracture site, which may result in additional complications, and some patients may develop adverse reactions to the material used in the implants, such as allergies or inflammatory reactions.[6-10]

Therefore, this study aims to evaluate the epidemiological profile and waiting time for osteosynthesis in patients admitted due to transtrochanteric fractures at a tertiary public hospital in the Federal District.

MATERIALS AND METHODS

A descriptive and retrospective observational study was conducted . The data collected are from patients over 18 years of age with transtrochanteric fractures who underwent osteosynthesis at the Regional Hospital of Taguatinga-DF between June and December 2023. This study was approved by the Human Research Ethics Committee of the Foundation for Teaching and Research in Health Sciences (FEPECS), under CAAE: 28246730 and opinion number 7,016,908. Signatures are being collected on the Free and Informed Consent Form.

Information was collected regarding the period of care, date of fracture, age, sex, associated comorbidities, type of fracture, mechanism of trauma, date of osteosynthesis, follow-up period, and outcome. To assess the epidemiological profile and waiting time for osteosynthesis in patients hospitalized due to transtrochanteric fractures, descriptive statistics were performed; to compare risk factors associated with waiting time and to assess the risk of mortality related to waiting time, logistic regression analysis was performed; to correlate the prevalence between sex and transtrochanteric fracture, the Chi-square test and Fisher's exact test were performed; to assess the risk of mortality related to waiting time and to assess the correlation between morbidity and mortality during the follow-up period, correlation analysis was performed. The analyses were performed using SPSS, version 22.

RESULTS

During the period covered by this study, 98 patients with various fractures were admitted, including diaphyseal fractures of the femur: 19.4%; femoral neck fracture: 13.3% and other less frequent fractures: 22.4%, while transtrochanteric fractures accounted for 44.9%, of which 61.4% were female and 38.6% were male; participants had an average age of 74 years (range: 21–96 years) with a standard deviation (SD) of 17.7 years. The participants included in this study were mostly patients aged 60 years or older (90.9%), about 29.5% of patients denied any type of comorbidity, and in 54.5% of patients with some comorbidity, circulatory diseases (62.5%) and endocrine/nutritional/metabolic diseases (33.3%) were the most frequent. (Table 1)

In 81.8% of cases, the most frequent mechanism of trauma was a fall from height or onto the ground. The average time between the occurrence of the fracture and treatment was 3.4 days (1–63 days) with a median of 10.1 days. The average period between fracture and osteosynthesis was 22.7 days (3–82 days) with a SD of 15.4 days (Table 2). In 25% of patients, outcomes were satisfactory, 40.9% were referred for rehabilitation, there were no unsatisfactory outcomes, and 6.8% of patients died; the average follow-up period for patients was 73.3 days (10–365 days) with a DP of 67.1 days. (Table 3)

Table 1. Sociodemographic data.

	Transtrocanteric				p-value
	Yes		No		
Gender					
Female	27	(61.4%)	19	(35.2%)	0.017
Male	17	(38.6%)	35	(64.8%)	
Age group					
Average	**74 years**		**52.5 years**		
18 to 19 years old	0	(0.0%)	1	(1.9%)	0.003
20 to 29 years old	1	(2.3%)	8	(14.8%)	
30 to 39 years old	1	(2.3%)	5	(9.3%)	
40 to 49 years old	2	(4.5%)	14	(25.9%)	
50 to 59 years old	6	(13.6%)	5	(9.3%)	
60 to 69 years old	1	(2.3%)	9	(16.7%)	
70 to 79 years old	11	(25.0%)	6	(11.1%)	
80 to 89 years old	14	(31.8%)	5	(9.3%)	
90 to 99 years	8	(18.2%)	1	(1.9%)	
Comorbidities					
Denies	13	(29.5%)	23	(42.6%)	0.172
Not available.	7	(15.9%)	8	(14.8%)	
Yes	24	(54.5%)	23	(42.6%)	
Circulatory System Diseases	15	(62.5%)	14	(60.9%)	
Endocrine, Nutritional, and Metabolic Diseases	8	(33.3%)	8	(34.8%)	
Nervous System Diseases	3	(12.5%)	5	(21.7%)	
Musculoskeletal and Connective Tissue Diseases	3	(12.5%)	0	(0.0%)	
Other less common comorbidities	11	(45.8%)	9	(39.1%)	

Table 2. Data referring to care provided up to treatment.

	Transtrocanteric				p-value
	Yes		No		
Time between the fracture occurring and my arrival.					
Average	**3.4 days**		**1.8 days**		
1 to 2 days	39	(88.6%)	46	(85.2%)	0.016
3 to 9 days	2	(4.5%)	5	(9.3%)	
≥10 days	2	(4.5%)	1	(1.9%)	
Not available.	1	(2.3%)	2	(3.7%)	
Mechanism of trauma					
Fall height/to the ground	36	(81.8%)	20	(37.0%)	0.007
Other less frequent mechanisms	8	(18.2%)	34	(63.0%)	
Period between fracture and osteosynthesis					
Average	**22.7 days**		**25.1 days**		
1 to 2 days	0	(0.0%)	5	(9.3%)	0.018
3 to 9 days	6	(13.6%)	5	(9.3%)	
10 to 19 years old	16	(36.4%)	17	(31.5%)	
20 to 29 days	11	(25.0%)	10	(18.5%)	
30 to 39 days	7	(15.9%)	5	(9.3%)	
40 to 49 days	1	(2.3%)	4	(7.4%)	
≥ 50 days	2	(4.5%)	6	(11.1%)	
Not available.	1	(2.3%)	2	(3.7%)	

Table 3. Data regarding final outcome and follow-up of patients.

	Transtrocanteric				p-value
	Yes		No		
Final outcome of the patient					
Satisfactory	11	(25.0%)	7	(13.0%)	0.740
Rehabilitation	18	(40.9%)	25	(46.3%)	
Unsatisfactory	0	(0.0%)	4	(7.4%)	
Death	3	(6.8%)	2	(3.7%)	
Not available/not applicable	12	(27.3%)	16	(29.6%)	
Follow-up period (in days)					
Average	**73.2 days**		**96 days**		
< 30 days	4	(9.1%)	5	(9.3%)	0.173
30 to 60 days	19	(43.2%)	17	(31.5%)	
60 to 120 days	9	(20.5%)	11	(20.4%)	
>120 days	4	(9.1%)	11	(20.4%)	

The average time from injury to treatment for transtrochanteric fractures was twice as long as for other fractures at the institution (transtrochanteric; Yes: 3.4 days; no: 1.8 days), between the occurrence of the fracture and osteosynthesis, the average time was slightly shorter in patients with transtrochanteric fractures (Yes: 22.7 days; no: 25.1 days).

Regarding waiting times for care, surgical treatment, and follow-up with the outcome of patients with transtrochanteric fractures, patients who had a satisfactory outcome or went to rehabilitation had an average period between the occurrence of the fracture and care that was 0.4 and 0.8 days longer when compared to patients with other fractures. Regarding the average period between the occurrence of the fracture and osteosynthesis, in all outcomes, the average time in days was shorter when compared to other fractures; and during the follow-up period, patients with other fractures had considerably longer follow-up in all outcomes when compared to patients with transtrochanteric fractures. (Table 4)

Approximately 4 to 5 patients out of every 10 who underwent osteosynthesis at the Taguatinga Regional Hospital between June and December 2023 had transtrochanteric fractures, the majority of which were female (61.4%), with an average age of 73 years. All deaths from this type of fracture occurred in female patients aged between 68 and 88 years, all of whom had some type of comorbidity. These had an average period between fracture and treatment of one day, and between fracture and osteosynthesis of 21.7 days, with an average follow-up period of 24 days.

Table 4. Average time in days from fracture occurrence to treatment, osteosynthesis, and follow-up of patients with transtrochanteric fractures.

	Transthoracic	
	Yes	No
Time between fracture occurrence and care		
Satisfactory	1.8	1.4
Rehabilitation	2.7	1.9
Unsatisfactory	-	1
Death	1	1
Period between fracture and osteosynthesis		
Satisfactory	19.2	33.2
Rehabilitation	23.8	26.6
Unsatisfactory	-	18.2
Death	18	25.5
Follow-up period		
Satisfactory	89	156
Rehabilitation	72	90
Unsatisfactory	-	150
Death	10	37

Table 5. Average time from initial treatment to osteosynthesis and follow-up of patients with associated comorbidities.

Period	Comorbidities			
	Denies	One	Two	Three or More
First contact	5.7 days	1.8 days	5.5 days	1.2 days
Performing osteosynthesis	28.2 days	17.8 days	21.6 days	21.8 days
Follow-up	83 days	86 days	45 days	62 days

DISCUSSION

The primary objective of the present study was to assess the epidemiological profile and waiting time for osteosynthesis in patients admitted due to transtrochanteric fractures at a regional hospital in the Federal District. It showed that women (61.4%) are more prone to transtrochanteric fractures. Furthermore, this type of fracture is more frequent in the elderly population (77.3%), with associated comorbidities (54.5%), mainly diseases of the circulatory system. These findings are consistent with those reported in the literature, which indicate a higher frequency of transtrochanteric fractures in the female population, the elderly, and individuals with more than one associated comorbidity.[11-15] In addition, as evidenced in the present study, the presence of comorbidities related to the circulatory system has also been frequently reported in the literature, especially in elderly patients.[13,16]

The mechanism of trauma was mostly falls from height/to the ground in 81.8% of cases. These findings are consistent with the literature, which indicates that transtrochanteric fractures in the elderly are primarily caused by low-energy falls, with osteoporosis being a significant risk factor.[13,16]

The ideal time for performing osteosynthesis depends on several factors, including the type of fracture, the patient's condition, and the presence of complications, and can range from 24 to 72 hours. In general, the literature suggests that, in cases of polytrauma patients or patients with open fractures, fixation should occur

early, within 24 hours, to minimize the risk of complications such as infections and fat embolism.[14,17]

In a study conducted by Mattisson L, et al. (2018), it was observed that patients who underwent surgery more than 36 hours after fracture had higher mortality rates at 30 days (9.8%) and 1 year (31%) compared to those who underwent surgery within 24 hours.[14] Cruz V, et al. 2023 emphasize that surgeries should not exceed 48 hours, as this period contributes to reducing mortality in elderly patients with transtrochanteric fractures. The authors observed higher mortality when surgery was performed after 48 hours, reaching 38.5%, compared to 14.3% when surgery occurred within 24 hours.[17]

Patients admitted to Taguatinga Regional Hospital between June and December 2023 due to transtrochanteric fractures usually wait an average of 3.4 days between the occurrence of the fracture and receiving care, and up to 22.7 days for osteosynthesis. The data from this study demonstrate that patients with other types of fractures who underwent osteosynthesis during the same period tend to have a mean time between fracture occurrence and treatment that is twice as short (p-value 0.016), however, in relation to the average time until osteosynthesis, patients with transtrochanteric fractures take at least two days less than those with other fractures (p-value 0.018). Lu et al. (2022) emphasize that delays in surgical timing, especially in patients with comorbidities, can result in higher mortality rates after three years. The authors pointed out that factors such as advanced age and low albumin are independent predictors of long-term mortality after surgery for transtrochanteric fractures.[18] Although patients with transtrochanteric fractures have a relatively shorter time to osteosynthesis compared to other fractures, the average time is still about eleven times longer than recommended (48 hours).[17]

This delay is associated with an increased risk of mortality, especially in patients with comorbidities. However, in the present study, even with surgery taking an average of 22.7 days, the frequency of deaths was lower than that observed in the literature (6.8%).[17] However, patients with transtrochanteric fractures had twice the frequency of deaths when compared to other non-transtrochanteric fractures, all of whom were female, aged between 68 and 88 years, and had some type of comorbidity. This finding is consistent with the literature, which highlights that older patients with comorbidities are at greater risk of complications and mortality when surgery is postponed.[11-14,17]

In the present study, patients with one comorbidity had an average of 1.8 days until the first visit, 17.8 days until osteosynthesis, and 86 days of follow-up; those with two comorbidities had 5.5 days until the first visit, 22 days until osteosynthesis, and 45 days of follow-up; and patients with three or more comorbidities had an average of 1.2 days until the first visit, 21.8 days until osteosynthesis, and 62 days of follow-up. However, when evaluating patients without any comorbidities, it was found that the first consultation took up to 6 days, osteosynthesis required 28 days, and follow-up lasted 83 days. This demonstrates that having an associated comorbidity was not a factor that influenced the waiting time for the first consultation and osteosynthesis at the institution.

However, it should be noted that the literature has observed that the presence of preoperative comorbidities significantly influences the waiting time for surgery. In patients with three or more comorbidities, the preoperative waiting time is usually longer, contributing to an increased risk of deep vein thrombosis (DVT).[13] Cruz V, et al. (2023) also highlight that delays in surgery can be influenced by factors such as the need to stabilize the patient, hospital bureaucracy, and lack of available resources.[17]

Another factor that plays a key role in recovery and the development of complications is the length of hospital stay. Patients with transtrochanteric fractures often require longer hospital stays due to the complexity of the fracture and prolonged recovery. In the study by Mattisson et al. (2018), it was observed that the length of hospital stay was directly related to the risk of postoperative complications, especially in older patients with multiple comorbidities.[14]

The incidence of deaths related to all cases of transtrochanteric fractures in the study period was 0.7. However, when evaluating only female patients, it was observed that for every ten cases of transtrochanteric fractures, one case could result in death, mainly in cases of patients aged 70 years or older and with three or more associated comorbidities.

Lu Y, et al. (2022), in their study aimed at investigating risk factors associated with mortality three years after surgery for intertrochanteric fractures in the elderly, demonstrated that in this population, cumulative mortality was 9.6% in the first year, 16.7% in the second year, and 24.4% in the third year after surgery. The greatest risk group is elderly individuals with low albumin levels.[18] Li X, et al. (2021) also highlighted a cumulative mortality of 10.8% during the follow-up period, with an annual mortality rate of 5.4%. These findings are closer to those of the present study.[12]

Overall, this study highlights that during the period studied, there was a high prevalence of elderly women and a significant waiting time for surgical treatment. This delay is directly associated with an increased risk of complications and mortality, especially in patients with comorbidities. In addition, prolonged hospitalization and inadequate follow-up also contribute to adverse long-term outcomes.

In this scenario, despite overall satisfaction in 25% of patients with transtrochanteric fractures who underwent osteosynthesis between June and December 2023 at the Taguatinga Regional Hospital. It remains essential to improve clinical outcomes for these patients by reducing waiting times for osteosynthesis, implementing effective strategies to manage comorbidities, and ensuring comprehensive long-term follow-up in the postoperative period. These efforts may contribute to reducing the frequency of morbidity and mortality associated with transtrochanteric fractures and improving the quality of life of affected patients.

CONCLUSION

After conducting this study, we conclude that the epidemiological profile of patients with transtrochanteric fractures in a public hospital in the Federal District is mainly composed of elderly individuals, predominantly female, with some associated comorbidity. The waiting time between fracture and osteosynthesis was longer than recommended, with an average of 22.7 days, which may negatively impact clinical outcomes, especially in patients with comorbidities. Although the study did not find a direct relationship between the number of comorbidities and the waiting time for care or surgery, the literature provides evidence that prolonged waiting times are associated with a higher risk of complications, including mortality and rehabilitation difficulties. Finally, we emphasize the importance of optimizing waiting times for surgery in transtrochanteric fractures, aiming to improve outcomes and reduce morbidity and mortality, especially in a high-risk population such as the one studied.

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MORTALITY PREDICTOR IN ELDERLY PATIENTS AFTER PROXIMAL THIRD FEMUR FRACTURE: ANALYSIS OF 395 CASES

PREDITOR DE MORTALIDADE EM IDOSOS APÓS FRATURA DO TERÇO PROXIMAL DO FÊMUR: ANÁLISE DE 395 CASOS

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ABSTRACT

Objective: To assess the risk factors associated with mortality in elderly patients with proximal femoral fractures up to one year after the fracture. Method: This was a prospective cohort study of patients aged 60 or older diagnosed with a proximal femoral fracture at a referral hospital in Belém, PA. Results: 395 patients were assessed. The risk factors age≥83 years ($p<0.0010$), fracture-surgery time ≥ 3 days ($p=0.0034$), hemoglobin < 9g/dL ($p<0.027$), leukocytosis ($p<0.00001$) and pulmonary infection ($p<0.0001$) were statistically significant in mortality up to 12 months after the fracture. Conclusion: It was observed that in the first year after fracture, gender, type of fracture and comorbidities were not determining factors in mortality. In this series, the mortality rate was 20.75% one year after the fracture, with pulmonary sepsis being the most frequent cause of death. ***Level of Evidence II; Cohort Study.***

Keywords: Aged; Mortality; Risk Factors; Femur; Fractures, Bone.

RESUMO

Objetivo: Avaliar os fatores de risco associados a mortalidade de pacientes idosos com fratura da extremidade proximal do fêmur em até 1 ano após a fratura. Método: estudo de coorte prospectivo e analítico, em pacientes com idade superior ou igual a 60 anos diagnosticados com fratura da extremidade proximal do fêmur atendidos em um hospital de referência em Belém-PA. Resultados: Foram avaliados 395 pacientes. Os fatores de risco idade≥83 anos ($p<0,0010$), tempo fratura-cirurgia ≥ 3 dias ($p=0,0034$), hemoglobina < 9g/dL ($p<0,027$), leucocitose ($p<0,00001$) e infecção pulmonar ($p<0,0001$) foram estatisticamente significantes na mortalidade em até 12 meses após a fratura. Conclusão: Foi observado que no primeiro ano pós fratura o gênero, tipo de fratura e a comorbidades não foram fatores determinantes na mortalidade. Nesta casuística, a taxa de mortalidade foi de 20,75% após um ano da fratura, sendo a sepse de foco pulmonar a causa mortis mais frequente. ***Nível de Evidência II; Estudo de coorte.***

Descritores: *Idoso; Mortalidade; Fatores de Risco; Fêmur; Fraturas Ósseas.*

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INTRODUCTION

Proximal femur fractures are common in older people, with an estimated 6 million cases in 2050.[1] They can account for up to 84% of bone injuries in people over 60 worldwide.[2] When they occur, these fractures are associated with high morbidity and mortality rates, social impact, and high hospital costs involved in patient care.[1]
It should be noted that the increase in the incidence of fractures in this segment is primarily influenced by demographic transition, with an increase in the number of elderly individuals reaching extreme ages due to advances in medicine and improvements in the population's quality of life.[3,4] In Brazil, for example, it is estimated that by 2060, there will be more elderly people than young people.[5]
These fractures are usually treated surgically with total or partial prostheses or osteosynthesis, and even with technical and therapeutic advances, they still have a high morbidity and mortality rate.[6-8]
Despite this, and even though Brazil has regional differences and unique characteristics in each state, especially in the North, there is no predictive model of mortality for patients with femur fractures based on this population profile.
It is well documented that the presence of associated comorbidities, such as pulmonary infection, pressure ulcers, and bed rest associated with embolisms, has devastating effects on patients with this type of fracture,[9,10] making it necessary to conduct studies on the morbidity and mortality of elderly patients with femoral fractures in the North of Brazil.
Thus, the objective of this study is to analyze the factors associated with mortality in patients over 60 years of age who underwent surgical treatment for proximal femur fractures, to identify predictors of mortality.

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

The study was conducted at Porto Dias Hospital, Orthopedics and Traumatology Department, Av. Alm. Barroso, 1454 - Marco, Belem, PA, Brazil. 66093-020.
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METHOD

This is a prospective cohort study based on medical records from Hospital Porto Dias, Belém do Pará, Brazil, a regional reference center for orthopedics and traumatology. The study was approved by the Research Ethics Committee of the State University of Pará, under number 2,724,974, protocol CAAE 91604318.8.0000.5167.

All elderly patients who underwent surgical treatment for fractures in the proximal third of the femur (neck, intertrochanteric, and subtrochanteric fractures), well documented by imaging tests, were included in the study, selected through convenience sampling. All patients aged 60 years or older were considered elderly. Patients with duplicate medical records, associated fractures in other body segments, and those treated non-surgically (n = 120) were excluded from the study. The study included 395 cases that were followed up for 1 year.

The variables defined were age, gender, time interval between fracture and surgery, type of surgery, red blood cell indices on admission (hemoglobin and leukocytes), postoperative complications, associated comorbidities, occurrence of death up to 1 year after fracture, and cause of death (when applicable), using a code from the International Statistical Classification of Diseases and Related Health Problems (ICD-10).

To minimize the risk of bias, the date and cause of death were confirmed by telephone contact with the families of patients who had such an outcome. A researcher recorded all data collected and independently triple-checked.

Statistical inference was implemented through hypothesis testing. Initially, the Odds Ratio test (Student's t-test or Mann-Whitney test) was applied, and factors with a significance level of less than 0.05 were submitted to bivariate logistic regression. The alpha significance level was previously set at 0.5 for rejection of the null hypothesis.

Microsoft Office software was used to prepare data, tables, and texts, and Bioestat 5.4 was used for qualitative statistical analysis.

RESULTS

Of the 395 patients included in this study, 20.75% (n = 82) died within 12 months after the fracture. Of these, 18.3% of patients in the death group and 18.2% in the survival group were male, with a p-value of 0.88. Thus, gender is not a statistically significant factor for mortality in patients with proximal femur fractures. In absolute numbers, there are way more women than men.

When analyzing the age group, it was observed that 58.5% (n = 48) of patients in the death group were aged 83 years or older, whereas only 37.7% (n = 118) of patients in the survival group were in this age group. The chance of a patient over 83 years of age dying was 2.4 times higher than patients under that age, and the mortality rate in the over-83 age group was 28.9% within 12 months of the fracture. Therefore, age is a statistically significant risk factor for mortality (p = 0.0010).

Considering the interval between fracture and surgery, a statistically significant difference was observed (p = 0.0034), as the mortality rate of patients treated after 3 days was 28.6%, compared to patients who were treated within 48 hours, in whom this percentage was 15.8%.

As observed in Table 1, although transtrochanteric fractures were the most common in absolute numbers, the type of fracture was not a determining factor for patient mortality (p = 0.4033). Similarly, the type of surgical treatment is not a determining factor for mortality in these patients (p = 0.731), with no statistically significant difference observed between the types of treatment.

Regarding red blood cell indices, it was observed that patients with hemoglobin levels below 9 g/dl had a 2.5 times higher risk of mortality than patients with hemoglobin levels above 9 (p = 0.0027).

Table 1. Assessment of the risk of death among 395 patients treated at a referral hospital in Belém, Pará, 2024.

	Death		Survival			Odds Ratio		
Risk Factor	**(n=82)**	**%**	**(n=313)**	**%**	**p-value**	**OR**	**95% CI**	**Mort.%**
Sex					**0.8858**	**1.1**	**0.5 to 1.8**	
Male	15	18.3	57	18.2				20.8
Women	67	81.7	256	81.8				20.7
Age group					**0.0010***	**2.4**	**1.4 to 3.8**	
83 years old or older*	48	58.5	118	37.7				28.9
60 to 82 years old	34	41.5	195	62.3				14.8
Fracture-surgery time					**0.0034***	**2.1**	**1.3 to 3.5**	
3 days or more*	44	53.7	110	35.1				28.6
Up to 2 days	38	46.3	203	64.9				15.8
Type Surgery					**0.7361**	**1.1**	**0.7 to 1.8**	
DCS	4	4.9	24	7.7				14.3
DHS	5	6.1	20	6.4				20.0
HASTE	50	61	182	58.1				21.6
Arthroplasty*	16	19.5	87	27.8				15.5
Hemoglobin					**0.0027***	**2.5**	**1.4 4.3**	
HB < 9.0*	24	29.3	45	14.4				34.8
HB >= 9.0	58	70.7	268	85.6				17.8
White blood cells					**<0.00001***	**5.1**	**3.0 to 8.6**	
Leukocytosis	49	59.8	70	22.4				41.2
No leukocytosis	33	40.2	243	77.6				12.0
Complications					**<0.0001***	**5.6**	**3.0 to 10.1**	
Lung infection*	29	35.4	28	8.9				50.9
Absence	53	64.6	285	91.1				15.7
Comorbidity AS					**0.3019**	**1.4**	**0.8 to 2.5**	
HAS present	63	76.8	220	70.3				22.3
Absence	19	23.2	93	29.7				17.0
Fracture type					**0.4033**	**1.2**	**0.7 to 2.2**	
Colo	21	25.6	93	29.7				18.4
Subtrochanteric	8	9.8	36	11.5				18.2
Transthoracic*	53	64.6	184	58.8				22.4

Source: Research protocol.

With regard to leukocyte count, patients with leukocytosis are 5.1 times more likely to die than patients with normal leukocyte indices. The complication of pulmonary infection is a significant risk factor, given the 5.6-fold increase in mortality compared to patients who did not develop it.

Systemic hypertension, despite being the most frequent in the case series, was not statistically significant when analyzing the outcome (p = 0.319).

Table 2 shows that Evans unstable fractures were more prevalent in both the death group (54.9%) and the survival group (44.7%). However, it was not statistically significant (p = 0.2508) as a direct risk factor for patient mortality within twelve months.

The multivariate model showed the predictive variables that had proven significance by logistic regression: age ≥ 83 years (OR = 3.33), fracture-surgery time ≤ 2 days (protective factor OR = 1.75), hemoglobin < 9 (OR = 1.64), leukocytes ≥ 10,000/mm^3 (OR = 1.48), and pulmonary infection (OR = 1.32), as shown in Table 3 and Figure 1.

Based on the logistic regression data, it was possible to develop a nomogram predicting death in elderly patients with femur fractures. In the nomogram, each risk factor is assigned a score: hemoglobin (1.64 points), age (3.33 points), pulmonary infection (3.73 points),

Table 2. Analysis of the classification of neck fractures (Garden), transtrochanteric fractures (Evans), and subtrochanteric fractures (Sensheimer) in 395 patients treated at a referral hospital in Belém, PA, 2024.

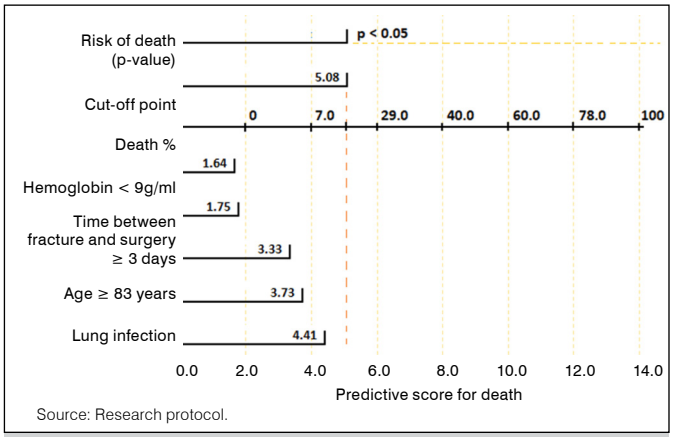
	Death		Survival		
	N (82)	%	N (313)	%	p-value
Garden					**0.8961**
With deviation	17	20.7	74	23.6	
Without deviation	3	3.7	15	4.8	
NSA	62	79.2	224	71.6	
Evans					**0.2508**
Stable	8	9.8	43	13.7	
Unstable	45	54.9	140	44.7	
NA	29	35.4	130	41.5	
Sensheimer					**0.1938**
IIA	0	0.0	7	2.2	
IIB	4	4.9	10	3.2	
IIC	0	0.0	3	1.0	
IIIA	0	0.0	4	1.3	
IIIB	0	0.0	6	1.9	
IV	1	1.2	1	0.3	
V	3	3.7	4	1.3	
NSA	74	90.2	277	88.5	

Source: Research protocol.

Table 3. Multivariate logistic regression model applied to 395 patients treated at a referral hospital in Belém, PA, 2024.

Variable	Coefficient	p-value	Odds ratio	95% CI
Intercept	-3.15			
Age ≥ 83	1.20	<0.0001*	3.33	1.89 to 5.89
Time between fracture and surgery ≥ 3	0.56	0.0485*	1.75	1.10 to 3.07
Hemoglobin < 9	0.49	0.1404	1.64	0.85 to 3.20
Leukocytosis	1.48	<0.0001*	4.41	2.50 to 7.78
Lung infection	1.32	0.0001*	3.73	1.91 to 7.30

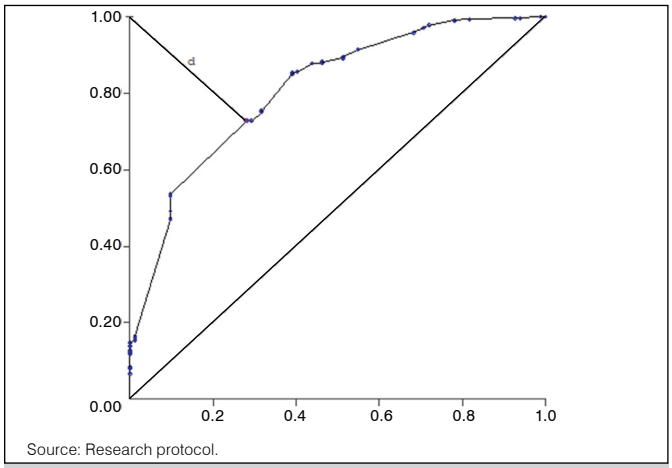
Source: Research protocol.



Source: Research protocol.

Figure 1. Nomogram predicting death among 395 patients treated at a referral hospital in Belém, Pará, 2024.

leukocytes (4.41 points), and time elapsed between fracture and surgery (1.75 points). The sum of the points for the six factors yields the overall score on the Nomogram, with a cutoff point of 5.08. If this value is reached, the probability of death is statistically significant (p-value < 0.05). This score shows Sensitivity = 0.728 (72.8%), Specificity = 0.720 (72.0%), and Accuracy = 0.726 (72.6%), as shown in Figure 02.



Source: Research protocol.

Figure 2. ROC curve of the death prediction nomogram for 395 patients treated at a referral hospital in Belém, PA, 2024.

DISCUSSION

Fractures of the proximal third of the femur are associated with a high mortality rate.[2,3] In an attempt to mitigate this situation, several institutional protocols have been developed, primarily based on risk stratification tools, to identify key factors associated with poor prognosis and to prevent them.[5] Thus, this study creates a simplified mortality predictor based on initial data acquired upon patient admission.

Considering the significant physiological impact caused by proximal femur fractures, there is a high incidence of death in the first year after the fracture. Studies show mortality rates ranging from 12% to 37% in one year and up to 50% in two years, which is quite similar to the findings of this study, which included 20.75 cases (n=82).[11-13] This high global mortality rate is justified by the decline in physical function in the elderly population, underlying diseases, and complications associated with the tissue trauma resulting from the fracture itself. This generates pathophysiological responses caused by inflammatory reactions that exacerbate inflammatory responses and, in some cases, can trigger systemic inflammatory response syndrome (SIRS) and multiple organ failure, especially when the patient already has underlying cardiopulmonary disease.[11]

In this study, no statistically significant difference was found between genders. However, in absolute numbers, females were proportionally higher, given the greater number of women who reach older ages compared to males, a finding consistent with other studies.[2] It is worth noting the possibility of osteoporosis developing in postmenopausal women and the longer life expectancy of women, which is a risk factor for a higher incidence of fractures in this population.[14,15]

There is a strong association between mortality in patients over 83 years of age.[16,17] As age increases, the ability to withstand trauma, anesthesia, and surgical treatment itself decreases, favoring the development of complications that contribute to death.

In our study, we found that the group of patients treated surgically within 48 hours of admission had a 1-year mortality rate of 15.8%, compared to patients who underwent surgery after this time, with a mortality rate of 28.6% (p < 0.0001). It can be said that delay in surgical treatment contributes to an increased risk of thrombosis, bronchoaspiration pneumonia, systemic changes in decompensated diseases, among other factors. It has been identified that for every 12 hours of delay in definitive treatment, there is a 7% increase in the risk of mortality within 12 months.

Some studies argue that the best period for surgical treatment is within the first 36 hours after admission, with a direct impact on reducing mortality in the short and medium term[10]. It has been

identified that for each year following surgical treatment, there is a 9.4% increase in the risk of death, corroborated by the greater vulnerability of this population.

Unfortunately, the clinical instability and advanced age of some patients require intensive care beds so that the patient can be stabilized and discharged for the definitive procedure. On the other hand, this often delays surgical treatment and triggers a higher risk of bronchoaspiration pneumonia and hospital infection.[17-19]

The fracture pattern ($p = 0.4033$) and type of surgical treatment ($p = 0.731$) were not determining factors for mortality in the patients evaluated in this study. Further studies with a larger number of participants are required to increase statistical reliability. Despite this, some studies agree with our results.[20,21]

In this study, patients with severe anemia were associated with a 2.5-fold higher risk of mortality compared to patients with hemoglobin levels above 9 ($p = 0.0027$).[22,23] Alteration of this red blood cell indices implies a poor prognosis given its association with various comorbidities, especially in patients at extreme ages with a certain degree of documented chronic disease anemia.[22]

When suffering a fracture of the proximal end of the femur, there is a small drop in hemoglobin levels between admission and surgery (average of 0.3 g/dL). In contrast, the average drop in hemoglobin after surgery was considerable (average of 2.8 g/dL), roughly equivalent to a loss of 2 to 3 units of blood. This decline is justified due to bleeding resulting from surgical treatment and hemodilution caused by intravenous fluids administered since the patient's admission to the hospital.

The degree of anemia is a strong and independent prognostic factor because it is a marker of underlying disease burden.[14]

In this study, leukocytosis was associated with a fivefold increase in the risk of death compared to patients without this laboratory abnormality at admission. Some studies have indicated that neutrophils are most closely associated with mortality.[1-3,17,18] In other words, elevated neutrophil counts reflect long-term prognosis.

It should be noted that other studies also report lymphopenia related to death resulting from late complications such as surgical site infection, pneumonia, and sepsis. Leukopenia is related to delayed and poor wound healing after a fracture, enabling the growth and proliferation of microorganisms that contaminate the surgical wound, constituting an important risk factor for postoperative sepsis and mortality.

In the nomogram, each risk factor is assigned a score: hemoglobin (1.64 points), age (3.33 points), pulmonary infection (3.73 points), leukocytes (4.41 points), and time elapsed between fracture and surgery (1.75 points). The sum of the points for the six factors yields the overall score on the Nomogram, with a cutoff point of 5.08. If this value is reached, the probability of death is statistically significant (p-value < 0.05). This score shows Sensitivity = 0.728 (72.8%), Specificity = 0.720 (72.0%), and Accuracy = 0.726 (72.6%), as shown in Figure 02.

It is essential to note that risk identification models are not a substitute for initial medical assessment, which remains a crucial factor in clinical and surgical decision-making. When advising patients with femur fractures and their families about the prognosis, or when deciding on surgical or palliative strategies, medical assessment may be more valuable than these models. Future studies should include clinical evaluation when investigating mortality prediction in elderly patients with proximal femur fractures.[10-17]

Nevertheless, it is important to note that early assessment of individual risk factors is crucial for the proper management of this type of injury and, consequently, for reducing mortality. As a limitation, we note that this study is based on a sample from a single reference center, which is a relatively small sample, and further studies are needed.

CONCLUSION

In this study, a mortality predictor for patients with proximal femur fractures was developed using hospital admission data. In a cohort of 395 patients evaluated, neither gender nor fracture type was identified as a significant risk factor for patient mortality. The time interval between fracture and surgery, hemoglobin level < 9.0 g/dL, leukocytosis, and age were directly associated with mortality in patients within 12 months after fracture as risk factors.

AUTHOR'S CONTRIBUTION: Each author contributed individually and significantly to the development of this article. MJK: conceptualization, clinical investigation, and final review; SECS: data curation, visualization, and final review; SDR: writing, analysis, editing, and statistical data processing.

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ALGORITHM FOR EARLY AMBULATION IN INDIVIDUALS UNDERGOING NON-CONVENTIONAL HIP ENDOPROSTHESIS

ALGORITMO PARA MARCHA PRECOCE EM INDIVÍDUOS SUBMETIDOS A ENDOPRÓTESE NÃO CONVENCIONAL DE QUADRIL

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ABSTRACT

Introduction: The incidence of bone metastases has increased in recent years, driven by population aging and the efficacy of treatments for visceral-origin cancers. Bone metastasis ranks as the third most common type, with approximately one-third located in the proximal femur. Prosthetic hip replacement is a key treatment option, enabling immediate weight-bearing and resumption of patients' normal activities. Objective: This study aims to develop an algorithm to encourage early ambulation in patients undergoing hip arthroplasty with non-conventional endoprostheses, targeting improved recovery and minimized complications. Method: The algorithm was designed by the multidisciplinary team of the Orthopedic Oncology Service at Irmandade da Santa Casa de São Paulo. It focuses on promoting early ambulation for hospital discharge, incorporating specific patient-guided milestones to ensure safe mobility progression while respecting clinical conditions. Results: The mean time to sitting position was 1.64 ± 0.66 days, while ambulation was initiated at 3 ± 0.42 days. Conclusion: The implementation of the algorithm demonstrated its efficacy in inpatient rehabilitation through personalized milestones. This approach promotes early ambulation and enhances patient confidence in mobility. ***Level of Evidence VI; Case series.***

Keywords: Arthroplasty; Arthroplasty, Replacement, Hip; Neoplasm Metastasis, Pathologic Fracture.

RESUMO

Introdução: A incidência de metástases ósseas tem aumentado nos últimos anos, impulsionada pelo envelhecimento populacional e pela eficácia dos tratamentos para câncer de origem visceral. A metástase óssea é a terceira mais comum, com cerca de um terço localizada no fêmur proximal. A substituição protética do quadril é uma opção de tratamento importante, pois permite carga imediata e a retomada das atividades normais dos pacientes. Objetivo: O objetivo deste estudo é desenvolver um algoritmo para incentivar a deambulação precoce em pacientes submetidos à artroplastia de quadril com endoprótese não convencional, visando melhorar a recuperação e minimizar complicações. Método: O algoritmo foi elaborado pela equipe multidisciplinar do Serviço de Oncologia Ortopédica da Irmandade da Santa Casa de São Paulo. Ele foca na promoção da deambulação precoce para a alta hospitalar, incorporando metas específicas que orientam os pacientes, assegurando um progresso seguro na mobilidade e respeitando as condições clínicas. Resultados: O tempo médio de sedestação ocorreu em 1,64 ± 0,66 dias, enquanto a marcha foi iniciada em 3 ± 0,42 dias. Conclusão: A implementação do algoritmo demonstrou eficácia na reabilitação de pacientes, priorizando metas personalizadas. Essa abordagem promove a deambulação precoce e aumenta a confiança dos pacientes em sua mobilidade. ***Nível de Evidência VI; Série de casos.***

Descritores: *Artroplastia; Artroplastia de Quadril; Metástase Neoplásica; Fraturas Espontâneas.*

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INTRODUCTION

The incidence of bone metastases has increased in recent years with the aging of the population and the large number of people who are monitored after a cancer diagnosis. It is estimated that this number of cases will double in 50 years.[1-3]

Of the 44 million people worldwide, who are treated for cancer, 30 to 80% will develop bone metastases. Metastatic bone disease can cause pain, loss of function, and pathological fractures,[4,5] with pain being associated with severity and being unresponsive to drug treatment, and with numerous questions regarding

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the pathophysiological mechanisms related to osteolysis and bone fragility.[6]

Pathological fractures usually occur in advanced stages of metastatic disease. Conservative treatment requires complete bed rest, and although surgical approaches carry risks, they may resolve cases and may be the sole treatment or an adjunct to radiotherapy and chemotherapy.[7-11] Surgery not only relieves pain but also improves function and maximizes independence, which is beneficial even if the patient's overall prognosis is poor.[5]

Metastatic bone lesions are commonly located in the proximal femur, and with the modernization of adjuvant treatment, patients are surviving longer. Consequently, reconstructive options have also evolved to keep pace with this increase in survival.[3] Preoperative assessment of patients with metastatic bone lesions in the hip region should be thorough and accompanied by a multidisciplinary team to guide treatment.[7]

The criteria described by Mirels[8] are used to guide the treatment of bone metastases that present an imminent risk of fracture. The score is based on the nature of the injury, location, and size of the injury, pain assessment, and functional activity. The higher the score, the greater the risk of fracture. When the score is low, radiotherapy is chosen as the treatment, while lesions with a score of eight or higher are those that receive a recommendation for internal fixation.[1,7,8]

In patients undergoing surgical treatment, when there is a fracture of the proximal femur due to metastasis, studies report one-year survival rates ranging from 17% to 63%. There are reports of survival rates of up to five years in 23.1% of the total population. This longer survival rate has an impact on the choice of surgical material, which must be planned according to the patient's prognosis, maximizing costs and implant failures in order to choose materials with lower complication rates.[1]

Before any surgical procedure, the possibility of adjuvant treatment is studied to increase the success of the surgery. Radiotherapy has shown good results in reducing pain and preventing disease progression. There are even indications for low-dose radiotherapy, which does not prevent bone or soft tissue healing, provided that it is started between 10 and 14 days after surgery.[1,9]

Bisphosphonates are used to prevent the progression of metastasis in bone tissue and can be used in combination with other treatments, showing increased survival, a 15% reduction in the risk of fractures, and pain relief.[1,10,11]

The most commonly used methods for surgical correction of metastatic fractures are endoprosthetic reconstruction, intramedullary nailing, open reduction, and internal fixation. Surgical approaches are pretty effective in palliative strategies, but there's still no clear consensus on the best surgical treatment.[1,12] When there's a lot of bone loss near the head or neck of the femur, endoprosthetic replacement is needed, and it's thought that endoprosthetic replacement gives better long-term results compared to intramedullary nails.[1,13,14]

One of the greatest benefits of prosthetic replacement is the possibility of immediate weight bearing and almost complete functionality of the limb. Dislocation is a worrying complication in this group of patients due to altered healing and loss of muscle mass typical of patients undergoing cancer treatment. Dislocation is less prevalent when the acetabulum is not affected, since in a hemiarthroplasty, the femoral head is larger; however, it is associated with residual pain and acetabular wear.[1,7] Despite all this evidence on the early rehabilitation process of cancer patients undergoing endoprosthesis after hip fracture, we did not find any established protocols in the literature. Thus, we aim to develop an algorithm to encourage early and safe walking in individuals with bone metastasis undergoing unconventional hip arthroplasty.

METHOD

Algorithm Creation

The algorithm was developed in response to the need for early mobilization to ensure safe hospital discharge for patients with hip fractures resulting from bone metastases, with fixation established using hip endoprostheses.

The algorithm was divided into goals that could be daily or not, depending on the clinical condition of each individual. Progression occurs when there are no adverse events and the patient is stable enough to move on to the next goal. All events and patient progress should be documented in minute detail on the follow-up form.

The algorithm was developed based on the multidisciplinary team's previous experience, which involves monitoring patients in the postoperative period in a surgical ward that follows the hospital's rehabilitation process. All hospitalized patients are monitored based on goals established during multidisciplinary meetings, which observe the implementation of the protocol and discuss any ongoing difficulties. For each surgical case, the surgical team creates a timeline that starts on the first day after surgery (day zero) and continues until discharge from the hospital. All patients followed the same sequence of gait progression and received guidance on the procedures, restrictions, and goals to be achieved at each stage. After surgery, patients continued to be monitored using traditional care and adhering to the guidelines outlined in the algorithm.

After creating the algorithm presented in the results section, a study was conducted using a series of cases that included 25 patients being monitored at the Orthopedic Oncology outpatient clinic of the Irmandade da Santa Casa de Misericórdia de São Paulo (ISCMSP). All participants were included after signing an informed consent form, and the cohort was established from January 2021 to January 2023. The Research Ethics Committee approved the study under CAAE 40326220.8.0000.5479.

The patients included were those over 18 years of age, of both sexes, followed up for bone metastasis and who underwent unconventional hip arthroplasty after hip fracture.

Patients with an imminent risk of fracture with a Mirels score > 8,[8,15] were excluded, as were patients who had undergone any other type of surgical approach for the treatment of pathological fractures due to bone metastases, those with complications requiring surgical reintervention within six months after the initial surgery, those with cognitive impairment, neuromuscular disease, and/or any need for urgent or elective surgical intervention during the protocol.

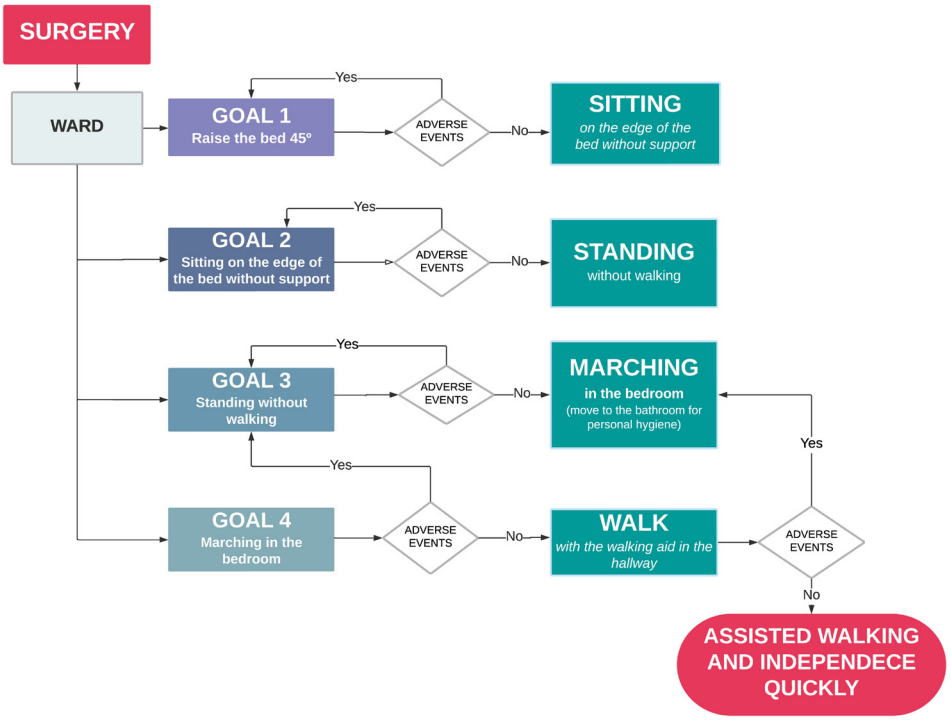
The descriptive data of the patients followed up were tabulated, and statistical analysis was used to relate the variables in terms of mean and standard deviation, with correlations of patterns identified using the SPSS program, with statistical significance set at $p \leq 0.05$.

RESULTS

The algorithm begins with the decision to proceed with hip replacement surgery and continues with patients being monitored in the orthopedic ward at the ISCMSP Central Hospital. (Figure 1)

The algorithm proceeds by establishing sequentially numbered goals that must be followed in numerical order at each stage. All patients should be monitored by a multidisciplinary team, which should guide care at each stage of the algorithm and provide support for transfers. To further understand the algorithm, the goals will be explained separately as shown.

• Goal 1 – Objective: Raise the bed to 45º. In the immediate postoperative period, the patient is referred to the ward. Upon arrival, the bed should be raised to 45º. After observation, if no adverse events occur, the patient may progress to sitting on the edge of the bed without support. In the event of any adverse event, the patient should return to bed and maintain an elevation of 45º.



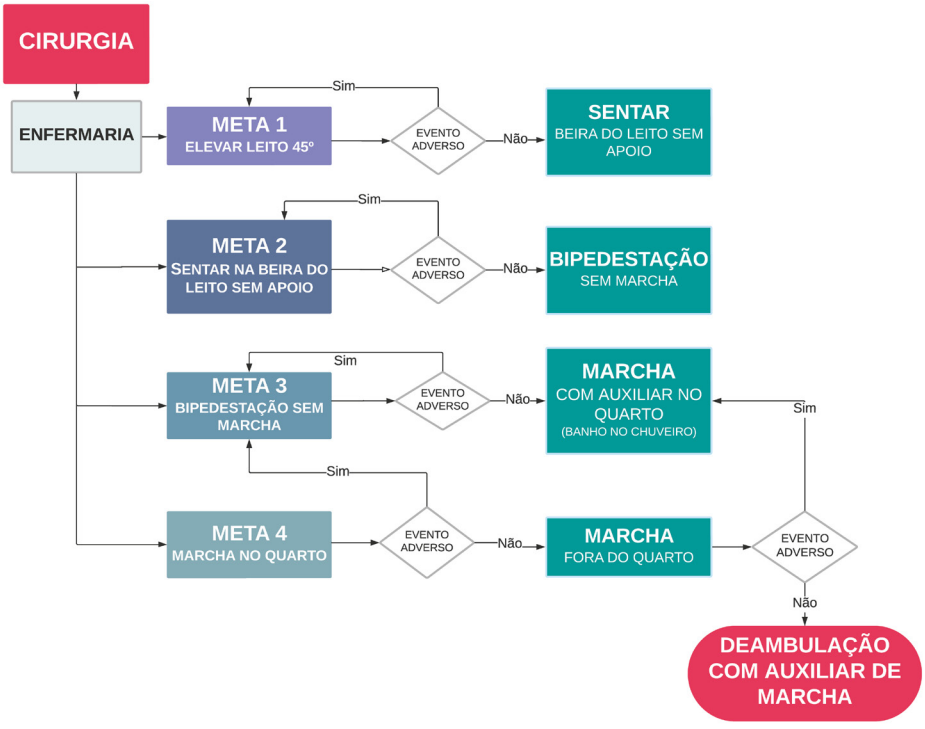


Figure 1. Algorithm for establishing safe walking in the immediate postoperative period of individuals with bone metastasis undergoing hip replacement.

• Goal 2 – Objective: Sitting on the edge of the bed without support. With the bed at a 45º angle, the patient should be encouraged to sit on the edge of the bed without support. If there are no adverse events, the patient may continue with the goal of standing without walking. If the patient experiences any adverse events, they should return to a sitting position at the edge of the bed without support.

• Goal 3 – Objective: Standing without walking. Initially, the patient should be encouraged to stand without walking. A member of the multidisciplinary team should assist with all transfers. If there are no adverse events, the patient may begin walking with the therapist and using a walking aid in the room to move to the bathroom for personal hygiene. If the patient experiences any adverse events, they should return to standing without walking.

• Goal 4 – Objective: Marching in the bedroom. Initially, the patient should stand without walking and, with the aid of a walking aid, should be able to move around for personal hygiene. If there are no adverse events, the patient will be encouraged to walk with the walking aid in the hallway. If the patient experiences any adverse events, they should return to walking in the room.

The goals outline the sequence of actions to enable the patient to return to assisted walking and independence quickly. The 25 patients who followed the established algorithm have the profile shown in Table 1.

The primary diagnosis of breast cancer was present in 32% of cases, followed by multiple myeloma (28%), prostate and kidney (12% each), thyroid with 8%, and lung or liver cancer in 4%, respectively.

Table 2 presents the average lengths of pre- and post-operative hospitalization, as well as the time in days required to achieve ambulation. There were no complications that required discontinuation of the protocol in the 25 cases analyzed. The goals were achieved slowly and cautiously, prioritizing patient safety and minimizing the risk of falls during hospitalization. This extremely cautious approach was crucial in ensuring that all patients remained stable and able to continue rehabilitation, as a fall in the ward could seriously compromise their future mobility.

Table 1. Characterization of the sample, with 25 patients evaluated and classified according to their primary tumor site.

Variables	n=25 (total)	%
Women	15	60
Between 40 and 49 years old	03	12
Between 50 and 59 years old	09	36
Between 60 and 69 years old	07	28
Between 70 and 79 years old	03	12
Between 80 and 89 years old	03	12

Table 2. Average length of stay (pre- and post-operative) and time to achieve ambulation.

Variables	Average (SD)
Days of preoperative hospitalization	09(5.7)
Days of hospitalization POS OP	04(1.22)
Days for sitting	1.64(0.66)
Days for walking	03(0.42)

DISCUSSION

The creation of an algorithm for early walking is not intended to categorize and generalize individuals, but rather to transform the acquisition of walking into a natural act without barriers. In this study, we aimed to create the algorithm and test its application based on the fracture risk classification according to Mirels[8] criteria, observing that all individuals submitted to the algorithm had no lower limb load restrictions to start the rehabilitation process.

The concern for creating the algorithm arose from observing the short-term mortality rate of patients undergoing surgical treatment for proximal femur bone metastasis. Statistics show that within 30 days postoperatively, bed rest is associated with death from pneumonia and pulmonary embolism.[16] To reduce mortality in these patients, it is recommended that surgery be performed within 48 hours of hospital admission and that early mobilization be initiated. The surgical approach to treating pathological fractures caused by bone metastasis allows for early mobilization, thereby preventing postoperative complications in these patients.

The length of hospitalization can be a significant factor in evaluating the overall recovery process and the utilization of healthcare resources for patients undergoing this type of surgery. A shorter hospital stay may indicate better postoperative recovery and fewer complications.[17]

Physical therapy should begin immediately after surgery to help with balance, walking, and muscle strength, allowing patients to return to their normal activities as soon as possible.[18] Immobilization has been linked to higher death rates and worse outcomes for these patients, and it's also been found that waiting to start walking increases the risk of pneumonia.[18]

Postoperative physical therapy reduces the incidence of pressure ulcers and improves balance, muscle strength, gait, function, and independence when initiated early, within 48 hours after surgery. It also reduces the length of hospital stay for these patients, promoting ambulation outside the hospital environment, while also increasing strength and balance. These patients tend to be less afraid of falling after hospital discharge, thus enabling them to accelerate their functional recovery, resulting in a decrease in dependence after discharge.[18,19]

Based on this information, we identified the need to develop a method to minimize mortality and enhance the functionality of these patients after surgery. Initially, we set daily goals with the objective of hospital discharge within three or four days. However, due to clinical and orthopedic changes, we need to respect individual timing and encouragement, shifting the algorithm to goals rather than days, thereby optimizing the postoperative approach in an individualized manner for each patient's response. The goals, as can be seen in the algorithm, have a sequence, but there is no set time frame for their achievement. The last goal may be reached on the first day after surgery, provided that the patient achieves all previous goals without any adverse events.

After applying the algorithm, we observed a fairly consistent pattern for sitting up. All individuals were able to sit up before the third day of hospitalization. Still, not all were able to walk independently with assistance at the time of discharge, due to individual clinical and postoperative conditions.

An algorithm is a set of instructions or sequential steps designed to solve a problem or perform a specific task. It provides a series of clear and organized steps that help guide the walking process for hospitalized patients. It is a type of visual guidance that facilitates clinical decision-making based on different criteria and patient conditions. This study may contribute to reducing the length of hospital stay for patients with bone metastases in the proximal femur who undergo unconventional endoprosthesis surgery, thereby preventing complications such as pneumonia and decreasing muscle strength, among other benefits already mentioned in this study. With shorter hospital stays, this algorithm will enable a reduction in mortality rates and complications in the immediate postoperative period for these patients, also reducing functional loss, which is essential for patients to return to their normal activities.

CONCLUSION

The implementation of the early gait algorithm proved to be an effective approach in patient rehabilitation. By prioritizing personalized goals and respecting each individual's pace and clinical condition, this strategy enables recovery tailored to each person's specific needs. Promoting early ambulation is essential, as it helps prevent complications such as pneumonia and pulmonary embolism, while also facilitating a quicker return to daily activities. This approach not only reduces hospitalization time but also strengthens patients' confidence in their ability to move independently, promoting a safer and more efficient recovery. The results suggest that adopting personalized rehabilitation goals, rather than strict deadlines, makes the postoperative process more flexible and effective, bringing significant benefits to patients' well-being in the medium and long term.

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ULTRASONOGRAPHY OF THE CARTILAGINOUS PATELLA IN PEDIATRIC PATIENTS: A CASE SERIES

ULTRASSONOGRAFIA DA PATELA CARTILAGINOSA EM PACIENTES PEDIÁTRICOS: UMA SÉRIE DE CASOS

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ABSTRACT

Objective: To analyze cases with clinical suspicion of patellar abnormalities, before ossification of the patella and to characterize the spectrum of abnormalities of the cartilaginous infantile patella by ultrasonography. Methods: Retrospective study using the keyword "patella" in ultrasonography reports in the Radiology Information System (RIS). The main researcher performed patellar measurements in the group of patients and in a control group (9 patients) without clinical or ultrasonography abnormalities. Results: Twelve patients with suspected patellar abnormalities were identified, with a mean age of 9 months and 4 days (±1.9 years), 75% male. Findings: dislocation or subluxation associated with patellar hypoplasia (7 knees), low lying patella and patellar hypoplasia (2), unilateral patellar agenesis (1), bilateral patellar agenesis (1), patellar instability in dynamic assessment and absence of patellar morphological changes (1). In two patients, ultrasonography was negative. The craniocaudal diameter of the hypoplastic patellas measured 0.94 cm ± 0.24 cm and in the control group 1.24 cm and ±0.12 cm ($p<0.01$). The Insall-Salvati index adapted for ultrasonography measured 0.63±0.07 for the low lying patella and 0.93±0.16 in the control group ($p=0.004$). Conclusions: Ultrasonography was useful to characterize abnormalities of the cartilaginous patella, and the most frequent findings were instability and hypoplasia. ***Level of Evidence IV; Case Series.***

Keywords: Patella; Patellar Dislocation; Nail-Patella Syndrome; Ultrasonography; Congenital Abnormalities.

RESUMO

Objetivo: Analisar casos com suspeita clínica de alterações patelares, antes da ossificação da patela ossificação da patela e caracterizar o espectro de anormalidades da patela infantil cartilaginosa pela ultrassonografia. Métodos: Estudo retrospectivo a partir da palavra-chave "patela" nos relatórios de ultrassonografia no Sistema de Informação em Radiologia (RIS). A pesquisadora principal realizou medidas patelares no grupo de pacientes e em grupo controle de 9 pacientes sem anormalidades clínicas ou ultrassonográficas. Resultados: Foram identificados doze pacientes com suspeita de alterações patelares, com idade média de 9 meses e 4 dias (±1,9 anos), 75% do sexo masculino. Achados: luxação ou subluxação associada a hipoplasia patelar (7 joelhos), patela baixa e hipoplasia patelar (2), agenesia patelar unilateral (1), agenesia patelar bilateral (1), instabilidade patelar na avaliação dinâmica e ausência de alterações morfológicas patelares (1). Em dois pacientes a ultrassonografia não mostrou alterações. O diâmetro crânio caudal das patelas hipoplásicas mediu 0,94 cm ± 0,24 cm e no grupo controle 1,24 cm e ±0,12 cm ($p<0,01$). O índice Insall-Salvati adaptado para ultrassonografia das patelas baixas mediu 0,63±0,07 e no grupo controle 0,93±0,16 ($p=0.004$). Conclusões: A ultrassonografia foi útil para caracterizar alterações da patela cartilaginosa e os achados mais frequentes foram instabilidade e hipoplasia da patela. ***Nível de Evidência IV, Série de Casos.***

Descritores: *Patela; Luxação Patelar; Síndrome da Unha-Patela; Ultrassonografia; Anormalidades Congênitas.*

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INTRODUCTION

The patella is the largest sesamoid bone in the skeleton, connecting at the proximal pole with the quadriceps femoris tendon and distally with the patellar ligament. It helps stabilize the knee, increases knee extension strength, improves the mechanical performance of the quadriceps, and protects the articular cartilage that lines the joint.[1] In humans, the patella undergoes endochondral ossification, which ends in late adolescence.[2]

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

The study was conducted at Hospital das Clinicas of the Ribeirao Preto Medical School of the University of São Paulo (HC-FMRPUSP), located at R. Ten. Catao Roxo, 3900, Vila Monte Alegre, Ribeirao Preto, São Paulo, SP, Brazil. 14015-010.
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The patella is cartilaginous in individuals under two years of age and is therefore not easily identifiable on X-rays. For this reason, the most appropriate imaging methods for its investigation are ultrasonography or magnetic resonance imaging.[2] The advantage of ultrasonography over magnetic resonance imaging is the possibility of performing dynamic maneuvers, studying different degrees of flexion or extension, faster execution, no need for patient sedation, and, additionally, lower cost.[3]

The absence or hypoplasia of the patella is a rare congenital anomaly that can occur in isolation, as part of specific syndromes, or associated with disorders such as trisomy 8.[4] The prevalence of patella agenesis or hypoplasia in newborns is difficult to determine because this structure is completely cartilaginous at birth,[5] but these conditions mainly result from developmental defects. There are no objective criteria for radiographic diagnosis of patella hypoplasia or reference measurements for different age groups, which means that assessment is subjective.[2]

Clinical diagnosis in young children is difficult because the absent, dislocated, hypoplastic, or unstable patella is difficult to palpate and evaluate. However, early diagnosis in the neonatal phase is important because it enables the investigation of genetic syndromes,[2] and allows for early planning and treatment.[3]

The aim of this study was to analyze cases with clinical suspicion of patellar abnormalities in children who had not yet undergone patellar ossification and to identify ultrasound abnormalities.

MATERIALS AND METHODS

Study approved by the Institutional Research Ethics Committee, with waiver of informed consent (CAAE: 19385819.3.0000.5440).

Patient selection

A retrospective search was conducted for cases with clinical suspicion of patellar abnormalities based on knee ultrasound reports identified in the institution's Radiology Information System (RIS). The search term was "patella". 750 reports containing this keyword were found, including the words "patellar" and "suprapatellar" which contain the word "patella." Examinations of adult patients were excluded. Next, the reports and images of pediatric patients were reviewed and correlated with the clinical history in the electronic medical record. Ultimately, only patients with clinical suspicion of patellar changes (n = 12) were included. The exclusion criteria were: previous patella surgery (in one case) and a lack of images in the digital archiving system (PACS) in two cases.

Ultrasonography examination protocol

All examinations were performed according to the following protocol. Patients were placed in the supine position and images of the patella were acquired in longitudinal and axial slices (transverse to the long axis of the patella), with the knee in flexion and extension. Cases with stiff knees were examined in the position in which they were found, without forcing correction of the deformity. Initially, the extensor mechanism was evaluated in longitudinal sections, where the quadriceps tendon, the patella, and the entire length and insertion of the patellar ligament were located (Figure 1). The patella and femoral trochlea were documented in the axial sections. If the patella was not identified in the anterior region of the knee, the lateral aspect of the knee was scanned, looking for possible images of the dislocated cartilaginous patella and in continuity with the extensor mechanism. Subsequently, if the patella was still not found, the medial aspect of the knee was assessed to confirm that the patella was not present.

Measurement of the patellae

The musculoskeletal radiology fellow measured the largest diameter (cephalocaudal) of the cartilaginous patellae previously classified as hypoplastic based on the senior radiologist's subjective assessment, using images available in the institution's digital image archiving and distribution system (PACS). He also performed retrospective measurements of the diameters of the cartilaginous patella and patellar tendon in cases subjectively classified as "low patella" to measure the Insall-Salvati index in a similar manner to that used for measuring the index on radiographs.

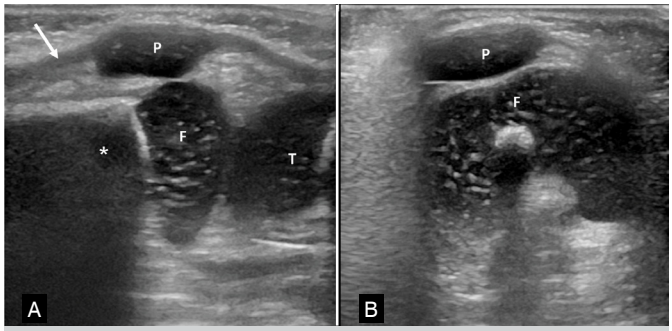

Figure 1. Normal examination to demonstrate the protocol in a male patient aged 2 months. The longitudinal section (A) shows the quadriceps tendon (arrow), the cartilaginous patella (P), the distal metaphysis of the femur (*), the distal epiphysis of the femur (F), and the proximal epiphysis of the tibia (T). The image in the axial plane (B) shows congruent patella (P) and femoral trochlea (F).

For comparison, images from a control group were used, retrospectively identified in the institutional PACS, belonging to nine patients (18 patellas) with no clinical or ultrasonographic abnormalities in the knees, and whose examinations had not been indicated for knee evaluation.

Evaluation of medical records and images

After collecting data from medical records (Table 1), ultrasound images were reviewed by a musculoskeletal radiology fellow and a musculoskeletal radiologist with 22 years of experience. The criterion for patella dislocation in ultrasound images was based on complete loss of contact between the articular surfaces of the patella and femoral trochlea, and subluxation was considered when there was partial loss of contact between the articular surfaces.

RESULTS

The average age of patients in the study group at the time the tests were performed was 9 months and 4 days, with a standard deviation of 1.9 years. Most patients were male (75%). In nine cases, ultrasound was performed before four months of age (75%), with four cases evaluated during the neonatal period (33%). In three patients, the examination was requested after this age due to significant deformities of the lower limbs; two of them had limb dysmetria, proximal femur shortening associated with fibular hemimelia and total hemimelia of the right tibia, conditions diagnosed in previous radiographs. (Figure 2)

In all cases with patellar abnormalities, there were also other musculoskeletal system changes, such as retroverted knees, hip dysplasia, congenital clubfoot, and bilateral meromelia, with the hands implanted directly into the chest.

Of the twelve patients included (Table 1), two had normal patellas, one had congenital clubfoot, and the other was diagnosed with bone dysplasia and dislocation of the hips and knees. Unilateral patella agenesis was found in one case (16% of patients) (Figure 3). Patella dislocation was found in five cases (41% of the sample), four of which were associated with patellar hypoplasia, and only one patient did not show a size reduction.

Table 1. Characterization of patients evaluated by ultrasound and with clinical suspicion of patellar abnormality.

Age and gender	Physical findings	Main clinical suspicion	Ultrasound findings
2 months 8 days Male	Congenital hip dislocation and bilateral cryptorchidism	Nail-patella syndrome	Hypoplasia and lateral dislocation of the right patella
6 days Women	Bone dysplasia, hip and knee dislocation	Arthrogryposis Larsen syndrome	Patellas without morphological alterations, but unstable during dynamic maneuvers.
12 days Women	Breech presentation, congenital hip dysplasia, congenital clubfoot	Congenital malformation	Hypoplasia and low lying patellas
4 months and 15 days Male	Total hemimelia of the tibia and dislocation of the right knee	Congenital malformation	Right patella agenesis and distal femur dysplasia
2 months and 14 days Male	Myelomeningocele and congenital clubfoot	Chiari type II and hydrocephalus	Patellae with no echographic changes
6 years and 9 months Male	Proximal femur deficiency and right fibular hemimelia	Congenital malformation	Right lateralized patella with trochlear dysplasia
27 days Male	Left genu recurvatum, contracture in hip adduction and elbow flexion, clinodactyly	VACTERL	Hypoplasia and lateral dislocation of the left patella
3 months and 10 days Male	Meromelia, deformity in flexion of the hips and knees. Absence of both arms and forearms	Arthrogryposis Fuhrmann syndrome	Patella agenesis
2 months and 23 days Male	Imperforate anus, acetabular dysplasia, and cryptorchidism	Intrauterine disruptive syndrome	Hypoplastic patellas and lateral subluxation on the right
1 year Male	Proximal focal deficiency of the femur with fibular hemimelia on the left	Femur-fibula-ulna syndrome Fuhrmann syndrome	Hypoplastic left patella and lateral dislocation associated with femoral trochlear dysplasia
25 days Male	Partial tibial hemimelia and focal proximal deficiency of the right femur, left hip dislocation	Malformations secondary to uncontrolled maternal diabetes	Hypoplastic right patella and medial dislocation associated with femoral trochlear dysplasia
1 month and 3 days Women	Contraction of the hips and genu recurvatum	Larsen syndrome	Anterior dislocation of the tibiae, hypoplastic patellae, and low position

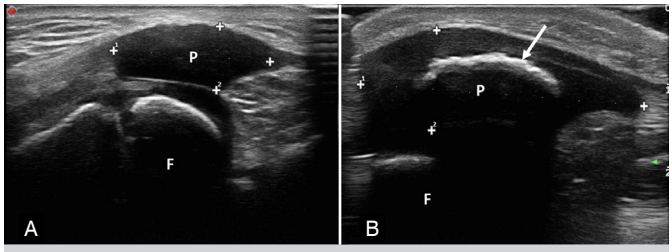

Figure 2. Male patient, aged 6 years and 9 months, with a previous diagnosis of right fibular hemimelia, complete agenesis of the fibula, and shortening of the ipsilateral femur and tibia. The right patella (A) was not easily identifiable on physical examination. The longitudinal ultrasound image shows patellar hypoplasia and absence of ossification, with the patella still cartilaginous, while the left patella (B) already shows ossification in the central region (arrow).

Of the dislocation cases, four presented lateral patella dislocation and only one presented medial dislocation. Two cases of congenitally low lying patellas associated with hypoplasia, but without dislocation, were also found.

Most patients had clinical suspicion of genetic syndromes or congenital malformations, including arthrogryposis, nail-patella syndrome, and VACTERL association or syndrome (V = vertebral anomalies, A = anal atresia, C = cardiovascular anomalies, T = tracheoesophageal fistula, E = esophageal atresia, R = renal and/or radial anomalies, L = limb defects). A complete description of the associated abnormalities in each patient is provided in Table 1. The Shapiro-Wilk test revealed that patellar diameter measurements did not follow a normal distribution, whereas ultrasonographic Insall-Salvati index measurements exhibited a normal distribution. The cranial-caudal diameter of the "hypoplastic patellae" measured 0.94 cm ± 0.24 cm, and in the control group it measured 1.24 cm ± 0.12 cm (Mann-Whitney $p < 0.01$). The Insall-Salvati index, adapted for ultrasound of "low lying patellas," measured 0.63 ± 0.07 in the study group and 0.93 ± 0.16 in the control group ($p = 0.004$).

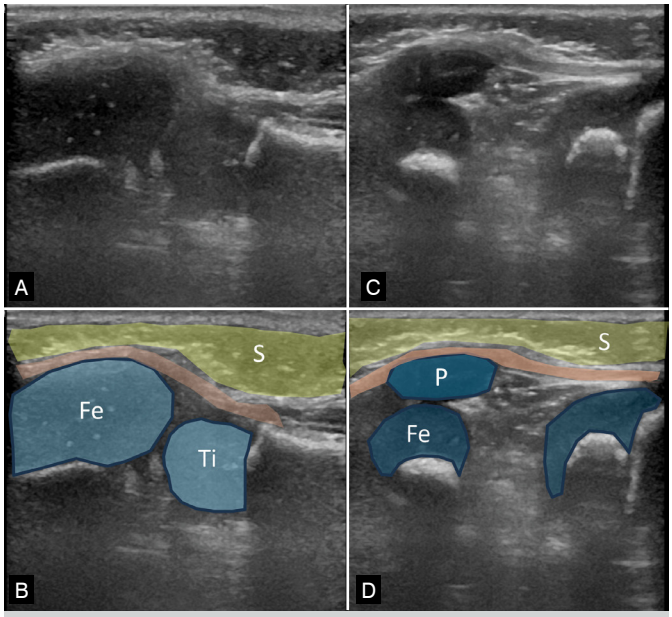

Figure 3. Male patient, four months old, diagnosed with right fibular hemimelia and knee dislocation. The patella was not palpable, and ultrasound confirmed the diagnosis of agenesis of the right patella (A). On the left side (C), the patella is present, and the longitudinal section shows the patella. In B and D, the subcutaneous tissue is marked in yellow, the epiphyseal cartilages in blue, and the extensor mechanism in orange; Fe = femur, P = patella, S = subcutaneous tissue, Ti = tibia.

DISCUSSION

This series of cases illustrates the spectrum of cartilaginous patella abnormalities identified by ultrasonography in the pediatric population. The most frequently detected abnormality was lateral patellar instability, which presented as dislocation, subluxation,

or dynamic instability. In most cases of patellar instability, this anomaly was accompanied by hypoplasia. However, we found patellar hypoplasia without signs of instability and vice versa (one case each). Ultrasonography was useful for identifying patellar agenesis and ruling out other patellar abnormalities, such as hypoplasia or dislocation.

There is scarce literature on the role of ultrasonography in the evaluation of the immature patella. Miller et al. described a series of three children with patellar abnormalities.[5] Another series of four children (two neonates, one three-year-old, and one four-year-old) reinforced the potential of ultrasonography for studying congenital displacement of the cartilaginous patella in the pediatric population.[6]

Congenital malformations of the patellae may manifest as complete agenesis, hypoplasia, or dislocation. The evaluation of patellar changes in children under two years of age should be performed using ultrasound due to the lack of ossification in this age group.[2]

Patellar malformations may manifest shortly after birth as external rotation of the tibia, valgus knee, and flexion contracture. However, in some cases, diagnosis may be delayed until early childhood. In less severe cases, where function is less impaired, diagnosis may be delayed, sometimes not occurring until adolescence or adulthood. The most common complaint among these patients in adulthood is pain due to instability and progression to osteoarthritis.[7]

Congenital malformations of the lower limbs without associated upper limb anomalies occur in 1 in every 10,000 live births.[8] More than thirty-five dysmorphic entities are associated with agenesis or reduction of the patella according to the Winter-Baraitser dysmorphology database (WBDD), version 1.0.4, London Medical Databases.[1]

Among the main malformation syndromes associated with patellar agenesis are nail-patella syndrome and small patella syndrome. According to Vanlerberghe et al.,[2] for these two syndromes, hypoplasia or agenesis of the patella is a constant or highly frequent feature that constitutes a primary clinical indicator aiding in diagnosis. On the other hand, patellar dislocation is associated with Rubinstein-Taybi and William-Beuren syndromes.[9] For other rare diseases, other clinical features are more important, but the identification of patella anomalies may be indicative of clinical genetic diagnosis.[2]

We found no data in the literature on the prevalence of isolated cases of patellar abnormalities or those associated with genetic syndromes. In the present study, all patients with patellar malformations had other clinical conditions, and none had isolated patellar malformation.

Cormier-Daire, V. et al reported seven cases (six boys and one girl) presenting with congenital absence of the patella, genital and renal anomalies, dysmorphic features, and mental retardation, and suggested classifying them as a new clinical entity named genito-patellar syndrome. In this study, patellar agenesis was confirmed in two patients over the age of six years by radiography.[4]

Miller et al. reported three cases of ultrasonographic evaluation in patients with congenital anomalies of the extensor mechanism, one of whom presented unilateral patellar subluxation and hypoplasia, the second with normal patellar development with patellar tendon hypotrophy and superior patellar dislocation, and the third with bilateral patellar agenesis with a clinical diagnosis of nail-patella syndrome.[5]

We did not find objective or quantitative criteria in the literature for defining patellar hypoplasia. In the current study, the diagnostic impression of hypoplasia was based on the interpretation of a senior radiologist with over 20 years of experience, as well as comparative analysis with the contralateral side when possible. We found a statistically significant difference in the cranial-caudal diameter of the patellae measured by ultrasound between patellae qualitatively classified as hypoplastic and control knees.

Studies describing patients with congenitally low lying patella do not report objective or quantitative criteria for obtaining this diagnosis, and presumably rely on the observer's experience and comparison with the contralateral side when possible.

Of the twelve patients in our study, two had bilateral congenitally low lying patellae (patella baja) based on qualitative assessment. We found a statistically significant difference in the Insall-Salvati index adapted for ultrasonography between patellas considered qualitatively as low lying patellas and patellas from a control group of knees.

According to Dejour et al., low lying patella is usually a complication of trauma, previous knee surgery, or neuromuscular disease, and is rarely a congenital condition.[10] There is a case report of two siblings with Larsen syndrome who had morphological abnormalities of the knees, including low patellae.[11] Another study evaluated 34 patients with congenital multiple arthrogryposis and found that four of them had low patellas; however, the authors did not report the criteria used for this classification.[12] In our case series, both patients with low lying patellas had *genu recurvatum*.

In recent years, several human genes important for patella development have been discovered through the study of malformation syndromes. These recent data show that patellar anomalies may result from the dysregulation of various cellular or developmental processes. Investigation of the ultrasonographic phenotype and genetics of patellar anomalies could potentially enhance our understanding of lower limb development and reveal information about the genes responsible for the normal development of other organic systems.

Ultrasound is the recommended examination for evaluating the immature skeleton in cases of suspected hip dysplasia,[13-17]. It can be used to evaluate fractures of the ossification centers of the elbow[18] and the proximal ossification centers of the humerus.[19] Ultrasound should be considered for investigating cartilaginous structures in the pediatric age group due to its low cost and the possibility of dynamic evaluation without the need for ionizing radiation or sedation.[5] MRI images can also be used to study the cartilaginous anatomical structures of the immature skeleton, but with relative disadvantages due to lower availability, the need for sedation, generally static evaluation, and the fact that comparison with the contralateral side is often not possible.[2]

The evaluation of patellar cartilage by ultrasound enables the identification or exclusion of patellar abnormalities that may have a potential impact on treatment choice and prognosis for patients. Patella agenesis or hypoplasia can cause pain, difficulty walking, running, or climbing stairs. Patellofemoral instability can progress to recurrent dislocations, accompanied by painful episodes and early osteoarthritis. Early diagnosis can prevent late sequelae and reduce the costs associated with medical care and the need for late correction of lower limb deformities.

The main limitations of this study are its retrospective design and small sample size. However, our study can contribute to the literature, given the scarcity of studies and the small sample sizes of those available.[6] In addition, most of our cases were not analyzed by molecular genetics to advance the etiology of genetic diseases, due to the difficulty of obtaining these tests.

Despite these limiting factors, the findings presented in this study confirm that ultrasonography can be a useful method for the early evaluation of children with suspected congenital patellar abnormalities. This is particularly relevant in the first years of life, when the patella has not yet ossified, making radiographic evaluation difficult. We did not find quantitative or objective criteria in the literature to establish the diagnosis of low lying patella and patellar hypoplasia. This limitation, as found in the literature, reinforces the need for prospective studies with a larger number of children evaluated by ultrasonography to establish criteria for normal pediatric patellar cartilage.

CONCLUSION

Ultrasonography was useful for characterizing abnormalities in the cartilaginous patella in the pediatric population. The most frequent anomaly was lateral patellar instability, identified by dislocation, subluxation, or dynamic instability. Ultrasonography also allows differentiation between patellar agenesis and dislocation associated with patellar hypoplasia.

AUTHOR'S CONTRIBUTION: Each author contributed individually and significantly to the development of this article. TLP: data collection and analysis, and initial drafting of the manuscript; N-BMH: review of ultrasound images, data analysis, and review of the manuscript; VJB: review of the article and intellectual concept of the article.

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SHORT-TERM MRI EVALUATION OF CAPSULOLABRAL REPAIR IN ATHLETES WITH ANTERIOR GLENOHUMERAL INSTABILITY: CORRELATION WITH CLINICAL OUTCOMES

AVALIAÇÃO POR RESSONÂNCIA MAGNÉTICA EM CURTO PRAZO DA REPARAÇÃO CAPSULOLABRAL EM ATLETAS COM INSTABILIDADE GLENOUMERAL ANTERIOR: CORRELAÇÃO COM OS DESFECHOS CLÍNICOS

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ABSTRACT

Objective: The aim of this study was to evaluate capsulolabral repair in athletes with traumatic anterior glenohumeral instability using magnetic resonance imaging (MRI) and correlate it with clinical and epidemiological data. Method: A prospective therapeutic clinical study was conducted with 36 athletes undergoing surgical treatment. MRI was performed preoperatively and in the third month postoperatively. The morphology, height, angulation, integrity and density of the repaired capsulolabral tissue were evaluated. Linear and logistic regression models were applied. Results: A total of 36 athletes were evaluated (mean age 29.64 ± 9.08 years). For all numerical variables (morphology, integrity, angles and heights) the differences were statistically significant, except for the coronal angle and homogeneity. Longer time to surgery or multiple dislocations reduced the improvement in morphology. There were no new episodes of dislocation. In the 3-month radiological evaluation, the integrity of the labrum was present in 97% of the patients, however, all patients still had a heterogeneous labrum. Conclusion: There are statistically significant differences between the morphology, height and angulation of the labrum between the pre- and postoperative periods of patients operated on for glenohumeral instability. Although the 3-month MRI showed integrity of the labrum in almost all athletes, this tissue still presented altered density even with satisfactory clinical results. ***Level of Evidence III; Prospective Study.***

Keywords: Shoulder Joint, Magnetic Resonance Imaging; Shoulder Injuries; Shoulder Dislocation.

RESUMO

*Objetivo: O objetivo deste estudo é avaliar por ressonância magnética (RM) o reparo capsulolabral de atletas com instabilidade glenoumeral anterior traumática e correlacionar com dados clínicos e epidemiológicos. Método: Foi realizado um estudo clínico prospectivo terapêutico com 36 pacientes atletas submetidos ao tratamento cirúrgico. Foi realizado RM no pré-operatório e no terceiro mês de pós-operatório. Foram avaliadas morfologia, altura, angulação, integridade e densidade do tecido capsulolabral reparado. Modelos de regressão linear e logística foram aplicados. Resultados: Um total de 36 atletas foram avaliados (idade média de 29,64 ± 9,08 anos). Para todas as variáveis numéricas (morfologia, integridade, ângulos e alturas) as diferenças foram estatisticamente significantes, exceto para o ângulo coronal e homogeneidade. Maior tempo para a cirurgia ou múltiplas luxações reduziram a melhora na morfologia. Não houveram novos episódios de luxação. Na avaliação radiológica de 3 meses, a integridade do lábio se fez presente em 97% dos pacientes, no entanto todos os pacientes ainda apresentavam o lábio heterogêneo. Conclusão: Há diferenças estatisticamente significante entre a morfologia, altura e angulação do lábio entre o pré e pós operatório dos pacientes operados com instabilidade glenoumeral. Apesar da RM de 3 meses mostrar integridade do lábio em quase todos os atletas, esse tecido ainda apresentou densidade alterada mesmo com resultados clínicos satisfatórios. **Nível de Evidência III; Estudo Prospectivo.***

Descritores: *Articulação do Ombro; Imagem por Ressonância Magnética; Luxação de Ombro.*

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INTRODUCTION

The shoulder is the most unstable joint in the human body, with anterior instability being the most common.[1–3] The incidence of dislocation can reach 23 cases per 100,000 people/year, being more common in males and Caucasians, with recurrence being related to younger ages at the first episode and the presence of associated bone injuries.[4-8]

Surgical treatment with arthroscopic capsulolabral repair has satisfactory success rates of around 95%.[9] Return to physical activities is generally permitted after 4–6 months, depending on the demands and type of physical activity. To determine this, we use functional assessments with strength and range of motion tests.[10,11]

Although magnetic resonance imaging (MRI) is a validated method for analyzing labrum morphology, it is not routinely used to study the integrity of capsulolabral surgical repair, as the computed tomography that can be used for assessing bone consolidation after bone blocking.[12]

There is little literature regarding postoperative image assessments in patients with anterior glenohumeral instability undergoing arthroscopic capsulolabral repair, especially regarding the integrity and morphology of the repaired tissue.[13–16] The aim of this study is to evaluate, using magnetic resonance imaging, the morphology and integrity of the labrum three months after arthroscopic capsulolabral repair in patients who practice physical activities with traumatic anterior glenohumeral instability and to correlate the results with clinical and demographic data from this population.

MATERIAL AND METHOD

This study was approved by the hospital's ethics committee and approved by Plataforma Brazil, under number 46089221.7.0000.5505. A prospective clinical study was conducted in which 36 athletic patients with traumatic anterior instability underwent arthroscopic surgery and were prospectively followed up from January 2021 to December 2022. All patients underwent magnetic resonance imaging (MRI) in the preoperative period and in the third month after surgery.

The epidemiological characteristics of the patients are shown in Table 1.

Table 1. Epidemiological characteristics of patients included in the study.

Characteristics of patients	Measures
Age (years)	29.64 ± 9.08
Sex	
male	32 (88.89%)
female	4 (11.11%)
Side	
right	21 (58.33%)
left	15 (41.67%)
Time of injury	
≤ 90 days	15 (41.67%)
> 90 days	21 (58.33%)
Number of episodes	
Unique	12(33.33%)
Multiples	24 (66.67%)
Sport type (Neutral)	
Pull	12 (33.33%)
Neutral	9 (25.00%)
Neutral	9 (25.00%)
Neutral	9 (25.00%)
Neutral	9 (25.00%)
Neutral	9 (25.00%)

The inclusion criteria were athletic patients with: (1) traumatic anterior dislocation (2) positive physical examination for anterior instability (3) presence of anterior and inferior capsulolabral injury on preoperative magnetic resonance imaging. The exclusion criteria were: (1) bone lesion in the glenoid > 20%, (2) off-track lesion, (3) associated rotator cuff lesion, (4) associated posterior labral lesion, (5) HAGH lesion, (6) multidirectional or posterior instability by clinical evaluation, (7) generalized ligament laxity (Beighton criterion > 4, sulcus test >2+), (8) advanced osteoarthritis (Samilson and Pietro grade 2 or 3), (9) patients who did not agree to participate in the study (TCLE). The exclusion criteria were: associated injuries found during surgery (such as rotator cuff injury and posterior labral injury) and loss of patient follow-up.[17,18]

Data from preoperative MRI and MRI 3 months after surgery were analyzed. Clinical outcomes such as range of motion, new episodes of dislocation, apreension rate, and functional scores (EROE, ROWE, and VAS) were assessed at 3 months postoperatively. The EROE score (Athlete Shoulder Outcome Rating Scale) is a score based on objective criteria (range of motion) and subjective criteria (pain, strength/resistance, intensity, athletic performance), totaling 100 points. A score above 90 is considered excellent, 70-89 is good, 50-69 is fair, and below 50 is poor.[19,20]

All patients included were athletes, according to Araújo and Scharhag.[21] The types of sports were categorized according to Allain et al. into three groups: neutral sports (no collision or throwing), collision/contact sports, and throwing sports.[22]

These athletes had the following characteristics: average age 29.6 ± 9.08 years, 32 (88.9%) were male, 21 (58.33%) had right shoulder dislocation, 15 athletes (41.67%) had an injury time of up to 90 days in relation to the first episode, and 24 (66.67%) athletes had multiple episodes of dislocation. With regard to the type of sport, 12 athletes (33.33%) practiced throwing sports, 15 (41.67%) practiced contact sports, and 27 (75%) were amateurs. (Figure 1)

Surgical procedure

All patients underwent arthroscopic surgery by the same surgeon in the lateral decubitus position and were examined under anesthesia, observing the inferior, anterior, and posterior translation.[8] The biocomposite anchors used were 3.0 mm double-loaded and knotted (SututeTak, Arthrex®, Naples, USA), with the stitches performed in a simple configuration. The average number of anchors used was 3.22 ± 0.58.

Post-operative protocol

After the procedure, the operated shoulder was placed in a simple sling and left for approximately 6 weeks. In the third week, passive

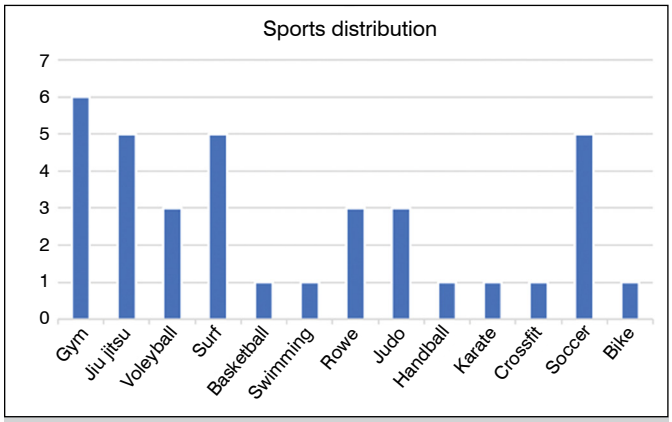

Figure 1. Distribution of types of sports practiced by athletes (frequency x type of sport).

movements were initiated, avoiding abduction and lateral rotation greater than thirty degrees until the sixth week. At 10 weeks, strengthening began, and at 3 months, a return to activities was permitted. Return to contact or collision sports only after 6 months.

Image evaluation

Magnetic resonance imaging evaluations of the lip were performed preoperatively and 3 months postoperatively, according to the established and validated protocol of Yoo et al.[23] applied in several studies. A 1.5 T magnetic resonance imaging (MRI) scanner (GE Signa Explore; GE Healthcare Medical SystemÒ, Boston, USA) with a dedicated shoulder coil was used in all patients. All measurements were performed on a communication and image archiving system monitor (PACS) using the RadiAnt program®.

The following characteristics analyzed by magnetic resonance imaging (MRI) were considered outcome variables in the study: morphology, axial height, coronal height, axial angle, and coronal angle of the anterior inferior labrum of the glenoid. The morphology of the labrum was measured in the axial section at T2 and graded from 0° to III° according to the descriptive grading published by Randelli et al.[24] (Figure 2)

Two other outcome variables were lip integrity and homogeneity, both defined based on morphology, using Randelli's classification as a parameter. Integrity was defined as follows: the repair is intact if the morphology is equal to 0, 1, or 2; and not intact if equal to 3 or if there is a continuity solution between the lip and the glenoid (Figure 3). Homogeneity was defined as morphology equal to 0; and heterogeneous if equal to 1, 2, or 3. (Figure 4)

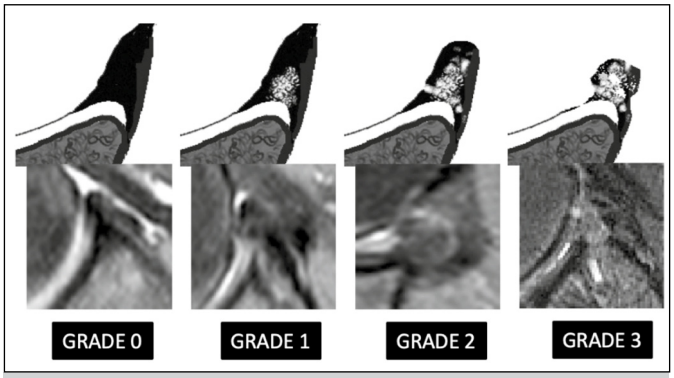

Figure 2. Randelli classification for lip morphology.

The parameters (morphology, homogeneity, height, and angle) were measured in the axial and oblique coronal images in the anteroinferior portion of the glenoid, immediately above the lowest anchor, thus avoiding the site of the lip where the suture was located so as not to be interpreted as a lesion. Height was defined as the distance (in millimeters) between the lowest portion of the glenoid and the maximum height of the lip tip (Figures 5 and 6). Angulation was defined as the angle formed by a tangential line drawn from the deepest portion of the glenoid (center of the glenoid) to the tip of the highest point of the lip. (Figures 7 and 8)

The measurements were taken at a single point in time by a radiologist who monitored and performed all examinations in consultation with the shoulder surgeon.

Statistical analysis

A descriptive analysis of the data was performed using the exposure variables. Categorical data are expressed as absolute numbers and percentages, while continuous data are presented as mean ± standard deviation.

For each outcome variable related to MRI, a preoperative comparison was performed and another comparison was performed after 3 months to verify whether there was a statistical difference between the MRI measurements. The nonparametric Wilcoxon-Mann-Whitney test was used for numerical variables, and the McNemar test was used for integrity and homogeneity, which are categorical variables. The power analysis of the test was performed using simulations. Clinically different results were considered, such as improvement in the functional score based on previously published studies, changes of at least 2 mm in axial/coronal height,5° in axial/coronal angle, and 1 point in morphology.[12–14,24,25] In the simulations, sample standard deviations, a sample size equal to 36, and a significance level of 0.05 were used. For all outcomes, the estimated test power was at least 0.9.

Linear regression models were applied to morphological characteristics, axial height, coronal height, axial angle, coronal angle, elevation, lateral rotation, EROE, ROWE, and VAS scores. Logistic regression models were used for the variables integrity, homogeneity, and medial rotation.

In all tests, a significance level of 0.05 was considered.

RESULTS

No patient in our prospective series presented a new episode of dislocation or sensation of subluxation during the first three months after surgery. With regard to the range of motion and functional

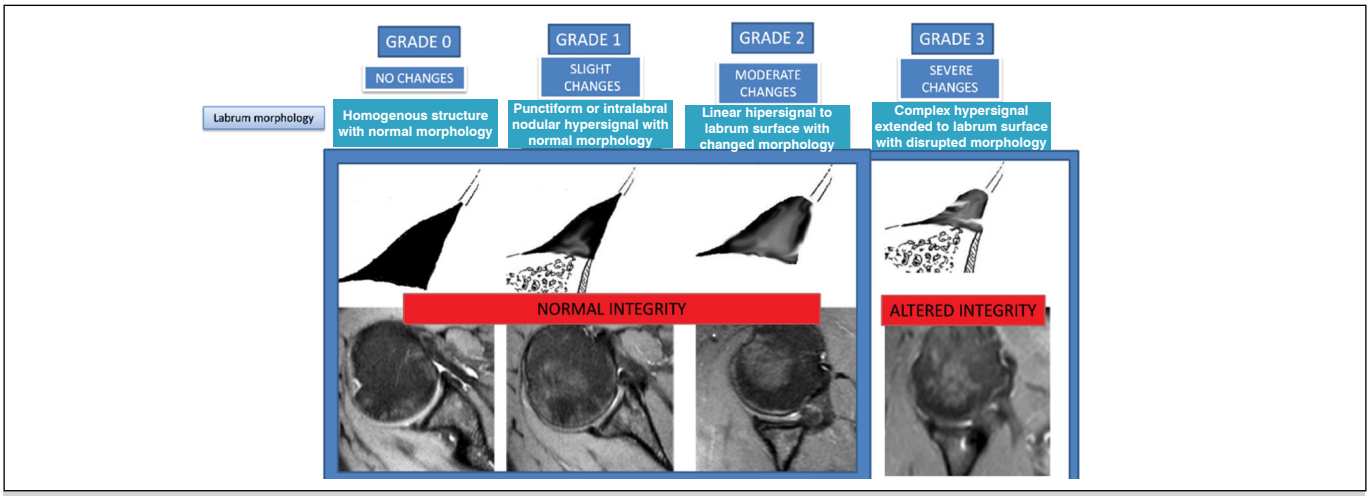

Figure 3. Randelli classification. Intact lip: grades 0, 1, and 2. Lip not fully formed: grade 3.

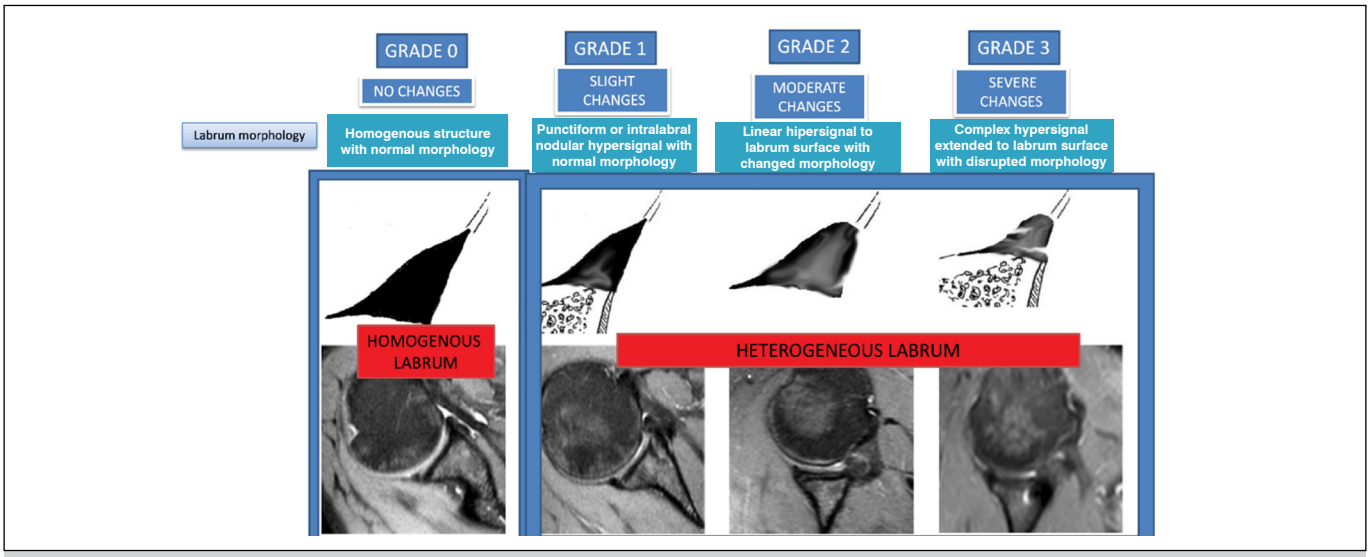

Figure 4. Randelli classification. Homogeneous lip: grade 0. Heterogeneous lip (hypersignal): grade 1, 2, and 3.

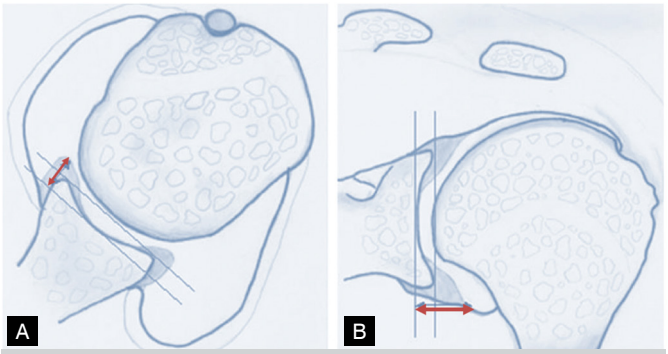

Figure 5. Drawing illustrating method for measuring lip height, axial and coronal sections.

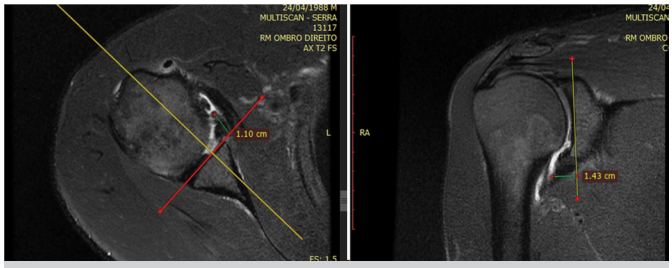

Figure 6. Method for measuring lip height, axial and coronal cuts, using magnetic resonance imaging.

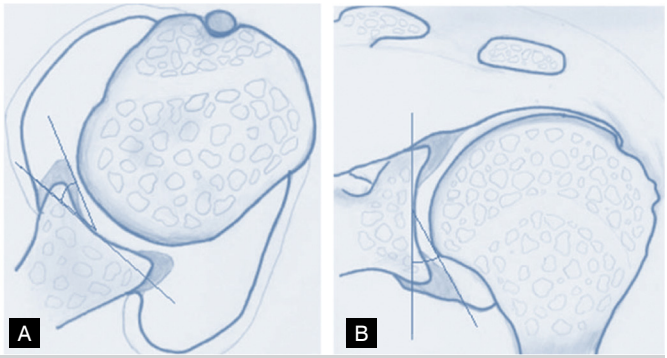

Figure 7. Drawing illustrating the method for measuring lip angulation (slope), axial and coronal sections.

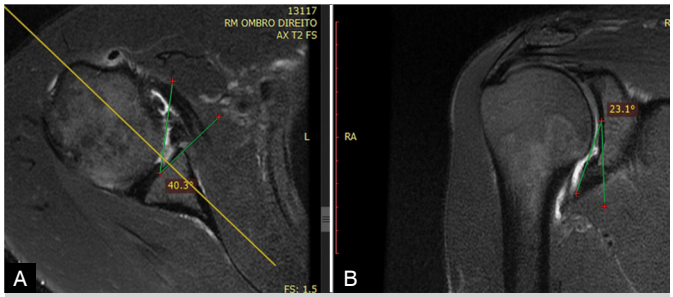

Figure 8. Method for measuring lip angulation, axial section (A) and coronal section (B), on magnetic resonance imaging.

scores in the third postoperative month, the results are shown in Table 2, with a mean EROE of 74.42 ± 12.39, ROWE 82.89 ± 13.72, and VAS 1.89 ± 1.89.

The data regarding the variables measured in the preoperative MRI and at 3 months are shown in Table 3. Except for the coronal angle variable, differences were statistically significant (p-value < 0.05) in all numerical outcome variables.

When evaluating the outcome, there was a significant difference between the proportions of patients with capsulolabral repair integrity in the preoperative and postoperative periods (3 months). With regard to homogeneity, no difference was observed. (Table 4)

The variables axial height, coronal height, and axial angle were not related to any of the exposure variables (age, time from injury to surgery, number of episodes, type of sport).

The association between exposure variables and the difference between pre- and postoperative morphology (called improvement in morphology) was also analyzed. This difference (improvement) was associated with patient age, multiple episodes of dislocation, and time since injury. (Table 5)

Next, we analyzed the association between exposure variables and the difference between pre- and postoperative coronal angles (improvement in angle). This difference (improvement) was associated with the variables time since injury and occurrence of multiple episodes of dislocation. (Table 6)

It was not possible to verify whether there were associations between the exposure variables and the following outcome variables: postoperative shoulder integrity, preoperative and postoperative shoulder homogeneity. This occurs because there is no variability in the results.

Taking into account the integrity and density of the labial tissue three months after surgery, 97% of athletes showed repair integrity; however, all still had increased (heterogeneous) signs on MRI evaluation. (Figures 9 and 10)

DISCUSSION

This study provides evidence that there are statistically significant differences between the preoperative period and 3 months postoperatively for magnetic resonance imaging measurements in athletes who underwent surgery due to shoulder instability. Even with good clinical results (range of motion, functional scores), the repaired lip tissue was heterogeneous in all cases. Athletes with a single episode and an injury duration of up to 3 months showed greater improvement in morphology (integrity).

Table 2. Clinical data 3 months postoperative

Characteristics	Measures
Elevating the arm	172.2 ± 11.2
Lateral rotation	60.03 ± 18.70
medial rotation (L1)	11 (30.56%)
Medial rotation (L2)	1 (2.78%)
Medial rotation (L5)	1 (2.78%)
Medial rotation (T8)	2 (5.56%)
Medial rotation (T10)	8 (22.22%)
Medial rotation (T11)	2 (5.56%)
Medial rotation (T12)	11 (30.56%)
HEROE	74.42 ± 12.39
ROWE	82.89 ± 13.72
VAS	1.89 ± 1.89

Table 3. Comparison of MRI outcome variables in preoperative and with 3 months.

Moments	Morphology	Alt Axial	Alt Cor	Ang Axial	Ang Cor
Pre-OP	2.58 ± 0.55	8.30 ± 2.79	9.26 ± 2.41	25.8 ± 7.32	23.7 ± 5.31
3 months post-op	1.50 ± 0.56	9.80 ± 2.31	10.4 ± 1.96	29.0 ± 6.45	24.6 ± 4.22
P-value	< 0.001	0,009	0,012	0,012	0,245

OP = operational, p-value for the Wilcoxon-Mann-Whitney test

Table 4. Comparison for integrity and homogeneity variables

Moments	Integrity	Homogeneity
Pre-OP	14 (38.89%)	0 (0.00%)
3 months post-OP	35 (97.22%)	0 (0.00%)
P-value	< 0.001	1

P-value of the McNemar test.

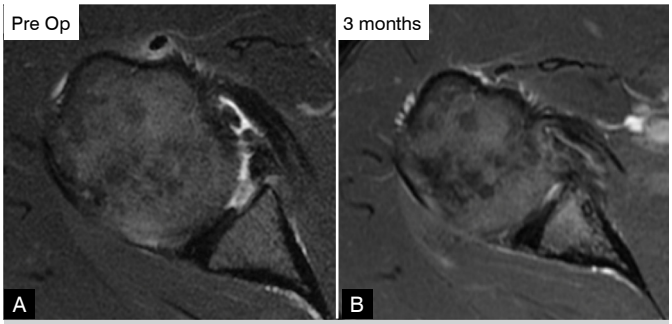

Figure 9. Axial MRI scan of the left shoulder. (A) Preoperative image showing a detached, incomplete labrum and (B) 3 months postoperatively showing an intact but heterogeneous labrum (grade I nodular hypersignal).

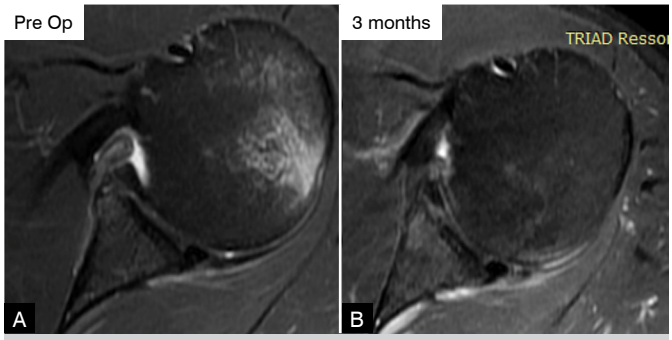

Figure 10. Axial MRI scan of the right shoulder. (A) Preoperative image showing a detached, incomplete labrum and (B) 3 months postoperatively showing an intact but heterogeneous labrum (grade II linear hypersignal).

Lee et al.[20] evaluated 50 patients with anterior shoulder instability who underwent surgery and underwent computed arthrotomography at 3 months and 12 months postoperatively. The group that presented postoperative apprehension had a higher capsular volume fraction when compared to the group that did not present apprehension. The height of the lip (bumper) measured by early and late arthrotomography showed no statistically significant difference between the two groups. In our study, we used magnetic resonance imaging without contrast due to lower risks of adverse effects. When we assessed the height of the lip in the 3-month MRI, we observed a statistically significant difference compared to the preoperative MRI. However, the labial height in the axial section did not correlate with any exposure variable, whereas the patient's preoperative coronal angle is associated with the duration of the injury and the occurrence of multiple episodes of dislocation. Patients with shorter injury time presented better morphology and better coronal angle gain at 3 months.

Table 5. Regression model for difference (morphology pre-morphological post-3months).

Parameter	Estimative	Standard Error	P-value
intercept	2.1848	0.3743	< 0.001
Age	-0.0305	0.0108	0.0079
Multiple episodes	-0.4743	0.2124	0.0327
time of injury (≤90)	0,2857	0,2072	0,1776

R^2 = 0.3203.

Table 6. Regression model for difference (3 months coronal angle - pre coronal angle).

Parameter	Estimate	Standard Error	P-value
intercept	-3.636	1.817	0.0537
Multiple episodes	3.68	1.829	0.0524
time of injury (≤90)	5,079	1,749	0,0065

R^2 = 0.2238.

Lobo et al.[21] in their study of 51 patients undergoing arthroscopic treatment for shoulder instability analyzed whether there were differences in functional and imaging results regarding the type of anchor (knotted or knotless) used in arthroscopic treatment of anterior shoulder instability. It concluded that clinical, radiographic, and recurrence results were similar at 24 months of follow-up in both groups. In our study, we used only anchors with knots and observed that the postoperative measurements at 3 months in relation to the parameters analyzed were statistically significant when compared to the preoperative measurements and that patients with up to 90 days of injury and those who do not practice contact sports tend to have a greater gain in the coronal angle (slope) value.

Some studies have evaluated the magnetic resonance imaging characteristics of anterior cruciate ligament reconstructions in the knee and ankle ligament reconstructions using grafts.[26,27] Although they are tissues with different healing processes when analyzing the labial tissue, some observations can be made. The literature on animal studies has shown that lower graft signal intensity is correlated with greater strength and superior biomechanical properties of the reconstructed ligament.[28,29] Lower signal intensity (more homogeneous) on preoperative magnetic resonance imaging of the anterior talofibular ligament of the ankle is associated with better clinical outcomes—particularly a higher rate of return to sports.[30] Although ACL reconstruction studies do not demonstrate a correlation between graft maturity and clinical outcomes,[3,21] understanding the periods when the graft may be most fragile allows for modification of rehabilitation exercises and even the return of these athletes to the field. When analyzing our results, in the 3-month MRI, the lip was intact in 97% of the athletes, but all still had a heterogeneous lip.

Correlating the MRI results with clinical findings, we observed that even athletes with good range of motion and satisfactory functional results still had hypersignal in the labial tissue in 100% of cases. Given these data, a more careful analysis should be made when allowing these athletes to resume their physical activities, as this tissue may not yet be fully prepared for high loads. It should also be noted that this elevated signal observed on magnetic resonance imaging at three months should be interpreted with caution when assessing the healing of the capsulolabral repair, so as not to be interpreted as a new lesion or lack of healing of the lip.

There are some limitations to our study. Our follow-up was too short to evaluate complications such as recurrence rate or osteoarthritis, as well as to make more detailed comparisons, due to the absence of a control group. However, this is a prospective study with a specific population of athletes, and we evaluated data that has been little explored in previous studies, such as type of sport, number of dislocation episodes, and characteristics of the glenoid labrum on magnetic resonance imaging. The current findings are also useful in postoperative radiographic evaluation. Understanding the normal evolution of capsulolabral tissue is important, and thus the MRI findings in our study can also be used as a reference for radiologists to determine how capsulolabral tissue should look at different time points after arthroscopic repair.

CONCLUSION

There are statistically significant differences between the morphology, height, and angulation of the lip between the pre- and postoperative periods in patients with glenohumeral instability who underwent arthroscopic surgical treatment.

Despite good clinical results three months after surgery, magnetic resonance imaging showed heterogeneity of the repaired lip tissue in all athletes.

AUTHOR'S CONTRIBUTION: Each author made significant individual contributions to the development of this manuscript. BBT: Substantial contribution to the conception or design of the work, or acquisition, analysis, or interpretation of data for the work. Performing the surgeries. TJS: Substantial contribution to the design, acquisition, analysis, and interpretation of data for the work. Performing the surgeries. Article review. AYA: analysis or interpretation of data for the work; PSB: analysis or interpretation of data for the work; critical review of its intellectual content. ACP: analysis or interpretation of data for the work; BE: critical review of its intellectual content; Final approval of the manuscript version to be published.

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BERTOLOTTI SYNDROME

SÍNDROME DE BERTOLOTTI

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ABSTRACT

Introduction: Lower back disorders are prevalent and a significant reason for emergency care visits. In 2020, 619 million people experienced low back pain, expected to rise to 843 million by 2050. A common cause is the presence of a lumbosacral transitional vertebra (LSTV). Objectives: This study evaluates the prevalence of Bertolotti Syndrome in patients with low back pain in an emergency setting and assesses interobserver reliability of LSTV classifications. Methods: A retrospective analysis of 1023 lumbar spine radiographs from patients presenting with low back pain from 2018 to 2020 was conducted. After exclusions, 469 radiographs were analyzed. Two orthopedists classified LSTVs using Tini and Castellvi's systems. Statistical analyses included the Kappa agreement index, two-proportion Z test, confidence interval for the mean, and p-value calculations. Results: The prevalence of Bertolotti Syndrome was 62.5% for observer A and 61.6% for observer B. Type I LSTV was the most common, with over 70% of cases, followed by type III at over 15%. The most frequent morphology was bilateral involvement of the transverse process, with more than 50% of cases exhibiting IB morphology according to both classifications. Conclusion: This study found a high incidence of Bertolotti Syndrome (over 60%) in patients with low back pain seeking emergency care, suggesting that LSTV should be more frequently considered in differential diagnoses. Improved recognition of LSTV could lead to better management strategies for low back pain associated with this congenital anomaly. ***Level of Evidence III; Retrospective Cohort Study.***

Keywords: Spine; Low Back Pain; Lumbosacral Region.

RESUMO

Introdução: Distúrbios na região lombar são prevalentes e uma razão significativa para visitas de emergência. Em 2020, 619 milhões de pessoas experimentaram dor lombar, com expectativa de aumento para 843 milhões até 2050. Uma causa comum é a presença de uma vértebra de transição lumbossacral (LSTV). Objetivos: Este estudo avalia a prevalência da Síndrome de Bertolotti em pacientes com dor lombar em ambiente de emergência e avalia a confiabilidade entre observadores das classificações de LSTV. Métodos: Uma análise retrospectiva de 1023 radiografias da coluna lombar de pacientes com dor lombar entre 2018 e 2020 foi realizada. Após exclusões, 469 radiografias foram analisadas. Dois ortopedistas classificaram as LSTVs utilizando os sistemas de Tini e Castellvi. As análises estatísticas incluíram o índice de concordância Kappa, o teste Z de duas proporções, o intervalo de confiança para a média e os cálculos de valor de p. Resultados: A prevalência da Síndrome de Bertolotti foi de 62,5% para o observador A e de 61,6% para o observador B. A LSTV tipo I foi a mais comum, com mais de 70% dos casos, seguida pelo tipo III com mais de 15%. A morfologia mais frequente foi o envolvimento bilateral do processo transverso, com mais de 50% dos casos exibindo morfologia IB de acordo com ambas as classificações. Conclusão: Este estudo encontrou uma alta incidência da Síndrome de Bertolotti (mais de 60%) em pacientes com dor lombar que buscaram atendimento de emergência, sugerindo que a LSTV deve ser mais frequentemente considerada nos diagnósticos diferenciais. O reconhecimento aprimorado da LSTV pode levar a melhores estratégias de manejo para a dor lombar associada a essa anomalia congênita. ***Nível de Evidência III; Estudo de Coorte Retrospectivo.***

Descritores: *Coluna Vertebral; Dor Lombar; Região Lombossacral.*

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INTRODUCTION

Disorders of the lumbar region are among the most common injuries in the general population and are one of the main reasons for seeking emergency care. It is estimated that 619 million people experienced low back pain in 2020, approximately 10% of the global population, and that this number is expected to increase by more than 35% over the next thirty years, reaching 843 million by 2050.[1] Only a small portion of these patients have well-established causes for the pathology, such as vertebral fracture, malignancy, or infection. Another known and widely discussed cause to justify low back pain is the presence of a lumbosacral transitional vertebra.[2,3] A transitional vertebra is the most common congenital anomaly of the lumbosacral spine,[4-5] with a prevalence ranging from 7% to 30% in various studies.[6-7] It is characterized by an abnormal enlargement of the transverse process of the most caudal lumbar vertebra, which may articulate or fuse with the sacrum unilaterally

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or bilaterally.[8] It is caused by ligamentous ossification, chronic arthritis, or true sacralization.[9]
Several studies have reported the presence of Bertolotti's Syndrome in the population,[7-10] however, they lack data correlating the percentage of patients with low back pain who have the condition.

METHODOLOGY

A retrospective study of 1,023 anteroposterior lumbar spine radiographs was conducted in patients who sought emergency care between 2018 and 2020 due to low back pain without a history of recent trauma, resulting in a final sample of 469 cases. Radiographs were excluded if they showed: significant spinal deformities, fractures of the vertebral bodies or transverse processes, poorly performed radiographs with overlapping structures or axial rotation that prevented proper analysis, postoperative images of instrumented arthrodesis, or bone resections. The patients were between 11 and 96 years old and were exempted from signing the Informed Consent Form, CAEE 46563815.9.0000.5479.
The radiographs were independently evaluated by two orthopedic surgeons, and the cases were classified using a standardized approach based on the radiographic classification systems of Tini and Castellvi.[2-3] The reviewers assessed the reproducibility of the descriptions and determined interobserver reliability. The variables were analyzed using the Kappa concordance index, two-proportion Z-test, confidence interval for the mean, and p-value.
The classifications used to detail the degrees of involvement of the megatransverse process are divided into grades (I to IV – referred to as "class") and their subdivisions (a, b, c – referred to as "morphology").
In the Tini classification[2] (Figure 1), type I represents only a change in the length of the transverse process of the presacral vertebra greater than 1.9 cm, which may be asymmetric (a) or symmetric (b) in relation to the contralateral side; type II represents the bilateral and symmetric appearance of the transitional vertebra, which may be fused by a bony bridge (a) or articulated (b) with the sacrum; type III presents the transitional vertebra bilaterally and asymmetrically, which may involve one side articulated and the other fused by a bony bridge with the sacrum (a), one articulated and the other normal (b), or one fused by a bony bridge and the other normal (c); and type IV represents combined disorders, with dysplasia of the transverse process on one side and a new joint or bony bridge on the other side.
In the Castellvi classification[3] (Figure 2), type I represents the presence of hypertrophy of the transverse process measuring at least 1.9 cm, without the formation of a bony bridge or new joint, and may be unilateral (a) or bilateral (b); in type II, a joint is formed between the transverse process and the sacrum, which may be unilateral (a) or bilateral (b); in type III, there is complete sacralization due to bony fusion, which may also be unilateral (a) or bilateral (b); and type IV presents both joint formation and bony fusion simultaneously.

RESULTS

Based on the data presented and the statistical analyses performed, the main results can be highlighted as follows: data variability was assessed using the coefficient of variation (CV), which was less than 50%, indicating low variability and high homogeneity of the data. The Confidence Interval (CI) was calculated for the mean age (Table 1), with 95% statistical confidence, resulting in a mean of 49.9 years ± 1.6, indicating that the mean age may range from 48.3 to 51.5 years.
For the analysis of the distribution of qualitative factors (Table 2), a two-proportion Z-test was performed to characterize the distribution

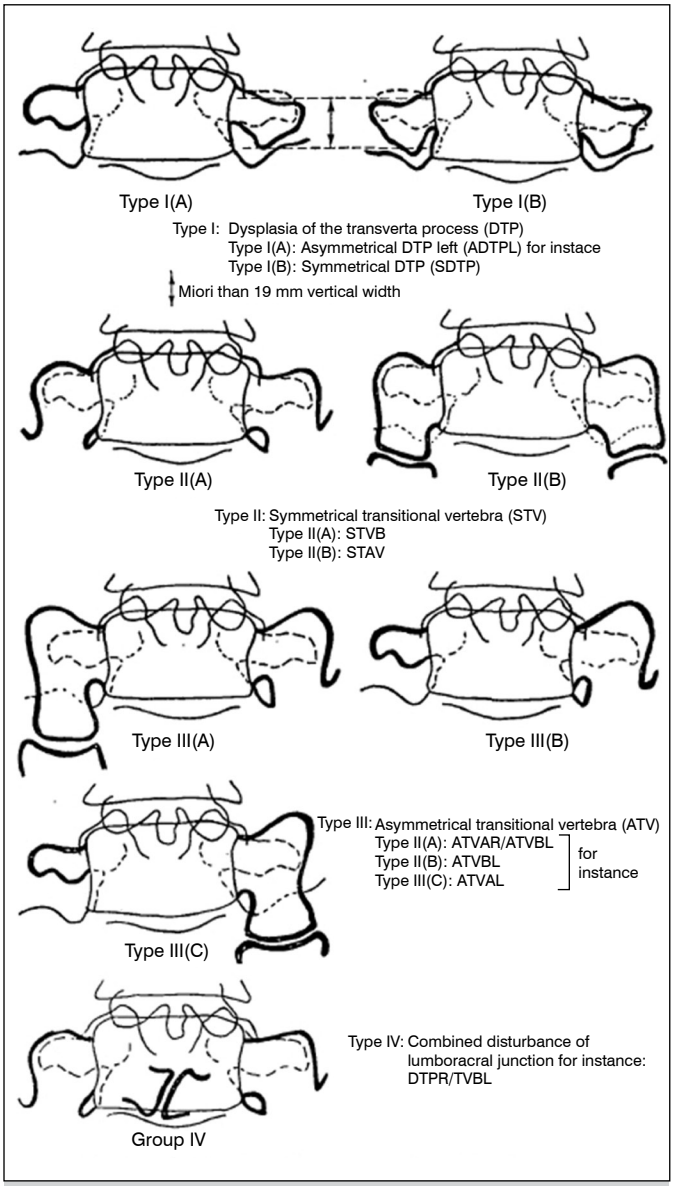
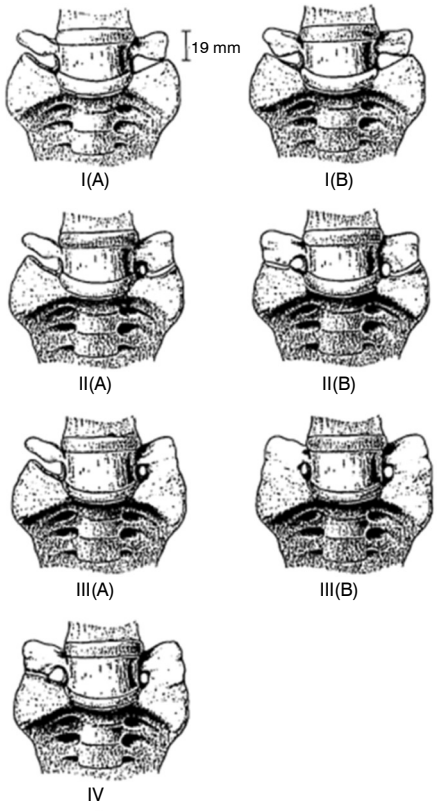


Figure 1. Tini Classification.[2]

of qualitative factors such as sex, syndrome, classes, and morphology, as evaluated by evaluators A and B. The results demonstrated statistical significance in all variables analyzed.
Regarding the Kappa concordance index (Table 3), it was calculated to assess the degree of agreement between evaluators A and B for the Castellvi[3] and Tini[2] classifications, considering different segmentations by age, sex, and age group. The results showed high levels of agreement, with Kappa values above 0.90 in all analyses performed.
In summary, the results indicate significant homogeneity in age data, statistical significance in the distribution of qualitative factors, and high agreement between evaluators for the classifications studied. These findings are important for the understanding and interpretation of results in the healthcare field, highlighting the reliability of the analyses performed.
Given the analysis of the results, the prevalence of Bertolotti's syndrome for observer A was 62.5%, while for observer B it was 61.6%. Among patients with the study syndrome, the class with the highest prevalence in both classifications was type I with more than 70% of cases. The second most prevalent class was type III, with more than 15% of cases. Among the morphologies, the bilateral pattern



Castellvi radiologic classification of lumbosacral transitional vertebrae. (1) Type I(A) (unilateral) and I(B) (bilateral): dysplastic, triangular-shape transverse processes measuting at least 19 mm. (2) Type II(A) (unilateral) and II(B) (bilateral): incomplete lumbarization/sacralization due to diarthrodial joint between the enlarged transverse process(es) and sacrum. (3) Type III(A) (unilateral) and III(B) (bilateral) with complete lumbarization/sacralization due to the total bony union of transverse processes to the sacrum. (4) Type IV: mixed unilateral type II and contralateral type III. Reused with permission from Castellvi et al.[13]

Figure 2. Castellvi Classification.[3]

Table 1. Complete Descriptive Analysis for Age.

Age	
Mean	49.9
Median	48
Standard Deviation	17.9
CV	35.8%
Q1	37
Q3	63
IQR	26
Mode	39
Min	11
Max	96
N	469
CI	1.6

of involvement of the transverse process was the most frequent. With more than 50% of the cases, IB morphology, Castellvi[3] and Tini,[2] was the most prevalent.

DISCUSSION

The causal relationship between the transitional vertebra and low back pain was first described in 1917 as Bertolotti's Syndrome.[9] Several factors support this relationship, as affected individuals have a higher likelihood of degeneration in adjacent segments due to the joint hypomobility generated at the level of the fusion, leading

Table 2. Distribution of Qualitative Factors.

		N	%	P-value
Sex	Female	289	61.6%	<0.001
	Male	180	38.4%	
CASTELLVI-A (Syndrome)	No	176	37.5%	<0.001
	Yes	293	62.5%	
CASTELLV-AI (Classes)	I	217	74.1%	Ref.
	II	22	7.5%	<0.001
	III	44	15.0%	<0.001
	IV	10	3.4%	<0.001
CASTELLVI-A (Morphology)	IA	55	18.8%	<0.001
	IB	162	55.3%	Ref.
	IIA	8	2.7%	<0.001
	IIB	14	4.8%	<0.001
	IIIA	26	8.9%	<0.001
	IIIB	18	6.1%	<0.001
	IV	10	3.4%	<0.001
CASTELLVI-B (Syndrome)	No	180	38.4%	<0.001
	Yes	289	61.6%	
CASTELLVI-B (Classes)	I	213	73.7%	Ref.
	II	19	6.6%	<0.001
	III	47	16.3%	<0.001
	IV	10	3.5%	<0.001
CASTELLVI-B (Morphology)	IA	50	17.3%	<0.001
	IB	163	56.4%	Ref.
	IIA	6	2.1%	<0.001
	IIB	13	4.5%	<0.001
	IIIA	25	8.7%	<0.001
	IIIB	22	7.6%	<0.001
	IV	10	3.5%	<0.001
TINI-A (Syndrome)	No	176	37.5%	<0.001
	Yes	293	62.5%	
TINI-A (Classes)	I	219	74.5%	Ref.
	II	14	4.8%	<0.001
	III	44	15.0%	<0.001
	IV	17	5.8%	<0.001
TINI-A (Morphology)	IA	57	19.4%	<0.001
	IB	162	55.1%	Ref.
	IIA	2	0.7%	<0.001
	IIB	12	4.1%	<0.001
	IIIA	17	5.8%	<0.001
	IIIB	20	6.8%	<0.001
	IIIC	7	2.4%	<0.001
	IV	17	5.8%	<0.001
TINI-B (Syndrome)	No	180	38.4%	<0.001
	Yes	289	61.6%	
TINI-B (Classes)	I	214	74.0%	Ref.
	II	13	4.5%	<0.001
	III	45	15.6%	<0.001
	IV	17	5.9%	<0.001
TINI-B (Morphology)	IA	51	17.6%	<0.001
	IB	163	56.4%	Ref.
	IIA	1	0.3%	<0.001
	IIB	12	4.2%	<0.001
	IIIA	18	6.2%	<0.001
	IIIB	19	6.6%	<0.001
	IIIC	8	2.8%	<0.001
	IV	17	5.9%	<0.001

Table 3. Kappa Concordance Index between Evaluators for CASTELLVI[3] and TINI.[2]

With Syndrome		CASTELLVI			TINI		
		Classes	Morphology	With Syndrome	Classes	Morphology	
Up to 49 years	Kappa	0.966	0.959	0.952	0.957	0.952	0.946
	IC	0.033	0.033	0.032	0.037	0.035	0.034
	P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
50 or more	Kappa	0.980	0.927	0.911	0.980	0.954	0.929
	IC	0.027	0.041	0.043	0.027	0.034	0.039
	P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Fem	Kappa	0.970	0.925	0.919	0.970	0.946	0.928
	IC	0.029	0.037	0.037	0.029	0.032	0.035
	P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Masc	Kappa	0.977	0.973	0.953	0.965	0.964	0.953
	CI	0.032	0.031	0.037	0.039	0.035	0.037
	P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
All	Kappa	0.973	0.943	0.932	0.968	0.953	0.938
	CI	0.022	0.026	0.027	0.023	0.024	0.026
	P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

to increased load on the disc immediately above it.[10-13] Cadaveric studies have shown that the iliolumbar ligament is significantly thinner and weaker at the level above the transitional vertebra.[11] Additionally, narrowing of the intervertebral foramen caused by the widening of the transverse foramen may lead to nerve root compression.[11]

The incidence of Bertolotti's Syndrome is 4% to 6% in the general population.[11] However, Quinland et al. reported that when isolating the young population (under 30 years old), the incidence rises to 11%.[8]

The diagnosis is based on radiological findings correlated with the clinical presentation. Normally anteroposterior radiography of the lumbosacral spine is sufficient, but in cases of milder hemisacralization, computed tomography is necessary for identification. In addition, the Magnetic Resonance is used to evaluate the root disturbances.[14]

In our study, patients with low back pain who sought care at the Emergency Department (approximately 60%) also had a transitional vertebra and, therefore, Bertolotti's Syndrome. Of these, the bilateral involvement of the transverse process, especially its hypertrophy without articulation with the sacred, was the most prevalent.

Bertolotti's syndrome is rarely considered as a differential diagnosis for patients presenting to emergency care with lower back pain, both due to physicians' lack of awareness and the limited dissemination and study of the condition in the literature. Various pathologies such as musculoskeletal distensions, degenerative disc disease, degenerative or rheumatic spinal disorders and spondylolisthesis are possibilities considered before Bertolotti's syndrome.

This study reveals an incidence of over 60% of Bertolotti's Syndrome among the 469 patients with low back pain who sought medical care, leading us to the conclusion that the condition should be more thoroughly considered when treating this population. It is worth noting that the presence of a transitional vertebra should receive greater attention, as it is associated with low back pain and is not always detected. This is particularly important considering that the incidence of this anomaly in the general population is much lower than the incidence of low back pain.

This opens up an even broader range of possibilities to be explored: regarding new approaches to the treatment of the megatransverse process associated with low back pain.

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ANATOMOTOPOGRAPHIC STUDY OF THE MARTIN-GRUBER ANASTOMOSIS

ESTUDO ANATOMOTOPOGRÁFICO DA ANASTOMOSE DE MARTIN-GRUBER

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ABSTRACT

Objective: To create, through anatomical dissections, a map of the location of the Martin-Gruber anastomosis (MGA) in the forearms of cadavers. Methods: One hundred forearms from 50 adult cadavers were used in this study. Dissection was performed through a median incision in the forearm and distal third of the arm. Lines between the humeral epicondyles (interepicondylar) and between the styloid processes of the radius and ulna (interstyloidea) were used as reference points for the topographic location of the anastomoses, and the forearms were divided into proximal, middle and distal thirds. Results: MGA was present in 27 forearms (27%). In four limbs (14.8%) the nerve fascicles originated from the median nerve proximal to the interepicondylar line. In two limbs (7.4%), at the level of the interepicondylar line and, in 21 of these (77.7%), they were found distal to this line. In 17 limbs (62.9%), the anastomosis occurred in the proximal third of the forearm, in eight limbs (29.6%), the anastomosis occurred in the middle third of the forearm and, in two limbs (7.4%), the anastomosis occurred with the ulnar nerve it occurred in the distal third of the forearm. Conclusion: Despite the great variation in their location, most anastomoses were found distal to the interepicondylar line, especially in the proximal third of the forearm. ***Level of Evidence IV; Case Series.***

Keywords: Peripheral Nervous System; Dissection; Surgical Procedures.

RESUMO

Objetivo: Criar, através de dissecações anatômicas, um mapa do local da ocorrência da anastomose de Martin-Gruber (AMG) em antebraços de cadáveres. Métodos: Cem antebraços de 50 cadáveres adultos foram utilizados neste estudo. A dissecação foi realizada por uma incisão mediana no antebraço e no terço distal do braço. Linhas entre os epicôndilos umerais (interepicondilar) e entre os processos estiloides do rádio e ulna (interestiloidea) foram usadas como pontos de referência para a localização das anastomoses e os antebraços foram divididos em terços proximal, médio e distal. Resultados: A AMG esteve presente em 27 antebraços (27%). Em quatro membros (14,8%) os fascículos nervosos se originaram do nervo mediano, proximalmente à linha interepicondilar. Em dois membros (7,4%) a origem deu-se no nível da linha interepicondilar e, em 21 destes (77,7%), foram encontrados distais à esta linha. Em 17 membros (62,9%) a anastomose aconteceu no terço proximal do antebraço, em oito membros (29,6%), a anastomose ocorreu no terço médio do antebraço e, em dois membros (7,4%), a anastomose com o nervo ulnar deu-se no terço distal do antebraço. Conclusão: Apesar da grande variação de sua localização, a maioria das anastomoses foi encontrada distalmente à linha interepicondilar, especialmente no terço proximal do antebraço. ***Nível de Evidência IV; Série de Casos.***

Descritores: *Sistema Nervoso Periférico; Dissecação; Procedimentos Operatórios.*

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INTRODUCTION

There are several possibilities for nerve communication in the upper limbs. These anatomical variations, when occurring between the median and ulnar nerves, are given different names according to their configurations. When the fascicles of the ulnar nerve branch toward the median nerve, they are known as Marinaci or reverse Martin-Gruber anastomoses.[1] They are called Cannieu and Riché anastomoses when the thenar motor branch of the median nerve anastomoses with the deep motor branch of the ulnar nerve[2,3] and Berretini anastomoses when they occur between the sensory branches in the palm of the hand.[4,5] When communication occurs at the point where the fascicles of the median nerve are directed toward the ulnar nerve in the forearm, it is known as Martin-Gruber anastomosis (MGA), in

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The study was conducted at Faculdade de Ciencias Medicas e da Saude de Sorocaba (Rua Joubert Wey, 290, Sorocaba, São Paulo, SP, Brazil. 18030-070).
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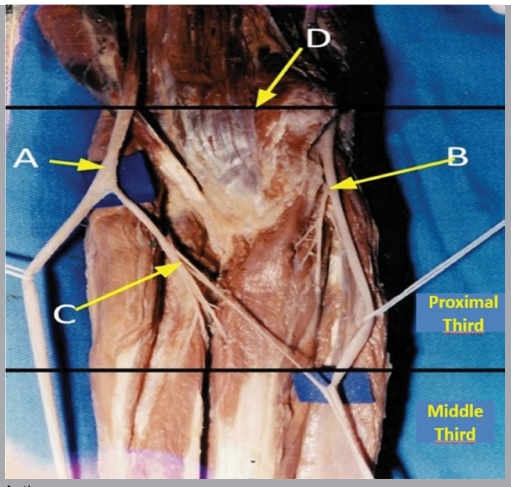
honor of the studies conducted by Martin and later by Gruber.[6,7] This anastomosis is responsible for creating variations in innervation, especially in the intrinsic muscles of the hand.[8,9]
Due to these variations in the pattern of innervation, compressive syndromes or isolated lesions of the median or ulnar nerve may have clinical presentations that differ from the classic patterns described in anatomy textbooks.[10] Anatomical and electrophysiological studies suggest that these communications have relevant clinical and surgical implications,[11-13] making their knowledge of great importance for the diagnosis, treatment, and performance of various procedures in the elbow and forearm regions.[11,12] The objective of this study was to create a topographic map of the sites of AMG occurrence to assist surgical procedures performed on the elbow and forearm.

MATERIALS AND METHODS

This research was approved by our institution's Ethics Committee under number 43267715.2.0000.5373. One hundred forearms from 50 adult cadavers were dissected for this scientific study. Forty-six bodies were male and four were female. The age range of the individuals varied from 28 to 77 years. Thirty-eight specimens were prepared using a 10% formaldehyde and glycerin solution. As the other 12 had recently passed away, they did not require this preparation. Forearms deformed by trauma or those with malformations were excluded from this study.
The dissection was performed through a median incision in the distal third of the arm and throughout the forearm. The two flaps created, including the skin and subcutaneous tissue, were reflected radially and ulnarly, respectively, and the same was done with the forearm fascia to expose all the muscles in this region. The interepicondylar line (between the medial and lateral epicondyles of the humerus) and the interstyloid line (between the styloid processes of the radius and ulna) were used as reference points to measure the topographic location of the AMG.
A Keeler magnifying glass with 2.5x magnification was used to improve visualization of the anatomical structures. The length of the communication between the median and ulnar nerves was measured with a caliper by two researchers. It was considered the average between the measurements obtained by the two individuals. We drew a line between the medial and lateral humeral epicondyles (interepicondylar) and another between the styloid processes of the radius and ulna (interstyloid), which were used as reference points for measuring the topographic location of the AMG. The region between the two lines was divided into proximal, middle, and distal thirds. All muscles of the forearm were dissected to analyze their innervation and the presence of nerve communication between the median and ulnar nerves. All Martin-Gruber anastomoses found were recorded and photographed.

RESULTS

AMG was detected in 27 of the 100 dissected forearms (27%). Of these, 13 presented nerve damage in the right upper limb (48.1%) and 11 in the left upper limb (40.7%). Bilateral involvement was observed in three cadavers (11.1%). With regard to the topographical location of the AMG, we observed that in four members (14.8%), the nerve fascicles were detached from the median nerve proximally to the interepicondylar line of the humerus (Figure 1), with measurements ranging from 2 to 12 mm (mean 4 mm). In two members, this occurred at the level of the interepicondylar line (7.40%) (Figure 2). In twenty-one members (77.7%), the nerve fascicles were detached from the median nerve distally to the interepicondylar line (Figures 3 and 4). In these, the length of nerve communication ranged from 45 to 227 mm (average 74 mm).



Source: Authors.

Figure 1. Anterior view of the right forearm divided into its proximal, middle, and distal thirds, where we can see the median nerve (A), ulnar nerve (B), and nerve fascicles detached from the median nerve (C) proximal to the interepicondylar line of the humerus (D).

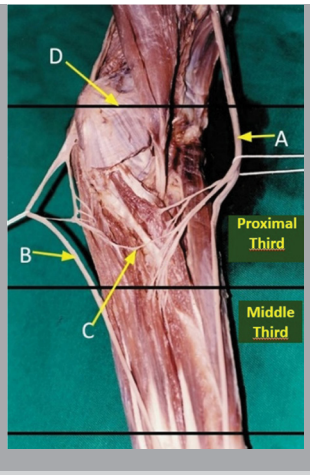


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Figure 2. Anterior view of a right forearm divided into its proximal, middle, and distal thirds, where we can see the median nerve (A), ulnar nerve (B), nerve fascicles detached from the median nerve (C) at the level of the interepicondylar line of the humerus (D), and the anastomosis occurred in the middle third of the forearm.

In five members (18.5%), the nerve connection was recorded inside the deep flexor muscle mass of the fingers, all of which were found in the proximal third of the forearm. In 17 members (62.9%), the anastomosis occurred in the proximal third of the forearm (Figure 3), in eight limbs (29.6%), anastomosis occurred in the middle third of the forearm (Figure 2), and in two limbs (7.4%), anastomosis with the ulnar nerve occurred in the distal third of the forearm (Figure 5). The most distal communication identified in this study was 75 mm proximal to the intersutural line.

DISCUSSION

The main finding of our study was that most Martin-Gruber anastomoses were found distal to the interepicondylar line, in the proximal third of the forearm, and that there was a wide variation in their location. The incidence of nerve communication between the median and ulnar nerves in the forearm varies in the literature. In this study, we found AMG in 27% of dissected forearms, while in other studies, the incidence of nerve communication ranged from 7.8 to 32%.[7,11-19,20]

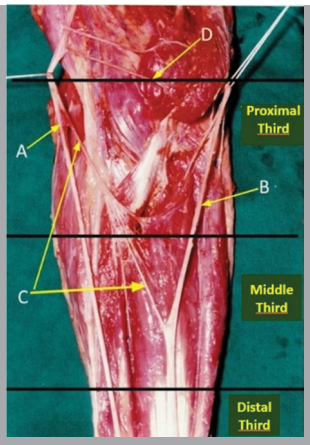

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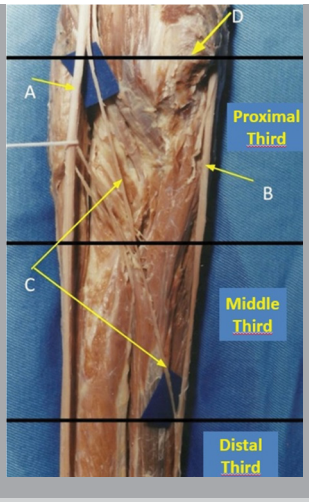
Figure 3. Anterior view of a left forearm divided into its proximal, middle, and distal thirds, where we can see the median nerve (A), ulnar nerve (B), nerve fascicles detached from the median nerve (C) distally to the interepicondylar line (D), and the anastomosis in the proximal third of the forearm.



Source: Authors.

Figure 4. Anterior view of a left forearm divided into its proximal, middle, and distal thirds, where we can see the median nerve (A), ulnar nerve (B), nerve fascicles detached from the median nerve (C) distally to the interepicondylar line (D), and the anastomosis performed in the middle third of the forearm.

In our series, 48.1% of nerve injuries occurred in the right upper limb, 40.7% in the left upper limb, and 11.1% were bilateral. In the study by Kaur et al.,[21] anastomoses occurred on the right side in 42.8% of specimens, on the left side in 28.5% of cases, and were bilateral in 28.5% of limbs. Roy et al.[22] in a meta-analysis, found that AMG was most commonly found unilaterally (66.8%), with 15.7% occurring on the right side. For these authors, the length of this nerve communication was 41.55 mm ± 13.77 mm, whereas in our assessment, the measurement varied significantly, ranging from 45 to 227 mm, with an average of 74 mm.

Electroneuromyographic studies also evaluated AMG. Hefny et al.[23] evaluated 280 forearms from 140 healthy Egyptians with a mean age of 36.5 years (range, 23-58 years) and found nerve connections in 20% of the individuals analyzed. Bilateral involvement occurred in 4.28% of these cases and was more frequent on the right side. In the study by Sur et al.[24] the AMG was found in 21.4% of 140 Indian individuals. Bilateral involvement occurred in 46.6% of the people evaluated, with AMG identified in the right forearm in 26.6% of cases and in the left forearm in 26.6% of cases. However, studies using electrical stimulation may show discrepancies due to minor variations in technique, such as placing the electrodes at different depths, making them less accurate.

In another article, Gans & Alfen[25] described a case of AMG in which the study was performed by ultrasound of the median and ulnar nerves, from the armpit to the palm. The anastomosis occurred in the proximal forearm, where the median nerve branch detached shortly after emerging, below the pronator teres muscle, to join the ulnar nerve 50 mm more distally. Although there are subsidiary tests to assess the existence of AMG, we believe that the study conducted through anatomical dissections is still of great importance and accuracy.

Upon reviewing the articles published on AMG, we observed that the authors evaluated its incidence, the nature of the nerve fibers, and its classification without, however, studying the topographical location of the anastomosis. Therefore, our research did not find any studies in the English-language literature that analyzed the location of AMG occurrence, so that we could not compare our results.

CONCLUSION

Although there is considerable variation in the location of occurrence, most Martin-Gruber anastomoses were found distal to the interepicondylar line, in the proximal third of the forearm.

AUTHOR'S CONTRIBUTION: Each author contributed individually and significantly to the development of this article. EBC: design, interpretation of results, and writing of the article; CSC: dissection of specimens and interpretation of results; NRS: assistance in dissection of specimens and bibliographic research; PMN: assistance in dissection of specimens and bibliographic research; LAV: dissection of specimens and interpretation of results; JCG: review and final writing of the article.

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EVALUATION OF ARTHROSCOPIC TREATMENT OF TRIANGULAR FIBROCARTILAGE

AVALIAÇÃO DO TRATAMENTO ARTROSCÓPICO DAS LESÕES DA FIBROCARTILAGEM TRIANGULAR

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ABSTRACT

Objective: To evaluate the clinical outcomes of surgical treatment by wrist triangular fibrocartilage complex (TFCC) lesions videoarthroscopy (VA) and analyze the correlation between magnetic resonance imaging (MRI) and intraoperative VA findings. Methods: Cross-sectional study of 28 patients undergoing VA from February 2021 to September 2023, selected by predefined inclusion/exclusion criteria. The mean age was 39.6 years (range: 20–58), with a mean follow-up of 13.6 months (6–20). Twelve surgeries (42.9%) were on the right wrist and sixteen (57.1%) on the left. Functional assessment used the 11-item Quick-Dash questionnaire. Results: Quick-Dash scores were excellent in 18 cases (64.3%), good in 7 (25.0%), and satisfactory in 3 (10.7%). MRI identified 4 (14.3%) extensive and 24 (85.7%) partial tears, while VA confirmed 2 (7.1%) extensive and 26 (92.9%) partial tears. Concordance between MRI and VA was found in 26 cases (92.9%). Conclusion: Surgical treatment by VA resulted in predominantly excellent functional outcomes. There was high agreement between MRI and VA findings, indicating good sensitivity and specificity. ***Level of Evidence IV; Case Series.***

Keywords: Magnetic Resonance Imaging; Arthroscopy; Diagnostic Imaging; Wrist Injuries; Triangular Fibrocartilage; Wrist.

RESUMO

Objetivos: Avaliar os resultados clínicos do tratamento cirúrgico por videoartroscopia (VA) das lesões da fibrocartilagem triangular do punho e correlacionar os achados da ressonância magnética (RM) com os observados na VA. Métodos: Estudo transversal com 28 pacientes submetidos à VA entre fevereiro de 2021 e setembro de 2023, selecionados por critérios de inclusão e não inclusão. A média de idade foi de 39,6 anos (20-58) e o seguimento médio de 13,6 meses (6-20). Do total, 12 cirurgias (42,9%) foram no punho direito e 16 (57,1%) no esquerdo. Para avaliação funcional, utilizou-se o Quick-Dash (11 questões). Resultados: Na escala Quick-Dash, 18 (64,3%) apresentaram resultados excelentes, 7 (25,0%) bons e 3 (10,7%) satisfatórios. A RM detectou 4 (14,3%) lesões extensas e 24 (85,7%) parciais, enquanto a VA confirmou 2 (7,1%) extensas e 26 (92,9%) parciais. Houve concordância entre RM e VA em 26 casos (92,9%). Conclusão: O tratamento por VA apresentou resultados clínicos satisfatórios, com maioria de casos classificados como excelentes na avaliação funcional. Verificou-se alta concordância entre RM e VA, demonstrando boa sensibilidade e especificidade dos exames. ***Nível de Evidência IV; Série de Casos.***

Descritores: *Ressonância Magnética; Artroscopia; Diagnóstico por Imagem; Fibrocartilagem Triangular; Punho.*

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INTRODUCTION

Triangular fibrocartilage complex (TFCC) injuries are common in the genesis of ulnar-side wrist pain, often combined with distal radioulnar joint (DRUJ) instability.

The etiology of pain in the TFCC may be related to both wrist trauma and degenerative processes associated with local wear and tear. In general, this process begins during the third decade of life and progresses in frequency and severity in subsequent decades.

The TFCC is located between the radius, ulna, and semilunar and pyramidal bones of the carpus. This anatomical structure consists of the central disc, the dorsal and volar radioulnar ligaments, the ulnar extensor sheath of the carpus, and the homologous meniscus. This complex has crucial functions in wrist biomechanics, such as stabilizing the ulnocarpal and distal radioulnar joints, distributing load between the ulna and carpus, and facilitating rotational movements of the wrist and forearm.[1,2]

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

The study was conducted at IFOR Hospital. R. Américo Brasiliense, 596, Centro, São Bernardo do Campo, São Paulo, SP, Brazil. 09715-021.
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No imaging modality demonstrates perfect sensitivity and specificity for detecting lesions. However, because it is noninvasive, MRI is the most frequently used resource. It offers up to 95% accuracy in detecting TFCC breaks. This technique can replace wrist arthrography; however, in lower-power magnetic fields, MRI has proven to be less accurate, especially for diagnosing peripheral tears, with a sensitivity of 17%.

However, some authors consider wrist AV to be the gold standard for diagnosing TFCC injuries to assess intrinsic wrist ligament injuries, as it allows direct visualization of the wrist joint. Although considered an invasive method, diagnostic arthroscopy is indicated for patients with unequivocal or negative imaging tests, but with a history, symptoms, and clinical examination consistent with the disease.

Considering the different treatment methods, initially conservative treatment with immobilization, modification of activities, corticosteroid injections, and the use of painkillers for a few weeks should be considered first. When symptoms do not go into remission, surgical procedures are recommended. Currently, there is no standard gold standard procedure, and no surgical procedure has been found to be superior.

PRP injection is a recent and commonly used option in the treatment of acute and chronic tendinopathies because it promotes cell viability and collagen synthesis by providing the growth factors TGF-β1 and PDGF-AB.

The *outside-in*, *inside-out, or all-inside* arthroscopic methods allow for appropriate treatment when indicated, where repair with an anchor to perform transosseous suturing is the most commonly used procedure. This feature has the advantage of avoiding open capsulotomy with capsular flap of the original method. This instrument minimizes scarring, soft tissue fibrosis, and joint stiffness. Considering the evaluation of the results, good and excellent results are generally obtained in 60% to 90% of cases.

To evaluate the results, we found that the Visual Analog Scale (VAS), modified Mayo score, arm, shoulder, and hand disability scores, grip strength, and range of motion (ROM) are the primary assessment tools used in the treatment of patients with TFCC injuries.

Therefore, this study aims to evaluate the clinical outcome of arthroscopic surgical treatment of conditions affecting the triangular fibrocartilage of the wrist. As a secondary objective, the authors will evaluate the correlation between the findings of the MRI scans and those found during wrist VA.

MATERIALS AND METHODS

Initially, this research project was submitted to bioethical evaluation by the Research Ethics Committee of Plataforma Brasil and approved for implementation by CAEE opinion 81673924.2.0000.0087. This is a retrospective cross-sectional cohort study whose sample included patients with TFCC lesions treated surgically between February 2021 and September 2023.

The following criteria were established for inclusion of patients in this study.

1. Patients of both sexes.
2. Aged between 18 and 60 years old.
3. Minimum follow-up period of 6 months.
4. With a diagnosis of traumatic (partial or extensive) or degenerative injury.
5. No previous trauma such as styloid process fractures of the ulna, distal radius fractures, or ARUD injury.
6. No previous history of inflammatory disease
7. Patients with failure of conservative treatment.
8. Patients who accept the terms of the TCLA
9. Patients undergoing MRI and wrist AV for repair or reconstruction of the TFCC.

Those who refused to sign the Informed Consent Form or who had other types of wrist injuries, such as distal radius fractures or previous surgery on the limb under study, were excluded.

Therefore, our case series consisted of 28 patients, 21 (75.00%) men and 7 (25.00%) women, with a mean age at the time of surgery of 39.60 years (minimum of 20 years and maximum of 58 years) and a mean follow-up time of 13.6 months (minimum of 6 months and maximum of 20 months). Twelve (42.86%) were performed on the right wrist and 16 (57.14%) on the left wrist.

Arthroscopic wrist surgeries at the research center in question are performed under general anesthesia with a tourniquet on the upper limb being operated on, with a pressure of approximately 250 mmHg. After sterile preparation, the patient's hand is placed in a traction device and a force of approximately 6 to 7 kg is applied. Using the dorsal approach, portals 3–4 and 4–5 are used for arthroscopy and *shaving*. A *shaver* is used to release the TFCC from the capsule in the *foveal* region. Peripheral and deep tears are visualized through portals 3–4 after release of the TFCC, and instability of this structure is assessed with the aid of a hook. The drill guide is passed through the ulnar surface toward the fovea of the ulna, then a guide wire is passed through and a 2.5 mm suture anchor is inserted. The grip is then released and the repair between the TFCC and the fovea is secured with three knots. The knots are positioned inside the sheath of the ulnar extensor tendon of the carpus to prevent skin irritation. When ligament reconstruction is not necessary, only debridement is performed. After removal of the arthroscope, the portals are sutured with 5-0 nylon. Finally, a sterile dressing is applied and the pneumatic tourniquet is deflated. During outpatient follow-up, the stitches are removed after two weeks and the axillary and palmar immobilization is removed after two weeks when ligament reconstruction is not necessary, or after three weeks when it is necessary. After this period, physical therapy treatment begins.

The Quick-Dash functional assessment method consisting of 11 questions was used. With 11 questions, the tool measures the impact of injuries in these regions, assessing functional limitations, pain, and the ability to perform daily activities.[3] Its main function is to monitor the progress of treatment and compare the effectiveness of interventions, and it already has a validated Brazilian version.[4] Responses to QuickDASH were presented based on the relative frequency of responses. The number of injuries identified, as well as their origins and characteristics, in addition to the need for sutures, were presented according to their absolute and relative frequencies in relation to the total sample size.

RESULTS

In the collective evaluation of responses to Quick-Dash, when patients were asked if they could open a new jar or one with a very tight lid, 76.7% responded that they had no difficulty, while 23.3% responded that they had little difficulty. Regarding the ability to perform heavy household tasks, such as washing walls or floors, 63.3% reported no difficulties, 26.7% reported little difficulty, while 10.0% reported moderate or severe difficulty. Regarding the ability to carry a bag or briefcase, 93.3% reported no difficulties, while 6.7% reported little or moderate difficulty. When asked about their ability to wash their own backs, 86.7% reported no difficulty, with 13.3% reporting minor difficulty. When asked about their ability to use a knife to cut food, 93.3% of patients reported no difficulty, with 6.7% reporting minor difficulty. Regarding the ability to participate in recreational activities that require some strength or impact on the arms, shoulders, or hands, such as playing volleyball or hammering, 66.7% of participants reported no difficulties, 23.3% reported little difficulty, and 10% reported moderate difficulty. In the assessment that identified the extent to which the wrist problem affected

normal activities with family, friends, neighbors, or colleagues, 80% of patients responded that activities were not affected, 16.7% responded that activities were slightly affected, while 3.3% stated that such activities were moderately affected. When asked whether the wrist problem affected their work or even limited their regular daily activities in the last week, 76.7% said there were no limitations, while 23.3% reported few limitations. Pain in the arm, shoulder, or hand was not reported by 73.3% of patients, while mild pain was reported by 26.7%. Skin discomfort (pinching) in the arm, shoulder, or hand was not reported by 90% of patients, being present in 10% of the sample (mild discomfort). Finally, when patients were asked whether they had difficulty sleeping because of pain in their arm, shoulder, or hand, 90% reported no difficulties, while 10% reported minor difficulties.

Soon after administering the Quick-Dash questionnaire, we obtained 18 (64.28%) excellent, 7 (25.00%) good, and 3 (10.72%) satisfactory results. MRI identified 4 (14.29%) extensive lesions and 24 (85.71%) partial lesions, while VA identified 2 (7.14%) extensive lesions and 26 (92.86%) partial lesions. With regard to agreement between RM and VA, we observed 26 (92.86%) cases.

DISCUSSION

Suspected TFCC damage is diagnosed through appropriate physical examination, which allows for a reliable diagnosis of foveal tears. Palpation of the bone near the ulnar styloid often causes pain, and when combined with a positive stress test, such as foveal compression, indicates a rupture. Occasional additional clicks may also indicate the presence of ARUD instability.

However, it is indisputable that diagnosis depends on resources such as radiography, arthrography, MRI, magnetic resonance arthrography (MRA), and wrist VA. However, there is no consensus regarding the sensitivity, specificity, and accuracy of such diagnostic imaging resources, despite their frequent use.

The diagnostic values of this modality range from 71 to 100% for central and radial ruptures of the TFCC. However, the diagnostic performance of conventional MRI for detecting peripheral tears is only 17%. This percentage is justified by the presence of high-sign vascularized fibrous tissue between the two ulnar insertions mimicking the rupture.

According to some studies, MRI is up to 95% accurate in detecting foveal tears of the TFCC complex.[5] This technique is sensitive for diagnosing such lesions, but according to some authors, arthroscopy appears to be the most accurate method for diagnosis.

However, according to hand orthopedic surgeons, the gold standard for evaluating intrinsic wrist ligament injuries is arthroscopy. His argument relates to the possibility of directly visualizing the articulation of the wrist. However, we also found divergent opinions questioning the degree of diagnostic confidence. It is considered an invasive and expensive method, so VA would be restricted to patients with unequivocal or negative imaging studies despite having a history, symptoms, and clinical examination consistent with the disease.

For ARM, we found the study by Haims et al.[6], which evaluated 86 MRI exams and found sensitivity of 17%, specificity of 79%, and accuracy of 64%. In the study by Morley et al.[7], we found 54 MRI studies that demonstrated sensitivity of only 44% and specificity of 87%.

The diagnostic accuracy of MRI increases with magnetic field strength (3 Tesla), coil technology, and pulse sequencing compared to examinations on 1.5 T machines.

In a study conducted by Smith et al.[5] in a systematic review that included 21 studies (982 wrists), we found that the sensitivity of MRI in detecting full-thickness ruptures of the LCC was 75% and the specificity was 81% with stronger fields. Your study recommended that ARM should be preferred over conventional MRI. The findings of Spies et al.[8] studies corroborate the outcomes described above. However, we should note that ARM is an invasive procedure that can cause pain and discomfort in the wrist due to the administration of intra-articular contrast. Due to synovial irritation. In rare cases, serious complications such as joint infection should be remembered. We believe that the absence of a standardized protocol for performing MRI in the evaluation of TFCC may contribute to low diagnostic accuracy. Variations in MRI parameters, such as magnetic field strength and contrast agent use, are not effective in detecting TFCC lesions. On the other hand, VA performed with specific portals allows a comprehensive assessment of the wrist structures, facilitating accurate classification of injuries according to Palmer's classification.[9] In this case, standardization of MRI could contribute to improving diagnostic accuracy and allow replication of results in different centers.

The importance of wrist AV in the diagnosis and treatment of TFCC injuries is indisputable. We highlight its importance in allowing arthroscopic inspection to achieve a correct diagnosis of injuries, as well as their morphological characteristics such as location, shape, and dimensions. Such assessments are possible thanks to the magnified view of the structures studied and the possibility of using various portals. They also allow visualization of the radiocarpal and midcarpal joints to diagnose and treat coexisting injuries.

Furthermore, arthroscopic techniques theoretically offer advantages, including smaller incisions, less tissue dissection, faster recovery, and greater patient satisfaction.

Our study compared the diagnostic efficacy of MRI in relation to VA. We observed that MRI detected TFCCP lesions in 100% of cases, with 4 (14.28%) being extensive and 24 (85.71%) partial. The VA showed 2 (7.14%) extensive lesions and 26 (92.85%) extensive lesions. However, the degree of agreement between the tests used in our study was 92.85%, with two cases showing no agreement regarding the extent of the damage. We agree with the opinion of several authors that there are advantages to VA. Still, the degree of agreement between the resources evaluated was considered excellent according to the Kappa classification (with the highest number of categories). The population sample evaluated in our Service, although small, indicates that arthroscopy allows direct and detailed visualization of intra-articular structures, enabling immediate interventions, as recommended in the literature.

Fleiss's Kappa is derived from Cohen's Kappa. The main difference between Fleiss's Kappa statistic and Cohen's Kappa is that Fleiss's Kappa allows us to assess the degree of agreement between three or more observers/evaluators. In contrast, Cohen's Kappa allows us to analyze only two. The value of the Kappa agreement coefficient can range from ($-p_e/1-p_e$) to 1. The closer the value is to 1, the greater the indication that there is agreement among the evaluators, and the closer it is to zero, the greater the indication that the agreement is purely random.

Based on the results observed, arthroscopy showed the same sensitivity of 100% in identifying lesions requiring surgical intervention. However, diagnostic accuracy in indicating the best treatment depended on the information obtained from its use. This suggests that, although MRI is highly specific, its sensitivity may be compromised, indicating that the severity of some lesions may not be accurately diagnosed by this method. The results of this study corroborate the findings of previous studies, showing that the diagnostic accuracy of MRI is inferior to arthroscopy, even considering technical variations among radiologists.[10]

We looked at the functional results across the board after the Quick-Dash questionnaire was completed and found that

Finally, it should be noted that the surgical procedures performed in our Service were effective, as no significant changes were noted

in the Quick-Dash scale scores. These data confirm the findings of Yao and Lee,[11] who reported excellent results in patients undergoing arthroscopy for the correction of wrist injuries.

The limitations of this study are related to several factors. Its retrospective design with inherent biases, small sample size, and lack of some clinical elements may interfere with the results. However, there is complete documentation with good quality images obtained. We believe that the evaluation of MR and ARM results, as well as the results of diagnostic arthroscopy, depend on the personal experience of the radiologists who perform the diagnostic interpretations, and the results are directly related to the expertise of the orthopedic surgeon who performs them.

We may not have documentation of low-grade complications such as skin problems or postoperative pain, as we did not find any such records. Other potential complications, though subtle and transient, could include sensory nerve damage. This study comprised a series of cases in which there was no randomization.

CONCLUSIONS

The study highlights the high specificity and sensitivity of MRI and VA for diagnosing TFCC lesions that require surgical intervention. The combination of advanced imaging technologies and minimally invasive techniques, such as arthroscopy, can significantly improve clinical outcomes by promoting more accurate diagnoses and effective treatments.

When the Quick-Dash questionnaire was applied, we observed that 18 (64.28%) patients obtained results classified as excellent, 7 (25.00%) as good, and 3 (10.72%) as satisfactory. The study revealed high specificity and sensitivity between MRI and VA examinations, with agreement in 26 (92.86%) cases.

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SURGICAL TREATMENT OF TIBIAL STRESS FRACTURE: NAIL X PLATE

TRATAMENTO CIRÚRGICO DE FRATURA POR ESTRESSE DA TÍBIA: HASTE X PLACA

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ABSTRACT

To analyze and compare two surgical treatment methods for tibial stress fractures: intramedullary nailing and tension plate, taking into account functional outcomes and postoperative results. This systematic review was conducted and written in accordance with the guidelines for systematic reviews – PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). The bibliographic search was carried out between January and September 2024 in journals indexed in the PubMed, Lilacs, Cochrane and Embase databases. Ten studies were selected. Among them, five were case reports, four were case series, and one was a retrospective cohort study. Intramedullary nailing offers good stabilization and a gradual return to sports activities, but it can cause complications such as knee pain and additional fractures. The anterior tension plate, on the other hand, provides effective stabilization with less anterior knee pain and faster healing times, but it is more invasive and may require implant removal and intensive rehabilitation. The choice between intramedullary nailing and tension plate should be based on a detailed assessment of the individual characteristics of the patient, the nature of the fracture, and the potential risks associated with each technique. ***Level of Evidence IIA; Systematic Review of Cohort Studies.***

Keywords: Tibia; Stress Fracture; Fracture Fixation, Intramedullary.

RESUMO

Analisar e comparar dois métodos de tratamento cirúrgico para fratura por estresse da tíbia: haste intramedular e placa de tensão, levando em consideração os desfechos funcionais e resultados pós-operatórios. A presente revisão sistemática foi conduzida e redigida de acordo com as diretrizes para revisões sistemáticas – PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). A pesquisa bibliográfica foi realizada entre janeiro e setembro de 2024 nos periódicos indexados nas bases de dados PubMed, Lilacs, Cochrane e Embase. Dez estudos foram escolhidos. Dentre eles cinco relatos de caso, quatro séries de casos, e um estudo coorte retrospectivo. A haste intramedular oferece boa estabilização e um retorno gradual às atividades esportivas, porém pode causar complicações como dor no joelho e fraturas adicionais. A placa de tensão anterior, por sua vez, proporciona uma estabilização eficaz com menor dor anterior no joelho e tempos de consolidação mais rápidos, mas é mais invasiva e pode exigir a remoção do implante e reabilitação intensiva. A escolha entre a haste intramedular e a placa de tensão deve ser baseada em uma avaliação detalhada das características individuais do paciente, da natureza da fratura e dos riscos potenciais associados a cada técnica. ***Nível de evidência IIA; Estudo de Revisão Sistemática de Estudos Coorte.***

Descritores: *Tíbia; Fratura por Estresse; Fixação Intramedular de Fraturas.*

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INTRODUCTION

Stress fractures of the tibia, particularly in the anterior region, are common among athletes and military personnel, with a notable prevalence in high-impact activities such as running and jumping.[1,2] These fractures, often described as the "feared black line" on radiographs, are challenging due to their location on the tension line of the bone, which hinders nonoperative healing.[3,4] The conservative approach, which includes rest and activity modification, is generally effective for posteromedial cortex fractures but may be inadequate for anterior cortex fractures, which often result in nonunion or prolonged healing.[5] When nonoperative treatments fail, surgical intervention becomes an option, with two main techniques to consider: intramedullary nailing and anterior tension plate fixation. Intramedullary nails have been successfully used in several cases, providing symptom relief and allowing for a gradual return to activities.[2] On the other hand, anterior tension plates have

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shown theoretical advantages, such as better fracture stabilization.[4] The choice between these methods depends on several factors, including the patient's profile and the severity of the fracture. This study aims to compare the efficacy and functional outcomes of these two treatment methods for tibial stress fractures, to provide evidence-based guidelines for clinical practice.

MATERIALS AND METHODS

This review was written in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The protocol was published in the PROSPERO registry (CDR42024534684). We conducted a systematic review of the PubMed, Lilacs, Embase, and Cochrane databases, using search terms such as "tibial stress fracture," "intramedullary nailing," "plate fixation," and "athletes" (Table 1). Studies evaluating the results of surgical treatments with intramedullary nails and plates in athletes with tibial stress fractures were included.

Table 1. Search syntax used in databases.

Database	Search strategy	Total
Base	('fracture fixation, intramedullary' OR 'intramedullary nailing'/exp OR 'intramedullary nailing' OR 'bone plate'/exp OR 'bone plate') AND ('tibia'/exp OR 'tibia') AND ('stress fracture'/exp OR 'stress fracture') AND [embase]/lim	149
Lilacs	((tibia) AND (fractures, stress)) AND ((fracture fixation, intramedullary) OR (bone plates) OR (fracture fixation, internal) OR (internal fixators)) AND (db:("LILACS"))	1
Pubmed	((("Tibia"[Mesh] AND "Fractures, Stress"[Mesh])) AND (("Fracture Fixation, Intramedullary"[Mesh] OR "Bone Plates"[Mesh] OR "Fracture Fixation, Internal"[Mesh] OR "Internal Fixators"[Mesh]))	18
Cochrane	Stress fracture AND Tibia AND (Nail OR Plate OR Fracture Fixation, Internal OR Internal Fixator)ail OR Plate OR Fracture Fixation, Internal OR Internal Fixator)	14

Data collection

The data extracted from the included studies were the number of patients evaluated, percentage of return to sport, consolidation time, consolidation percentage, functional scores (SF-36, FAOS, Lysholm), complication rate, number of patients operated on with intramedullary nails, number of patients operated on with plates, clinical, and functional outcomes.

Inclusion and exclusion criteria

The inclusion criteria were: (1) randomized clinical trials, (2) prospective cohort studies, (3) retrospective cohort studies, and (4) case reports.

The exclusion criteria were: (1) literature reviews, (2) studies that did not evaluate the outcomes proposed in our research protocol.

Data extraction

Two independent researchers reviewed the results to select eligible studies, using pre-established inclusion and exclusion criteria. Disagreements were discussed with a third investigator. (Figure 1)

RESULTS

Using the search method, 182 potential studies were found in scientific databases, and after applying the exclusion criteria, 10 scientific studies remained. Based on the analysis of the selected articles, it is evident that there is significant diversity in the approaches and results of fracture treatment across different studies. Table 2 summarizes these articles, including the following data: treatment modality used, number of patients, percentage of

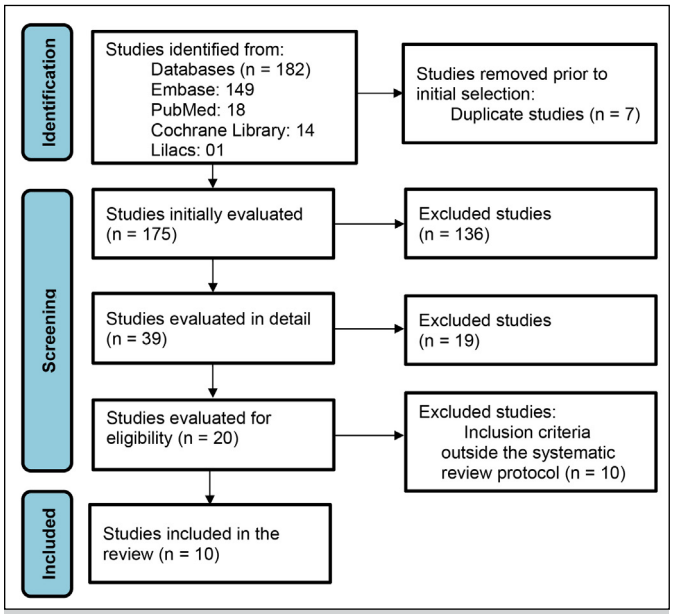

Figure 1. Flowchart of the search for articles in databases.

patients returning to sports, mean time to bone union, percentage of union, and complication rate. Results vary depending on the type of intervention and follow-up provided.

Studies evaluating the use of rods, such as those conducted by Chung et al.[3] and Komatsu et al.[5], have shown a 100% return-to-sport rate, with an average bone consolidation time of 16 weeks and a consolidation rate of 100%. These results suggest that the use of rods may be highly effective in promoting return to sport, especially in patients seeking rapid and complete recovery.

In studies evaluating the use of plates and rods, a slight decrease in the return-to-sport rate was observed, with a rate of 98%, although the average consolidation time was shorter, at 11 weeks. The consolidation rate also remained high at 96%.

Cruz et al.[9] analyzed the use of plates and rods and reported 100% return-to-sport rates, with a mean consolidation time of approximately 12 weeks and a consolidation rate of 100%.

Studies, such as that by Zbeda et al.,[4] which involved 13 patients treated with plates, highlighted a 100% consolidation rate and consistent return to sport, despite reporting complications, including medial tibial pain. Medial tibial pain, despite being a significant complication, did not prevent return to sport, suggesting that even with some adversity, treatment with plates may be a viable option.

On the other hand, Miyamoto et al.[7] reported a longer consolidation time of 20 weeks for patients treated with plates and rods, but still achieved a 100% consolidation rate and a full return to sports. These findings indicate that, although consolidation time may vary, the final efficacy in terms of return to sport and bone consolidation remains high.

Additional studies, such as those by Pandya et al.[8] and Martinez et al.[6], which also used rods, demonstrated a 100% return to sport after 40 and 20 weeks, respectively, with no reported complications. These results highlight the durability and effectiveness of the rods in prolonged treatment scenarios, especially when the goal is to ensure a full return to sports.

Yamada et al.[10] reported a 100% return-to-sport rate within a shorter period of 10 weeks, but with a lower consolidation rate of 33%. This study suggests that although a return to sport can be achieved quickly, complete bone healing may not be guaranteed in all cases, especially when follow-up and treatment are limited.

Table 2. Evaluation of data and characteristics of the included studies.

Study	Method	Number of Patients	Percentage of Return to Sport	Consolidation Time (weeks)	Consolidation Percentage	Complication Rate	Rod/ Plate	Outcomes	Methodology
Baublitz et al. (2004)[1]	Nail	1	100%	9 months	100%	100%	1/0	New acute fracture. Consolidation and return to sport afterwards.	Case report
Chung et al. (2019)[3]	Nail	1	100%	15 weeks	100%	0%	2/0	Bilateral consolidation and return to sport afterwards.	Case report
Komatsu et al. (2019)[5]	Nail	1	100%	20 weeks	100%	0%	2/0	Bilateral consolidation and return to sport afterwards.	Case report
Martinez et al. (2005)[6]	Nail	1	100%	10 weeks	100%	100%	1/0	Reoperation after refraction. Return to sport after.	Case report
Miyamoto et al. (2009)[7]	Nail	24	100%	6 weeks	100%	0%	3/0	Successful surgical treatment after conservative treatment failure.	Case series
Pandya et al. (2007)[8]	Nail	1	100%	40 weeks	100%	100%	1/0	Reoperation after a new fracture. Return to sport after.	Case report
Cruz et al. (2013)[9]	Plate	3	100%	12 weeks	100%	0%	0/4	Consolidation of all cases. Return to sport after.	Retrospective cohort
Varner et al. (2005)[2]	Nail	7	100%	12 weeks	100%	18%	11/0	Consolidation of all cases. Return to sport after.	Case series
Yamada et al. (2004)[10]	Nail	3	33%	8–12 weeks	100%	100%	3/0	Re-treatment for residual pain. Resolution in 2; 1 in programming	Case series
Zbeda et al. (2015)[4]	Plate	12	92%	9.6 weeks	100%	38%	0/13	High rate of return to sport.	Case series

DISCUSSION

This systematic review analyzed several studies on the surgical treatment of tibial stress fractures in athletes who used intramedullary nails or tension plates. The reviewed articles provided data on postoperative complications, the percentage of patients returning to sport, fracture healing rates, and healing times.

The main findings indicate that both intramedullary nails and tension plates are viable options for treating tibial stress fractures, but each technique has its advantages and disadvantages. The effectiveness of treatments may vary depending on the type of fracture, the athlete population, and the individual characteristics of the patients.

Complications associated with different surgical techniques were a significant concern. Treatment with intramedullary nailing showed a range of complications, including the possibility of additional acute fractures and persistent pain. Yamada et al.,[10] for example, discuss complications associated with intramedullary nails in athletes, concluding that there is a high incidence of associated complications and a need for additional surgical intervention. Similarly, Baublitz et al.[1] report that acute fractures can occur in previously stabilized chronic fractures with intramedullary nails. On the other hand, Varner et al.[2] in their study of seven athletes treated with intramedullary nails, reported that only one presented with residual pain at the nail insertion point, which was quickly resolved.

Treatment with tension plates also presented complications, although generally less severe. Zbeda et al.[4] in their study with 12 athletes, reported a 38% need for removal of prominent implants, but without any rate of infection or non-union. The same was reported by Cruz et al.[9] in their investigation of three high-level athletes treated with tension band using a plate.

The rate of return to sport after surgical treatment was a focal point. The data from the articles indicate that the rate of return to sport is high, but that it can vary depending on the time required to achieve this. Some studies show relatively quick and successful recovery. In contrast, others highlight the need for longer follow-up and intensive rehabilitation to ensure a full return to sports activities, especially when complications such as residual pain and non-union of the fracture are present.

Treatment with intramedullary nails often resulted in healing times ranging from 10 weeks to 40 weeks in a case of nonunion reported by Pandya et al.[8] On the other hand, tension plate demonstrated potential for faster healing times in studies by Zbeda et al.[4] and Cruz et al.[9], however, the exact times may vary depending on the complexity of the fracture and the rehabilitation protocol followed.

The studies reviewed showed variations in methodological quality. Some studies presented a solid approach with more details and greater follow-up, while others had limitations due to small sample sizes and less rigorous designs. The lack of standardization in surgical techniques and in the assessment of complications also affected the comparability of results.

The findings suggest that both intramedullary rods and tension plates have distinct advantages and disadvantages. The choice of treatment should consider not only the effectiveness in consolidating the fracture, but also the profile of complications and the rate of return to sport. The decision should be tailored to the individual needs of the athlete and the specific nature of the fracture.

Additionally, implementing strategies to optimize recovery, such as careful monitoring and targeted rehabilitation, is crucial for ensuring a successful return to sport and minimizing complications.

Future research should focus on studies with larger samples and more rigorous designs to directly compare different treatment methods. Longitudinal studies evaluating the effectiveness of rehabilitation approaches and the impact of factors such as nutrition and metabolism on recovery are also needed to provide a more complete understanding.

CONCLUSION

The results indicate that both approaches are feasible and effective; however, each has its advantages and disadvantages that should be considered when choosing a treatment.

The intramedullary nail has proven to be an effective option, as it stabilizes fractures and allows for a gradual return to sports activities. However, the technique has been associated with a range of complications, such as anterior knee pain and the possibility of additional fractures. On the other hand, the anterior tension plate offers theoretical advantages in terms of fracture stabilization and a lower risk of anterior knee pain, although it is a more invasive approach that may require implant removal and more intensive rehabilitation.

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