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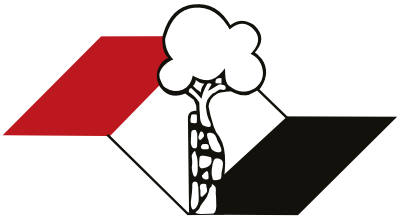

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SUMMARY

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Original Article

Review Article

ORTHOPEDIC TRAUMA

Systematic Review Article

ORTHOPEDIC TRAUMA

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ANALYSIS OF ARTHROPLASTIES IN ELDERLY PATIENTS WITH FEMORAL NECK FRACTURES AT A HOSPITAL IN SÃO PAULO

ANÁLISE DE ARTROPLASTIAS EM IDOSOS COM FRATURA DO COLO DO FÊMUR EM SERVIÇO PAULISTANO

Marcos Gabriel Falcão[1], *Marcelo Añez Suarez*[1], *Anna Clara Oliveira Paranhos Ferreira*[1], *Lucas Verissimo Ranzoni*[1], *Tajher Iunes Netto*[1], *Alberto Maranon Terrível*[1]

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ABSTRACT

Objective: To analyze the outcomes related to partial and total hip arthroplasties in elderly patients with femoral neck fractures at a hospital in the city of São Paulo. Material and methods: We reviewed the medical records of patients undergoing hip arthroplasty between 2020 and 2024 and extracted data on demographics, type of arthroplasty, length of hospital stay, and any postoperative complications such as infection and death. Results: 198 patients, mean age 84 years. Women (80.2%), men (19.8%). The mean time to surgery was 2.3 days, with 71.6% undergoing surgery within two days (early surgery). Length of ICU stay was significantly longer ($p = 0.002$) in the late surgery group ($M = 47$, $SD = 40$) compared to the early surgery group ($M = 31$, $SD = 41$). The total length of hospital stay was longer in the Late Surgery group ($M = 17$ days) compared to the Early Surgery group ($M = 7$ days), with statistical significance ($p = 0.001$) and a moderate-to-large effect size ($ES = 0.695$). Conclusion: Late surgery in elderly patients with femoral neck fractures increases hospitalization and ICU length of stay, but does not affect complications, mortality, or functional recovery. Although early surgery reduces hospitalization, management requires a multifactorial approach. ***Level of Evidence IV; Retrospective Cohort.***

Keywords: Hip Arthroplasty; Fractures, Bone; Femur; Postoperative Care; Postoperative Complications.

RESUMO

Objetivo: Analisar os desfechos relacionados a artroplastias parciais e totais em idosos com fratura do colo do fêmur em serviço hospitalar da cidade de São Paulo. Métodos: Realizamos revisão de prontuários dos pacientes submetidos a artroplastia de quadril no período entre 2020 e 2024 e extraímos dados demográficos, tipo de artroplastia, tempo de internação e eventuais complicações pós-operatórias como infecção e óbitos. Resultados: 198 pacientes, média de 84 anos. Mulheres (80,2%), homens (19,8%). O tempo médio até cirurgia foi 2,3 dias, com 71,6% operados em até dois dias (cirurgia precoce). Tempo de permanência em UTI foi significativamente maior ($p = 0,002$) no grupo de cirurgia tardia ($M = 47$, $DP = 40$) em comparação ao grupo precoce ($M = 31$, $DP = 41$). O tempo total de internação foi maior no grupo Cirurgia Tardia ($M = 17$ dias) em comparação ao grupo Precoce ($M = 7$ dias), com significância estatística ($p = 0,001$) e tamanho de efeito moderado-alto ($TE = 0,695$). Conclusão: A cirurgia tardia em idosos com fratura do colo do fêmur aumenta o tempo de internação e UTI, mas não afeta complicações, mortalidade ou recuperação funcional. Embora a cirurgia precoce reduza a hospitalização, o manejo exige abordagem multifatorial. ***Nível de Evidência IV; Coorte Retrospectiva.***

Descritores: *Artroplastia De Quadril; Fraturas Ósseas; Fêmur; Cuidados Pós-Operatórios; Complicações Pós-Operatórias.*

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INTRODUCTION

Femoral neck fractures are a public health problem, with a global incidence estimated at 1.6 million cases annually, projected to reach 4.5 million by 2050 due to population aging.[1] In Brazil, data from DATASUS reveal approximately 589,826 hospitalizations from 2019 to 2023, ranging from 109,189 admissions in 2019 to 131,425 in 2023, with a constant increase during this period.[2] It is a fracture with a bimodal peak incidence, occurring in young individuals due to high-energy trauma, such as car accidents, or in low-energy trauma, predominantly in elderly individuals from falls from their own height.[3]

These fractures are a rupture of the cortical bone between the femoral head and the greater trochanter, classified by Garden according to the degree of displacement and alignment of the bone trabeculae.[4] The diagnosis is usually made with X-rays in anteroposterior and lateral views of the hip, with high sensitivity. However, in cases with clinical findings that diverge from imaging

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

The study was conducted at Hospital IGESP, Sao Paulo, SP, Brazil.
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results, such as in the suspicion of occult fractures, the literature indicates the use of Magnetic Resonance Imaging (MRI).[5]
Surgical treatment is the gold standard, with two main surgical modalities: osteosynthesis and arthroplasty. The surgical definition depends on several factors, such as the fracture pattern, degree of prior functionality, life expectancy, and surgical risk. For osteosynthesis, one option is cannulated screws, which are indicated for non-displaced fractures, preserving the bone anatomy. Total or partial arthroplasty is indicated for unstable and displaced fractures, but it comes with a higher financial cost related to the implant.[6-9]
Surgical treatment for these fractures is based on achieving better pain control, as well as early mobilization and loading for these patients. In the literature, there are also better morbidity and mortality rates in patients who were approached early, leading to shorter hospital stays and fewer postoperative complications.[5-9] In this study, we present a retrospective evaluation of cases operated on in a hospital service in São Paulo – SP – Brazil between 2020-2024.

OBJECTIVES

To analyze the outcomes related to partial and total arthroplasties in elderly patients with femoral neck fractures in a hospital service in the city of São Paulo.
1. Analyze perioperative complications (incidents during anesthesia, intraoperative fracture, drop in hemoglobin in the immediate postoperative period, death)
2. Analyze postoperative complications (need for reoperation, infection, need for blood transfusion, deep vein thrombosis – DVT or pulmonary embolism – PE)
3. Analyze time to surgery, need for Intensive Care Unit (ICU), and length of hospital stay.
4. Measure progress in motor physiotherapy (sitting and standing)

MATERIALS AND METHODS

This is a retrospective observational study in a single hospital center. Approved by the ethics committee, protocol number: 87627325.6.0000.5450.
A review of the medical records of patients who underwent hip arthroplasty between January 1, 2020, and June 30, 2024, was conducted.

Inclusion criteria

- Age ≥ 65 years;
- Radiographically confirmed femoral neck fracture (Garden I-IV);
- Partial and total hip arthroplasty

Exclusion criteria

- Pathological fractures (e.g., metastatic);
- Polytrauma patients (to avoid bias from multiple injuries);
- Incomplete follow-up data;
- Elective arthroplasties;
- Patient using anticoagulants (dabigatran, rivaroxaban, apixaban, edoxaban).

Access to the medical record was through an electronic system. In addition to demographic information, the surgical information collected includes

- Operative time (minutes)
- Surgical access route
- Serum hemoglobin variation (ΔHb)
- Presence of intraoperative fracture
- Need for ICU and length of stay
- Outcomes at 7 days, 30 days, and 6 months
- Time to progress in motor physiotherapy to sitting and standing
- Complications: need for reoperation, infection, blood transfusion; venous thrombosis; death.

Data Analysis

For statistical analysis, categorical variables were described in absolute and relative frequencies, being compared between groups using Fisher's exact test or chi-square test, as applicable. Continuous variables were described as mean and standard deviation or median and interquartile range, depending on the data distribution, and compared using Mann-Whitney tests. The significance level adopted was 5% ($p < 0.05$). The analyses were conducted using Jamovi software v2.3.

RESULTS

The sample consisted of 198 patients with femoral neck fractures, with an average age of 84 years (SD = 7). There was a predominance of females, representing 80.2% of the sample (n = 158), and males 19.8% (n = 39).
The time to surgery had an average of 2.3 days (SD = 2.1). Of the total, 71.6% of the patients (n = 141) underwent surgery within two days after admission (early surgery), and 28.4% (n = 56) were operated on after this period (late surgery).
In the comparison between the groups, the average age was slightly lower in the early group (M = 83.85 years; SD = 7.79) compared to the late group (M = 85.66 years; SD = 6.79), with no statistically significant difference (p = 0.191). The distribution by sex was also similar between the patients operated on early or late, with a predominance of women in both (early group: 82.3% female; late group: 75% female; p = 0.248).
The operative time in the total sample was, on average, 99.1 minutes (SD = 37.5). Among the patients operated on early, the average was 110.6 minutes (SD = 45.5), while among those operated on late, the average was 87.5 minutes (SD = 23.5), with no statistically significant difference between the groups (p = 0.270). (Table 1)
The average variation of hemoglobin was 2.3 g/dL (SD = 1.4) in the total sample, being 2.4 g/dL (SD = 1.4) in the early group and 2.3 g/dL (SD = 1.5) in the late group, also with no significant difference between the groups (p = 0.872). Regarding the type of arthroplasty, most patients underwent partial arthroplasty (62.9%, N = 124), with a higher frequency in the late group (71.4%, N = 40) compared to the early group (59.6%, N = 84), although without statistically significant difference (p = 0.142). (Table 2)

Outcome in the immediate postoperative period

In relation to the immediate postoperative variables, it was observed that the length of stay in the ICU was significantly longer (p = 0.002) in the late surgery group (M = 47, SD = 40) compared to the early surgery group (M = 31, SD = 41), with a small to moderate effect size (ES = 0.292). Similarly, the total length of hospitalization was considerably longer in the Late Surgery group (M = 17 days)

Table 1. Operative time in patients undergoing surgery.

	Total				Early				Late				
	N	Med	Min	Max	N	Med	Min	Max	N	Med	Min	Max	p
Operative Time (minutes)	32	90	55	210	16	105	55	210	16	90	60	135	0.191

Note: N= Frequency; Med= Mean; Min= Minimum; Max= Maximum; p = p-value.

Table 2. Type of arthroplasty performed.

		Total	Early	Late	
		N	N	N	p
Type of arthroplasty	Partial	124	84	40	0.142
	Total	73	57	16	

Note: N= Frequency; p = p-value.

<< SUMÁRIO

compared to the Early group (M = 7 days), with statistical significance (p = 0.001) and a moderate-high effect size (ES = 0.695). (Table 3 and Figure 1).

Regarding the time to progress to sitting, the Late group (M = 2.3; SD = 2.8) showed a slightly higher average compared to the early surgery group (M = 1.7; SD = 1.1), with no statistically significant difference between them (p = 0.479). The time to standing also showed no significant difference between the groups (p = 0.106). Almost all patients were admitted to the ICU, with only two patients from the Early group not requiring intensive care. The occurrence of sitting was high in both groups (92.7% in the Early group and 89.8% in the Late group), with no significant difference (p = 0.547). Similarly, standing was achieved by 84.4% of patients in the Early group and by 77.1% in the Late group, also with no statistically significant difference (p = 0.284). These findings indicate that, despite differences in the length of hospitalization and stay in the ICU, immediate functional progression was similar between the groups, as shown in Table 4.

The only complications or outcomes observed in the 7-day postoperative period were deep vein thrombosis (DVT), prosthesis dislocation, and pulmonary embolism (PE), all occurring exclusively in the group undergoing early surgery, while readmissions were recorded only in the group undergoing late surgery. A total of 4 deaths (2.84%) were recorded, with 3 (3.23%) in the early group and 1 (2.08%) in the late group, with no statistically significant difference between the groups (p ≈ 1). (Table 5)

In the 30 days following surgery, infections were recorded in 6 patients (3.05%), with 3 in the early surgery group (6.38%) and 3 in the late surgery group (8.82%). Only one case of DVT was identified (1.37%), belonging to the early group (3.23%). There were two readmissions in total, one in each group, with the late group readmission occurring due to worsening clinical conditions. Additionally, four new deaths were recorded during this period, with one in the early group (2.33%) and three in the late group (9.09%), totaling eight deaths in the first month postoperatively.

In the follow-up up to six months after surgery, three cases of infection were identified (4.17%), of which two occurred in the early surgery group (4.88%) and one in the late surgery group (3.23%). Six deaths were recorded during this period, evenly distributed between the groups (n = 3 each), totaling 14 deaths by the sixth month of postoperative follow-up, with seven in each group.

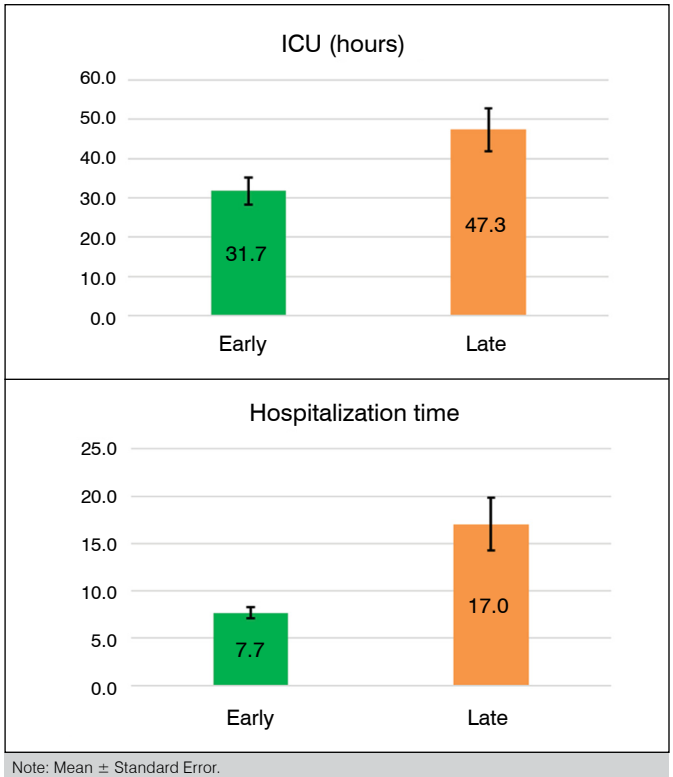
In total, 21 patients (10.7%) experienced some type of complication after surgery, with 18 (9.1%) corresponding to non-fatal complications. In the group undergoing early surgery, 12 patients (8.5%) experienced complications, while in the late group this number was 9 patients (16.1%). Despite the apparent difference between the groups, the comparison of proportions did not reveal statistical significance (p = 0.121).

Throughout the six months of postoperative follow-up, complications occurred in both groups, with no statistical difference.

Table 3. Postoperative variables in patients undergoing surgery.

	Total		Early		Late		
	N	Med	N	Med	N	Med	p
ICU (hours)	194	25	139	24	55	36	0.002
Length of stay (Days)	197	7	141	6	56	11	0.001
Time to sitting (days)	185	1	134	1	51	1	0.479
Time to standing (days)	162	2	118	2	44	3	0.106

Note: N= Frequency; Med= Mean; p = p-value.



Note: Mean ± Standard Error.

Figure 1. Length of stay in the ICU and hospitalization time of patients undergoing surgery.

Table 4. Patients who required ICU after surgery and those who achieved sitting or standing.

		Total	Early	Late	
		N	N	N	p
ICU	No	2	2	0	1.000
	Yes	192	137	55	
Sitting	No	12	7	5	0.547
	Yes	133	89	44	
Standing	No	26	15	11	0.284
	Yes	118	81	37	

Note: N= Frequency; p = p-value.

Table 5. Possible complications and deaths in patients undergoing surgery.

		Total	Early	Late	
		N	N	N	p
Infection (30 days)*	No	191	138	53	1
	Yes	6	3	3	
Infection (180 days)*	No	194	139	55	1
	Yes	3	2	1	
DVT (7 days)*	No	196	140	56	1
	Yes	1	1	0	
DVT (30 days)*	No	196	141	55	0.284
	Yes	1	0	1	
Death (7 days)	No	137	90	47	1
	Yes	4	3	1	
Death (30 days)	No	72	42	30	0.311
	Yes	4	1	3	
Death (180 days)	No	61	36	25	0.688
	Yes	6	3	3	
Complications	No	176	129	47	0.121
	Yes	21	12	9	

Note: N= Frequency; p = p-value.

DISCUSSION

Femoral neck fractures in the elderly represent a significant public health challenge, and surgical management, especially arthroplasty, is an already standardized approach. The discussion regarding the timing of surgery and its impacts on outcomes such as length of stay, complications, and mortality is central in the literature. This retrospective study aimed to analyze the impact of timing for surgery (early vs. late) in elderly patients undergoing arthroplasty for femoral neck fracture.

Our results did not demonstrate statistically significant differences in clinical and functional outcomes between elderly patients with femoral neck fractures undergoing early surgery compared to those undergoing late surgery. Although the group undergoing late surgery had a longer stay in the ICU and hospital, with the ICU showing a significant difference, the immediate functional outcomes (sitting and standing) and the rate of postoperative complications, including mortality, were similar between the groups over the six months of follow-up.

In total, 10.7% of patients experienced complications, with 9.1% being non-fatal complications. The distribution of adverse events was numerically higher in the late group (16.1% vs. 8.5%), but without statistical significance ($p = 0.121$). These findings indicate that, although early surgery is associated with shorter hospitalization and ICU stay, it did not result in a significant reduction in complications or mortality when compared to late surgery. Thus, the data suggest that the time to surgery was not a determining factor for the main clinical outcomes analyzed. However, the finding of shorter ICU time is consistent with the literature. Schneider et al.[10], in a retrospective review, identified that prolonged hospitalization after arthroplasty for hip fractures in the elderly is associated with an increased risk of mortality at 30 days. Although our study did not directly associate prolonged hospitalization with a statistically significant increased risk of mortality, the correlation between longer hospitalization and late surgery in our cohort reinforces the importance of optimizing care flow to reduce hospital stay. The study by Thornburgh et al.,[11] although focused on rehabilitation in a private setting, also recognizes that hospitalization time is a relevant outcome influenced by various factors after hip fracture.

Regarding postoperative complications and mortality, we found no statistically significant differences between the early and late surgery groups, despite a numerical trend of more complications in the late group. This finding is particularly relevant when compared to Ko et al.,[12] who investigated trends in hospitalization time, complication rates, and mortality in patients with hip fractures. The authors observed a substantial decrease in hospitalization time but concluded that the complication and mortality rates remained comparable across the different periods analyzed. This suggests that while early surgery may reduce hospitalization time, other factors may play a more determining role in the occurrence of complications and survival.

The presence of certain short-term complications exclusively in the early surgery group in our study, while early readmissions were seen only in the late group, raises questions about the nature of the complications associated with each surgical timing strategy. It could be that patients undergoing late surgery were, on average, more clinically stable before the intervention, or that the wait allowed for the optimization of conditions that reduced acute risks but increased length of stay. Thornburgh et al.[11] identified a series of factors, such as comorbidities, delirium, and home support, that influence hospitalization time and discharge destination, which may modulate risk profiles at different surgical times.

Our results indicate that, although early surgery is associated with a shorter hospitalization time and need for ICU, its impact on reducing complications or mortality has not been statistically proven. This shows that comprehensive clinical management of elderly patients with hip fractures is essential to optimize outcomes, as suggested by Ko et al.[12] and Schneider et al.[10].

Limitations

This study is not without limitations. We believe that larger samples may be of great value for a statistic with greater comparative power and more conclusive results.

Our sample also has a quite high average age. This becomes a bias as it is very common for very elderly patients to be referred to the ICU in the immediate postoperative period as a precaution, leading to an increase in the number of ICU days, even in patients who would eventually tolerate recovery directly in the ward, for example.

Finally, our sample is also unbalanced, with a predominance of the female sex. We consider this finding related to the higher prevalence of osteoporosis in the female population, associated with a prolonged menopause duration.

CONCLUSION

We found in this study that late surgery in elderly patients with femoral neck fractures is associated with a significant increase in the length of stay in the ICU and the total hospital stay, with the latter data showing a moderate to high effect size. No statistically significant differences were observed in the rates of overall postoperative complications or mortality at 7, 30, and 180 days between the groups undergoing early or late surgery. Immediate functional progression (sitting and standing) also showed no significant differences between the groups. Although early surgery may contribute to reducing the length of hospital stay, the complexity of managing hip fractures in the elderly requires a multifaceted approach.

CONTRIBUTIONS OF THE AUTHORS

Each author made a personal and significant contribution to the development of this article. MGF, MAS, and ACOPF: Substantial contribution to the conception or design of the work, or acquisition, analysis, or interpretation of data for the work. LVR: Drafting the work or critically revising its intellectual content. TLN and AMT: Final approval of the version of the manuscript to be published.

DATA AVAILABILITY DECLARATION

The authors confirm that all data supporting the findings of this study are available within the article.

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INFECTION PROFILE IN HIP ARTHROPLASTY AT A REFERRAL HOSPITAL

PERFIL DE INFECÇÕES EM ARTROPLASTIA DE QUADRIL EM HOSPITAL DE REFERÊNCIA

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ABSTRACT

Objective: To analyze the occurrence of infections in patients undergoing hip arthroplasty at a tertiary hospital in Teresina, Piauí, Brazil, between 2020 and 2023. Methods: A retrospective, longitudinal, and observational study conducted at Hospital Getúlio Vargas, Teresina, Piauí, with patients who developed prosthesis-related infections during the study period. Results: A total of 1,420 surgeries were performed, with an infection rate of 2.0% (22 cases). Female patients predominated (59.1%) with a mean age of 68.8 years. Trauma was the main surgical indication (77.3%). Total arthroplasty was performed in 68.2% of cases, with 59.1% done without cement. The most common pathogens were Escherichia coli (22.7%) and Acinetobacter baumannii (18.2%). The main antibiotics used were ciprofloxacin (31.7%), clindamycin (25%), and vancomycin (15%). Hospital discharge occurred in 86.4% of cases, with no significant association between variables and outcomes ($p > 0.05$). Conclusion: The findings highlight the importance of preventive protocols and surveillance to reduce infections in hip arthroplasty. ***Level of Evidence II; Retrospective Study.***

Keywords: Arthroplasty; Epidemiology; Cross Infection; Prostheses and Implants.

RESUMO

Objetivo: Analisar a ocorrência de infecções em pacientes submetidos à artroplastia de quadril no Hospital Getúlio Vargas, Teresina, Piauí, entre 2020 e 2023. Método: Estudo retrospectivo, longitudinal e observacional realizado no Hospital Getúlio Vargas, com pacientes que apresentaram infecção relacionada à prótese no período. Resultados: Foram realizadas 1.420 cirurgias, com taxa de infecção de 2,0% (22 casos). Predominou o sexo feminino (59,1%) e a média de idade foi de 68,8 anos. Trauma foi a principal indicação (77,3%). Artroplastia total foi realizada em 68,2%, e 59,1% sem uso de cimento. Os patógenos mais comuns foram Escherichia coli (22,7%) e Acinetobacter baumannii (18,2%). Os principais antibióticos usados foram Ciprofloxacino (31,7%), Clindamicina (25%) e Vancomicina (15%). A alta hospitalar ocorreu em 86,4% dos casos, sem associação significativa entre as variáveis e os desfechos ($p > 0,05$). Conclusão: Destaca-se a importância de protocolos preventivos e de vigilância para reduzir infecções em artroplastias de quadril. ***Nível de Evidência II; Estudo Retrospectivo.***

Descritores: *Artroplastia; Epidemiologia; Infecção hospitalar; Próteses e implantes.*

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INTRODUCTION

Hip arthroplasty has become a widely used surgical approach to restore mobility and improve the quality of life for patients suffering from pain and limitations caused by conditions such as osteoarthritis or inflammatory arthritis[1]. Despite the significant functional benefits, the procedure still requires special care in the postoperative period, especially regarding the risk of infections. These complications, although infrequent, can compromise the expected outcomes and require more complex and prolonged therapeutic strategies than in cases without infection, making careful follow-up of these patients essential[1,2].

Surgical Site Infections (SSI) are one of the main complications in the postoperative period, being associated with increased morbidity, prolonged hospitalization, and elevated healthcare costs[3]. Various risk factors contribute to the occurrence of these infections, including advanced age, frailty, presence of comorbidities such as diabetes mellitus, as well as the complexity and duration of the surgical procedure[4].

In the realm of orthopedic surgeries, periprosthetic joint infection (PJI) stands out as a complication that occurs after the implantation of joint prostheses, such as hip prostheses[3]. Considered one of the most serious complications following total hip arthroplasty, PJI has

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The study was conducted at Universidade Estadual do Piaui, Department of Orthopedics, Teresina, PI, Brazil.
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an increased risk in the presence of comorbidities[5]. In addition to significantly compromising the patient's health, potentially leaving them in worse condition than before the surgery[6], this infection frequently results in hospital readmissions and, in many cases, requires revision surgical procedures, contributing to a substantial increase in hospital costs and the associated economic impact[7].
According to clinical and laboratory criteria established by international guidelines, the diagnosis of PJI is confirmed by findings such as positive deep tissue cultures, fistula with joint communication, or the presence of inflammatory markers and changes in synovial fluid. Considering its severity and impact on the clinical evolution of patients, monitoring the incidence of SSI, especially in arthroplasties, is essential for improving care protocols and prevention strategies[3].
Since 2013, an international consensus has established specific diagnostic criteria for periprosthetic infection, underscoring the importance of detailed clinical data, including microbiological cultures, histological findings, and synovial fluid examinations. However, the unavailability of this data in national information systems, such as DATASUS, limits the application of these criteria in population studies in Brazil, highlighting the need for improvements in the standardization and quality of health records[8].
The treatment of periprosthetic infection varies according to the severity, the time of onset of the infection, and the clinical conditions of the patient[9]. Therapeutic options may include anything from the administration of antibiotics with preservation of the implant to more invasive procedures, such as prosthesis replacement in one or two surgical stages or, in extreme cases, resection arthroplasty (Girdlestone procedure)[10].
The choice of treatment should be individualized, taking into account factors such as prosthesis stability, presence of fistula, systemic inflammatory response, and microbiological profile of the infection, with the aim of eradicating the infectious agent, preserving joint function, and reducing recurrence and associated morbidity rates[11].
In this context, hip prosthesis infection is one of the greatest challenges in the postoperative period of arthroplasty, both for patients and healthcare professionals. In addition to potentially significantly prolonging the length of hospitalization, these infections often require surgical reinterventions and can lead to severe conditions, including death. Factors such as advanced age, associated comorbidities, and previous clinical status increase patients' susceptibility to these complications. In this scenario, investigating the incidence of infection in hip arthroplasties becomes essential to strengthen prevention strategies, early diagnosis, and appropriate treatment, promoting better clinical outcomes and contributing to the sustainability of healthcare systems.

OBJECTIVES

The overall objective of this study is to analyze the incidence of infections associated with hip prostheses in patients undergoing arthroplasty procedures at a tertiary hospital in Teresina, Piauí. Specifically, the aim is to calculate the incidence rate of surgical site infection (SSI) in patients undergoing hip arthroplasty at Getúlio Vargas Hospital from 2020 to 2023; analyze the association between the occurrence of SSI and clinical and surgical factors, such as type of anesthesia, type of arthroplasty (partial or total), ASA classification, age, need for ICU admission, use of antibiotic prophylaxis, use of cement, history of previous orthopedic surgery, and cause of fracture; verify the types of antimicrobials administered in the treatment of surgical site infections; and identify the microorganisms involved in these infections.

METHODOLOGY

This is a mixed, longitudinal, retrospective observational study with a descriptive approach, conducted at Getúlio Vargas Hospital (GVH). The sample was selected for convenience, including patients undergoing arthroplasty procedures who presented prosthesis-related infections from 2020 to 2023.
Patients who underwent hip prosthesis insertion through arthroplasty surgery at GVH during this period were included, while those without a diagnosis of local or systemic infection related to the prosthesis, as well as those with incomplete, illegible, or inconsistent medical records, were excluded. In the end, the analysis included 22 participants.
Data collection was performed through a systematic analysis of the medical records of the selected patients, using a standardized instrument to ensure uniformity and reliability. General information was extracted, such as age, sex, and comorbidities; data related to hospitalization, including admission date, length of hospital stay, and procedures performed; clinical information related to the infection, such as signs, symptoms, and laboratory and microbiological results; as well as data on clinical evolution, instituted treatments, and outcomes.
The collected data were organized and tabulated in Microsoft Excel 2016 and subsequently analyzed using SPSS version 26.0. Initially, descriptive analysis was performed, presenting qualitative variables by absolute and relative frequencies, and quantitative variables by measures of central tendency (mean and median) and dispersion (standard deviation). To verify associations between variables, the Pearson chi-square test was used, with Yates' correction for continuity when necessary. The significance level adopted was 5% ($p < 0.05$), with a 95% confidence interval.
The study strictly followed the ethical principles established by Resolution No. 466/2012 of the National Health Council, having been approved by the Research Ethics Committee with Human Beings of the institution under opinion No. 6.835.596 and CAAE 77819923.7.0000.5209, ensuring confidentiality, anonymity, and responsible use of information.

RESULTS

Between 2020 and 2023, 1,420 hip arthroplasties were performed at Getúlio Vargas Hospital in the city of Teresina, PI. Among these patients, a surgical site infection rate of 2.0% was observed, totaling 22 cases. (Figure 1)
Table 1 presents the social and clinical characteristics of surgical site infections in patients undergoing hip arthroplasty at Getúlio Vargas Hospital – PI, from 2020 to 2023.
Regarding the sociodemographic profile, a predominance of female sex (59.1%) was observed, with an average age of 68.8 years and a higher frequency of patients aged 60 years or older (77.3%), indicating greater vulnerability among the elderly to postoperative complications.

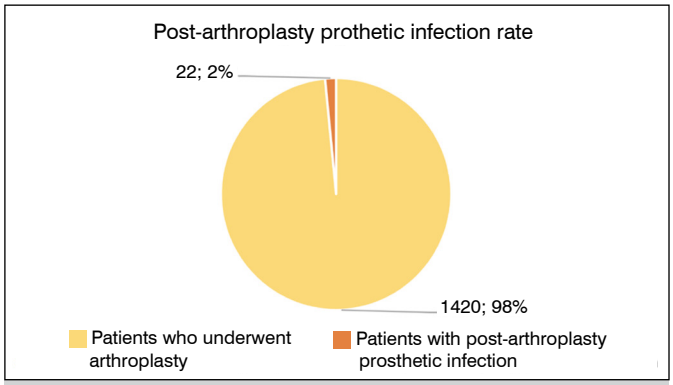

Figure 1. Occurrence of surgical site infection among patients undergoing arthroplasty at Getúlio Vargas Hospital from 2020 to 2023, Teresina-PI. (n = 22).

Table 1. Social and clinical characteristics of surgical site infections resulting from hip arthroplasties, based on information from medical records of patients undergoing hip arthroplasty at Getúlio Vargas Hospital – PI, from 2020 to 2023. (n = 22).

Variables	N(%)	IC-95%	Mean (CI-95)	SD
Social Profile				
Gender				
Male	9(40.9)	(22.5-61.5)		
Female	13(59.1)	(38.5-77.5)		
Age Range			68.82(62.75-74.89)	13.69
40-59 Years	5(22.7)	(9.2-42.9)		
≥60 Years	17(77.3)	(57.1-90.8)		
Clinical Profile				
Cause				
Hip Osteoarthritis	4(18.2)	(6.5-37.6)		
Avascular Necrosis	1(4.5)	(0.5-19.3)		
Trauma	17(77.3)	(57.1-90.8)		
Anesthesia				
Spinal	22(100.0)	(62.4-93.5)		
ASA				
1	4(18.2)	(6.5-37.6)		
2	10(45.5)	(26.3-65.7)		
3	8(36.4)	(18.9-57.1)		
UTI				
No	10(45.5)	(26.3-65.7)		
Yes	12(54.5)	(34.3-73.7)		
Prophylactic Antibiotic				
Cephalothin 48h	3(13.6)	(4.0-32.1)		
Cephalothin 24h	19(86.4)	(67.9-96.0)		
Previous Surgery				
No	20(90.9)	(73.9-98.1)		
Yes	2(9.1)	(1.9-26.1)		
Previous Surgery (type)				
Dislocation revision	1(50.0)	(6.1-93.9)		
Trochanteric	1(50.0)	(6.1-93.9)		
Partial or total				
Partial	7(31.8)	(15.5-52.6)		
Total	15(68.2)	(47.4-84.5)		
Cement				
With cement	9(40.9)	(22.5-61.5)		
Without cement	13(59.1)	(38.5-77.5)		

Source: Authors (2025). [1]CI-95% for proportion, at the 5% level. [2]CI-95% for mean, at the 5% level. Med: Median/ SD: Standard Deviation.

Clinically, the main surgical indication was trauma (77.3%), followed by hip osteoarthritis (18.2%) and avascular necrosis (4.5%). All patients underwent spinal anesthesia, suggesting a standardized anesthetic protocol. The majority were classified as ASA class 2 (45.5%) and 3 (36.4%), reflecting prior clinical impairment.

More than half (54.5%) required ICU admission, highlighting the severity of the cases. Antibiotic prophylaxis with cephalothin for 24 hours was adopted in 86.4% of patients. Regarding surgical technique, total arthroplasty predominated (68.2%), with cementless fixation (59.1%).

Figure 1 illustrates the distribution of bacteria identified in surgical site infections. The most prevalent pathogens were *Escherichia coli* (22.7%) and *Acinetobacter baumannii* (18.2%), followed by *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and other bacteria in smaller proportions. The predominance of *E. coli* may indicate contamination of endogenous origin, while *S. aureus* is a common pathogen in hospital and surgical infections.

Figure 2 shows the bacteria isolated in surgical site infections after hip arthroplasty. *Escherichia coli* (22.7%) and *Acinetobacter baumannii* (18.2%) were the most prevalent, followed by *Enterococcus faecium* (13.6%). Other pathogens, such as *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Providencia stuartii*, appeared with lower frequency. The presence of *E. coli* may indicate endogenous contamination, while *A. baumannii* and *S. aureus* reflect common hospital infections.

Figure 3 shows the antibiotics used to treat infections. It is observed that Ciprofloxacin (31.7%) was the most used, followed by Clindamycin (25.0%) and Vancomycin (15.0%). The choice of antimicrobials reflects the need for coverage against Gram-negative and Gram-positive pathogens, with a focus on the main identified pathogens.

Figure 4 illustrates the outcomes of the infections. The high percentage of patients discharged (86.4%) indicates a good treatment response. However, the need for Girdlestone in two patients and the death of one patient highlight the severity of complications associated with infections.

Table 2 presents the associations between infection outcomes and clinical and sociodemographic variables.

It is noted that no statistically significant associations were observed between the outcomes and the analyzed variables ($p > 0.05$ in all comparisons). However, it was observed that death occurred in a patient with ASA 3, over 60 years of age, and a diagnosis of hip osteoarthritis, factors that may indicate a higher risk of postoperative complications.

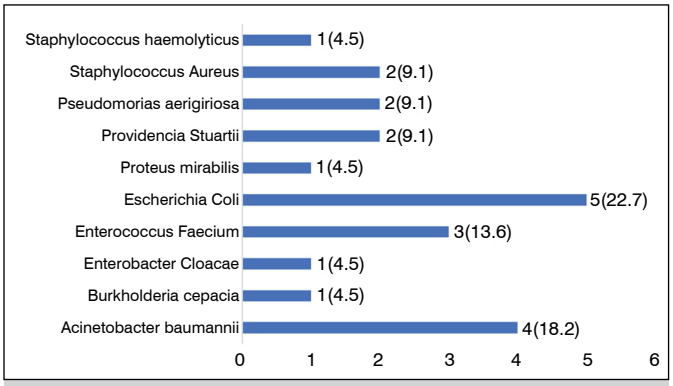

Figure 2. Characteristics of surgical site bacteria resulting from hip arthroplasties, based on information from medical records of patients who underwent hip arthroplasty at Getúlio Vargas Hospital – PI, from 2020 to 2023. (n = 22).

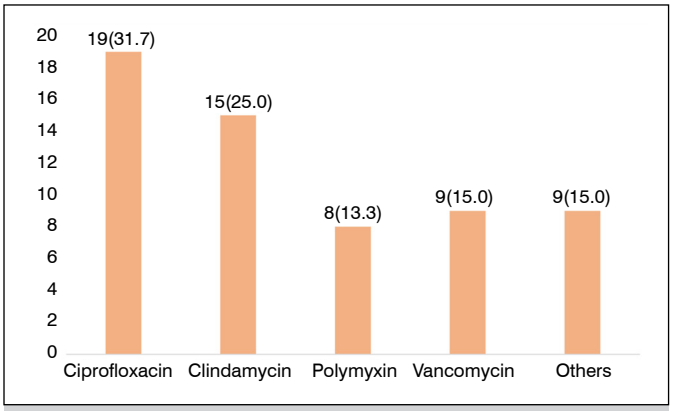

Figure 3. Characteristics of the antibiotics used in surgical patients resulting from hip arthroplasties, based on information from medical records of patients who underwent hip arthroplasty at Getúlio Vargas Hospital – PI, from 2020 to 2023. (n = 22).

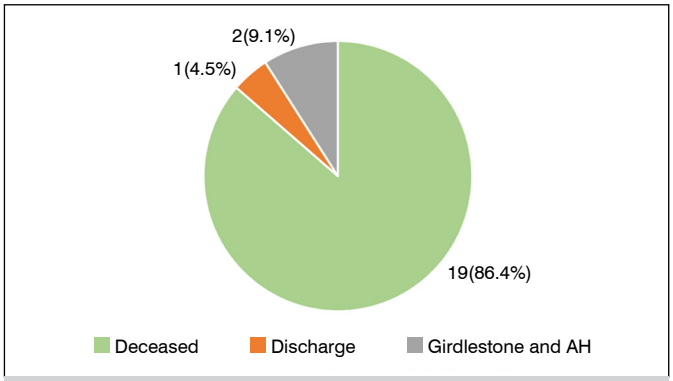

Figure 4. Characteristics of the outcomes of surgical site infections resulting from hip arthroplasties, based on information from medical records of patients who underwent hip arthroplasty at Getúlio Vargas Hospital – PI, from 2020 to 2023. (n = 22).

Table 2. Association between the outcomes of surgical site infections resulting from hip arthroplasties, based on information from medical records of patients who underwent hip arthroplasty at Getúlio Vargas Hospital – PI, from 2020 to 2023. (n = 22).

Variables	Outcome			P-value
	High	Death	Performed Gilderstone and AH	
	N(%)	N(%)	N(%)	
Sex				**0,680**
Male	8(42.1)	0(0.0)	1(50.0)	
Female	11(57.9)	1(100.0)	1(50.0)	
Age Range				**0.600**
40-59 years	5(26.3)	0(0.0)	0(0.0)	
≥60 years	14(73.7)	1(100.0)	2(100.0)	
Cause				**0.270**
Hip osteoarthritis	3(15.8)	1(100.0)	0(0.0)	
Avascular necrosis	1(5.3)	0(0.0)	0(0.0)	
Trauma	15(78.9)	0(0.0)	2(100.0)	
Anesthesia				**-**
Spinal	19(100.0)	1(100.0)	2(100.0)	
ASA				**0.193**
1	4(21.1)	0(0.0)	0(0.0)	
2	10(52.6)	0(0.0)	0(0.0)	
3	5(26.3)	1(100.0)	2(100.0)	
UTI				**0.235**
No	10(52.6)	0(0.0)	0(0.0)	
Yes	9(47.4)	1(100.0)	2(100.0)	
Prophylactic Antibiotic				**0.278**
Cephalothin 48h	2(10.5)	0(0.0)	1(50.0)	
Cephalothin 24h	17(89.5)	1(100.0)	1(50.0)	
Previous surgery				**0.841**
No	17(89.5)	1(100.0)	2(100.0)	
Yes	2(10.5)	0(0.0)	0(0.0)	
Previous surgery				**-**
Dislocation revision	1(50.0)	0(0.0)	0(0.0)	
Transtrochanteric	1(50.0)	0(0.0)	0(0.0)	
Partial or total				**0.081**
Partial	5(26.3)	0(0.0)	2(100.0)	
Total	14(73.7)	1(100.0)	0(0.0)	
Cement				**0.156**
With cement	7(36.8)	0(0.0)	2(100.0)	
Without cement	12(63.2)	1(100.0)	0(0.0)	

Source: Authors (2025). [1]Chi-square test, with Yates' correction, at the 5% level.

DISCUSSION

This study reveals relevant data on surgical site infections (SSI) and Periprosthetic Joint Infection (PJI) in patients undergoing hip arthroplasty at Getúlio Vargas Hospital from 2020 to 2023. PJI represents one of the most serious complications following hip arthroplasty, bringing significant impacts both for patients and the healthcare system due to high morbidity, mortality risk, and treatment costs. However, diagnosing this condition remains a major challenge in clinical practice, as there is no universal consensus on its definition[12].

In this research, the observed infection rate was 2.0%, consistent with the literature, which indicates a variable incidence between 1% and 2% in large hospitals[13-16]. Despite this, it is emphasized that this data, although within the expected range, should not be underestimated, as SSIs in orthopedic procedures such as hip arthroplasty are associated with high morbidity, the need for surgical reinterventions, and, in extreme cases, death[2].

The profile of infected patients showed a predominance of females, an average age of 68.8 years, and a higher frequency of elderly individuals (≥ 60 years), which corroborates findings from other previously conducted studies[11,15,17]. These findings indicate advanced age as a risk factor for postoperative complications due to the presence of comorbidities and lower functional reserve[18]. Additionally, most patients had an ASA classification of 2 or 3, reinforcing the previous clinical picture of systemic compromise.

It is noteworthy that the most frequent indication for performing arthroplasty was trauma, followed by hip osteoarthritis, a pattern also reported in similar studies in Brazilian public hospital contexts[19,20]. The predominance of traumatic cases may reflect the emergency nature of the service and the high demand for urgent surgeries in elderly populations, often victims of falls[21,22].

From a technical standpoint, standardized adoption of spinal anesthesia and antibiotic prophylaxis with cephalothin for 24 hours was observed in most cases. Although this practice aligns with established protocols[22], the occurrence of infections suggests the need for periodic reassessment of the effectiveness of the prophylactic regimen, also considering local microbiological profiles[11].

The most frequently isolated bacteria were *Escherichia coli* and *Acinetobacter baumannii*, both known for their resistance and ability to colonize in hospital environments. The presence of *E. coli*, a typically enteric pathogen, raises the hypothesis of endogenous contamination or failures in aseptic measures in patients with immunosenescence[23]. Meanwhile, *A. baumannii* is strongly associated with difficult-to-manage nosocomial infections, requiring strict protocols for hospital infection control[24].

It is noteworthy that PJIs caused by *A. baumannii* have garnered increasing attention in clinical practice, primarily due to its remarkable ability to develop resistance to various antibiotics and form biofilms, which significantly complicates treatment and contributes to infection persistence[24].

Regarding treatment, the predominant use of Ciprofloxacin, Clindamycin, and Vancomycin highlights the need for broad initial empirical coverage that addresses both Gram-negative and Gram-positive bacteria. The choice of these antimicrobials seems to align with the sensitivity patterns observed in the identified pathogens, which may have contributed to the good therapeutic outcomes in most cases[25].

Although there are international diagnostic criteria for periprosthetic infection, such as those established in 2013 by the International Consensus, which consider clinical, laboratory, and microbiological findings, their application in this study was hindered by the lack of clinical data in public databases. This limitation reinforces the need to improve and standardize national records, such as those from DATASUS, to enable analyses more aligned with international guidelines[8].

Regarding the duration of antimicrobial therapy, a period of 4 to 12 weeks of antibiotic treatment directed against the isolated pathogens is recommended, especially after prosthesis removal in revision procedures 11. Recent evidence suggests that a six-week antibiotic regimen may be effective in this context, showing good clinical results[23,11]. However, there remains a lack of consistent data on the efficacy of antibiotic treatment in single-stage revision cases, which limits the development of standardized care in these cases. Indeed, the clinical outcome was satisfactory in most patients, with 86.4% being discharged from the hospital. However, it is important to highlight the occurrence of serious complications, such as the need for Girdlestone surgery in two patients and the death of one patient. The latter case occurred in an elderly patient, classified as ASA 3, with a diagnosis of hip osteoarthritis, suggesting that such factors may be associated with a worse prognosis, although they did not reach statistical significance in this study.

According to Shah and Parker[26], Girdlestone resection is considered a salvage measure, usually indicated in situations where the patient has significant comorbidities that limit the performance of more complex reconstructive procedures, or when previous therapeutic approaches have failed. This technique, although associated with loss of joint function and reduced mobility, may be essential for controlling infection and improving quality of life in severe and refractory cases.

Furthermore, the absence of statistically significant associations between clinical/sociodemographic variables and outcomes may be due to the small sample size, which limits statistical power.

These findings reinforce the need for ongoing prevention strategies, including active microbiological surveillance, review of antibiotic protocols, and strengthening infection control practices, especially among vulnerable populations such as the elderly and those with comorbidities.

CONCLUSION

The analysis of surgical site infection cases in patients undergoing hip arthroplasty at Hospital Getúlio Vargas, between 2020 and 2023, revealed an infection rate of 2.0%, a figure consistent with the literature, but still underscores the importance of preventive strategies in the surgical environment. The profile of affected patients indicated greater vulnerability among the elderly, especially females with pre-existing clinical comorbidities, reflected in ASA classifications 2 and 3.

From a clinical perspective, the predominance of surgeries performed due to trauma and the high need for admission to intensive care units reinforce the severity of the cases. The presence of multidrug-resistant microorganisms, such as *Acinetobacter baumannii* and *Escherichia coli*, highlights the challenge in therapeutic management, requiring antimicrobial regimens with broad coverage. Despite this, most patients showed favorable progression, with hospital discharge in 86.4% of cases, although there were significant complications, such as the need for prosthesis resection (Girdlestone) and one case of death.

The absence of statistically significant associations between outcomes and the analyzed variables may be related to the small number of cases with infection, but it does not exclude the clinical relevance of factors such as advanced age, high ASA status, and previous joint diseases as potential aggravating factors.

In light of this, the findings reinforce the need for continuous surveillance, infection prevention and control protocols, as well as a multidisciplinary approach in perioperative care, especially for patients with higher clinical risk. Studies with larger sample sizes and longitudinal follow-up may contribute to a deeper understanding of factors associated with joint prosthesis infection and improve surgical outcomes.

CONTRIBUTIONS OF THE AUTHORS

Each author made a personal and significant contribution to the development of this article. FRNNF: substantial contribution to the conception or design of the work and final approval of the manuscript. IVM: analysis or interpretation of data for the work. DNV: drafting the work or critical revision of its intellectual content.

DATA AVAILABILITY DECLARATION

The underlying contents of the research text are contained in the manuscript.

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USE OF AN ABDUCTION ORTHOSIS AFTER FEMORAL OSTEOTOMY IN CHILDREN WITH CEREBRAL PALSY

USO DE ÓRTESE DE ABDUÇÃO APÓS OSTEOTOMIA DO FÊMUR EM CRIANÇAS COM PARALISIA CEREBRAL

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ABSTRACT

Objective: To evaluate the effectiveness and potential benefits of using customized abduction orthoses in the postoperative management of patients with cerebral palsy undergoing derotational osteotomy of the hip. Methods: A retrospective study was conducted with 14 patients (26 hips) with cerebral palsy and hip (sub)luxation, operated between 2021 and 2025 in private hospitals using the varus derotational femoral osteotomy technique. The analysis considered synthesis material positioning, achieved angle (Reimers' Index), joint congruence on postoperative radiographs, and clinical outcomes recorded in medical charts after the use of the customized abduction orthosis. Results: Postoperative outcomes were satisfactory, with only 3.8% of hips presenting a new dislocation episode, requiring reoperation, and 7.6% showing superficial wound complications. All medical records reported comfort and practicality with orthosis use for both patients and caregivers. Conclusion: The use of customized abduction orthoses in the postoperative period of varus derotational femoral osteotomy in patients with cerebral palsy showed comparable effectiveness to traditional spica cast immobilization, while providing greater ease of home care and reducing the physical and emotional burden on caregivers. ***Level of Evidence II; Retrospective cohort study.***

Keywords: Cerebral Palsy; Osteotomy; Postoperative Period; Quality of Life.

RESUMO

Objetivo: Avaliar a eficácia e os benefícios do uso de órteses de abdução customizadas no pós-operatório de pacientes com paralisia cerebral submetidos à osteotomia derrotatória do quadril. Método: Estudo retrospectivo com 14 pacientes (26 quadris) com paralisia cerebral e subluxação do quadril, operados entre 2021 e 2025 em hospitais da rede privada pela técnica de osteotomia derrotatória varizante do fêmur. A análise considerou posicionamento do material de síntese, ângulo obtido (Índice de Reimers), congruência articular em radiografias pós-operatórias, além da evolução clínica registrada em prontuário após uso da órtese abdutora customizada. Resultados: Foram observados resultados pós-cirúrgicos satisfatórios, com apenas 3,8% dos quadris apresentando novo episódio de luxação, o que demandou reabordagem, e 7,6% registrando complicações superficiais de ferida operatória. Todos os prontuários relataram conforto e praticidade no uso da órtese, tanto para pacientes quanto para cuidadores. Conclusão: O uso da órtese abdutora customizada no pós-operatório da osteotomia derrotatória varizante do fêmur mostrou eficácia semelhante à imobilização tradicional com gesso spica, oferecendo maior facilidade nos cuidados domiciliares e reduzindo o impacto físico e emocional sobre os cuidadores. ***Nível de evidência II; Estudo de corte retrospectivo.***

Descritores: *Paralisia Cerebral; Osteotomia; Período Pós-Operatório; Qualidade de Vida.*

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INTRODUCTION

Cerebral palsy (CP) is the leading cause of physical disability in childhood, affecting approximately 2-3 per 1,000 live births [1]. Initially described by William Little in 1862, it is now characterized by permanent disorders of movement and posture development, causing limitations in motor activity, attributed to non-progressive changes occurring in the development of the fetal or infant brain[2]. Thus, it becomes a pathology that can lead to bone and joint deformities, with significant implications for the mobility and quality of life of patients.

One of the common symptoms in individuals with CP is muscle spasticity which, in the case of the hip, can culminate in a subluxation or even dislocation of the joint due to anteversion of the femoral neck and proximal femur valgus[3] (Figure 1). The incidence of hip

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The study was conducted at Ortoped Clinic, Salvador, BA, Brazil.
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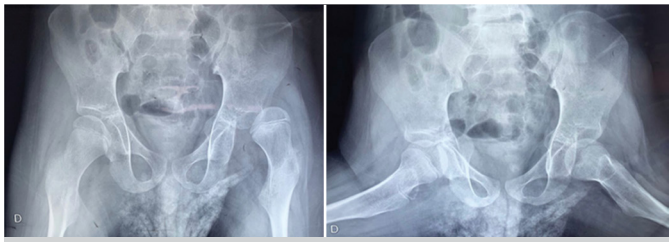

Figure 1. Preoperative pelvic radiographs in the AP and frog-leg views (left and right, respectively) of a child with cerebral palsy and left hip dislocation.

dysplasia in children with cerebral palsy varies significantly, being reported between 18% to 90% of patients, depending on the functional level according to the GMFCS (Gross Motor Function Classification System), where grades IV and V present a higher risk of developing hip subluxation and dislocation, with incidences that can reach 90%[4,5,6]. Therefore, surgical treatment of hip derotation osteotomy is indicated for those with indices suggesting unfavorable evolution, weighing the risks and benefits of the surgical procedure, aiming to relieve pain and improve locomotor function, potentially restoring the ability to ambulate and consequently the quality of life of the patient[7] (Figure 2). Traditionally, postoperative immobilization after hip reconstruction in children with cerebral palsy has been performed using a spica cast, which encases the trunk and one or both legs, keeping the hip in an abducted position[8]. This method has been considered the gold standard for decades, aiming to protect the osteotomy during the bone healing process and prevent loss of surgical correction. However, the use of spica casts is associated with various complications and significant challenges for both patients and their caregivers.

The proposed alternative to reduce such complications is the abductor orthosis, as used in this study, which consists of a triangular foam device with dimensions of 30-35 cm in length, a maximum width of 20-25 cm, a minimum width (at the bottom) of 10-15 cm, and adjustable height (Figure 3). This allows adjustment for different heights, with a range of up to 60 cm above the knee. To maintain knee extension, the orthosis is made of canvas with posterior duralumin stays and PVC sides, an elastic strap for knee compression, and a Velcro closure ranging from 20 to 80 cm, respecting the anatomical limits of 5 cm below the inguinal region and 3 cm above the malleolus (Figure 4).

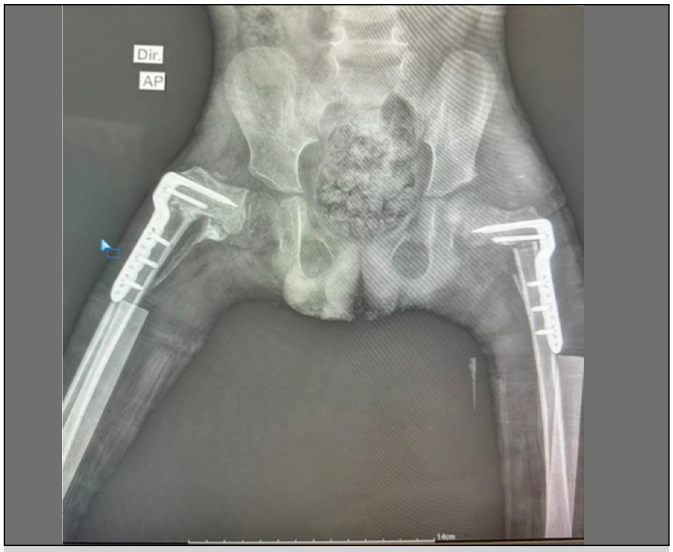

Figure 2. Postoperative follow-up radiograph of a child with cerebral palsy who underwent bilateral varus derotational femoral osteotomy.

The objective of this study is to evaluate the postoperative evolution in patients with cerebral palsy and hip subluxation who underwent hip derotation osteotomy, with special emphasis on the use of the customized abductor orthosis instead of plaster immobilization. The research will analyze the positioning of the locked synthesis material (plate and screws) in the radiographs following the procedure, as well as the acquired angulation and recovery of joint congruence. Thus, the evaluation of these criteria was made after the use of the orthosis, seeking to equate the results already identified in the literature with traditional immobilization approaches (spica cast). This study aims to highlight the effectiveness and potential benefits of using orthoses in postoperative management, contributing to the improvement of patient care and consequently the quality of life of both the patient and the caregiver during this period.

Figure 3. Custom abduction orthosis used in the study.

Figure 4. Patient using the custom-made abduction orthosis in the immediate postoperative period.

MATERIALS AND METHODS

This is a retrospective study conducted through the analysis of medical records and follow-up radiographs of patients who underwent surgical procedures between 2021 and 2025, who used a customized abductor orthosis in the postoperative period. The research was conducted in an orthopedic clinic.

Patients with a diagnosis of cerebral palsy and hip subluxation or dislocation, who underwent hip derotation osteotomy during the established period, with documented postoperative follow-up, use of the customized abductor orthosis, and at least one follow-up consultation conducted within one year after the procedure, during which follow-up radiographs were evaluated, were included.
Patients whose medical records contained incomplete information about the postoperative period; those who did not undergo postoperative follow-up; patients who did not have follow-up radiographs after surgery; and those with severe comorbidities that could compromise the analysis of postoperative evolution of the hip, aiming to increase the reliability of the obtained data, were excluded from this study.
As this is a retrospective study, the risks to participants are minimal. All collected data was stored securely and anonymously, ensuring patient privacy in accordance with current ethical and legal standards. All patients included in the study signed the informed consent form.

RESULTS

Among the sample of 20 patients diagnosed with cerebral palsy who underwent varus derotation femoral osteotomy, it was possible to include 14 patients (a total of 26 hips) with surgical approach dates between October 2021 and March 2025. The age of the patients at the time of surgery averaged 8.21 years, ranging from 5 to 14 years, with 6 female patients (42.8%) and 8 male patients (57.1%). The age of the patients at the time of surgery averaged 8.21 years, ranging from 5 to 14 years, with 6 female patients (42.8%) and 8 male patients (57.1%). This age distribution is consistent with the literature, which indicates that most hip reconstruction surgeries in cerebral palsy are performed in the first decade of life[9].
Among the studied patients, the majority underwent the derotation osteotomy procedure on both hips (85.8%), with only 14.2% of the patients included in the study undergoing the procedure unilaterally. During postoperative follow-up, the custom abduction orthosis was used by all patients included in the study without exception (Table 1). During the follow-up (minimum of 2 months), only 1 recurrence of dislocation was observed (3.8% of the total hips studied), with a new approach made to correct the deformity, which progressed without further complications. This recurrence rate is within the acceptable parameters reported in the literature, where studies show recurrence rates ranging from 3.1% to 9.4%[10,11].
In addition, 2 cases of superficial wound infection were identified (7.6%), which were treated with antibiotics without further repercussions or interference in the anatomical/mechanical outcome of the procedure. This rate of superficial infection is comparable to that reported by Amen et al., who found 2.7% of postoperative infections in their study[12]. (Table 2).
Of the 14 cases analyzed, no other negative outcomes were found, such as loosening of the synthesis material, delayed consolidation, nonunion, osteomyelitis, or neurovascular changes. The absence of these more serious complications suggests that the abduction orthosis provided adequate protection during the critical period of bone healing.
An important finding of this study was that 100% of the medical records contained reports of satisfaction regarding comfort and practicality for the patient and caregiver concerning the use of the orthosis. This result corroborates studies that demonstrate greater satisfaction among caregivers with alternative immobilization methods[13,14].

Table 1. Demographic data of the study sample.

Variable	Data
Total number of patients evaluated	14 patients (26 hips)
Surgery period	October 2021 to March 2025
Average age at the time of surgery	8.21 years
Age range	5 to 14 years
Gender	6 females (42.8%) 8 males (57.1%)
Type of surgery performed	Bilateral: 12 patients (85.8%) Unilateral: 2 patients (14.2%)

Table 2. Quantitative results of the study.

Variable	Data
Use of abduction orthosis in the postoperative period	100% of patients
Recurrence of dislocation	1 case (3.8% of hips)
Comparison with the literature	Recurrence rate consistent (literature: 3.1% to 9.4%)

DISCUSSION

Historically, postoperative immobilization of patients undergoing derotation osteotomy has been performed using spica casts, aiming to prevent loosening of the synthesis material and loss of the procedure due to the quality of osteoporotic bone, common in patients with cerebral palsy[15]. Segundo Vasconcellos et al. (2022) e Pisecky et al. (2022), the use of such immobilizations presents a rate of (sub)luxation in the postoperative period of 9.4% and 3.1%, respectively[16,17].
In the present study, the dislocation recurrence rate was 3.8% (1 case in 26 hips), which is lower than the results reported in the literature for spica cast immobilization. This finding is particularly significant as it demonstrates that the use of abduction orthoses does not compromise the effectiveness of treatment in terms of maintaining the surgical correction achieved.
This study shows that the use of customized abduction orthoses in the postoperative period of varus derotation femoral osteotomy in children with cerebral palsy has an effectiveness equivalent to the traditional method of spica cast immobilization, with significant advantages in terms of comfort, practicality, and quality of life for both patients and their caregivers.
The study by Vasconcellos et al., which included 233 children (436 VDROs) directly comparing spica cast versus abduction orthosis, found no statistically significant differences in the radiographic parameters (aMPFA, AI, MP) after one year of follow-up [17]. These findings corroborate the results of the present study and reinforce the evidence that abduction orthoses are a safe and effective alternative to traditional spica cast.
One of the main advantages of abduction orthoses over spica cast lies in the ease of maintaining personal hygiene and skin care. The cast, due to its rigid and non-removable nature, creates an environment conducive to the accumulation of moisture, dirt, and organic debris, complicating hygiene care [18]. This limitation is problematic in children with cerebral palsy, who often experience urinary and fecal incontinence, increasing the risk of contamination and infections [19].
Pressure ulcers represent a serious and potentially severe complication in immobilized patients [20]. The spica cast, due to its rigidity and inability to adjust after application, can create excessive pressure points on bony prominences, leading to this complication [21].
In contrast, abduction orthoses allow full access to high-risk areas for the development of pressure ulcers, facilitating daily hygiene and allowing regular skin inspection. The material used in the fabrication of the orthoses, typically viscoelastic foam or similar materials, offers better pressure distribution [22].

In the present study, no significant skin complications related to the use of the abduction orthosis were observed, which may be attributed to the ease of cleaning and the possibility of temporarily removing the device for specific care. This finding favorably contrasts with the rates of skin complications reported for spica cast in the literature.

The impact of the immobilization method on the quality of life of caregivers is an often underestimated aspect, but it is extremely important in the choice of postoperative treatment[23]. Children with cerebral palsy often require intensive and specialized care, and the addition of a spica cast can significantly increase the workload and stress of caregivers, as it demands logistics that include difficulties in transportation, the need for special equipment, and limitations in daily life[24].

Studies on caregivers' perceptions of orthotic devices demonstrate that ease of use and practicality are determining factors in treatment adherence[25].

Additionally, patient comfort is a fundamental aspect that directly influences quality of life during the postoperative immobilization period[26]. The spica cast, due to its rigidity and weight, often causes significant discomfort, especially in children with cerebral palsy who may exhibit spasticity and involuntary movements.

Abduction orthoses allow for adjustment of pressure and positioning to optimize individual comfort for each patient, which further promotes treatment adherence with less need for analgesia and better sleep quality[26]. In the present study, 100% of the records contained reports of satisfaction regarding comfort, a finding that corroborates the literature on the advantages of orthoses in terms of patient comfort.

Although evaluating economic aspects was not a specific objective of this study, it is important to consider the financial implications of different immobilization methods. The spica cast, despite having a seemingly lower initial cost, can generate significant additional costs related to complications and special care needs[27].

The skin complications associated with the spica cast may require additional medical treatment, including unscheduled consultations, medication use, and in severe cases, surgical procedures for the treatment of pressure ulcers. Additionally, the need for special equipment for the transport and care of children with spica casts may represent additional costs for families.

Shirley et al. demonstrated that alternative immobilization methods, including orthoses, can be cost-effective when considering the total treatment costs, including complications and additional care needs[27]. The previously mentioned reasons are factors that contribute to the cost-effectiveness of orthoses.

It is also worth noting that this study presents some limitations that should be considered in the interpretation of the results. First, this is a retrospective study with a relatively small sample (14 patients, 26 hips), which may limit the generalization of the findings.

Second, the assessment of patient and caregiver satisfaction was based on medical records, which may not fully capture the subjective experience of the participants. Future studies using validated instruments for quality of life and satisfaction assessment could provide more robust data on these aspects[28].

Finally, the absence of a contemporary control group using spica casts limits the ability for direct comparison. Although the results were compared with data from the literature, variations in surgical techniques, patient characteristics, and evaluation criteria may influence these comparisons.

On the other hand, the findings of this study have important implications for clinical practice. The demonstration that customized abduction orthoses can offer clinical outcomes equivalent to the spica cast, with significant advantages in terms of comfort, financial practicality, and quality of life, suggests that this method should be considered as a first-line treatment for postoperative immobilization in children with cerebral palsy undergoing femoral derotation osteotomy.

CONCLUSION

The data obtained showed that the use of the customized abduction orthosis in the postoperative period of the varus derotation osteotomy of the femur in patients with cerebral palsy presents satisfactory radiographic results, with adequate maintenance of surgical correction and joint congruence equivalent to the use of the traditional immobilization method (spica cast).

The observed dislocation recurrence rate (3.8%) is within the acceptable parameters reported in the literature for traditional immobilization methods, demonstrating that the abduction orthosis does not compromise the treatment's effectiveness in terms of maintaining the surgical correction achieved.

In light of the comprehensive analysis of the collected data and the methodology of the study in question, it was identified that the abduction orthosis presents itself as a safe and effective alternative, bringing significant clinical, practical, social, and financial benefits compared to the traditional spica cast, without compromising the surgical outcome.

It is recommended that customized abduction orthoses be considered as a first-line method for postoperative immobilization in this patient population, with the need for more randomized prospective studies with larger samples and longer follow-up to confirm these findings and establish evidence-based guidelines for clinical practice.

CONTRIBUTIONS OF THE AUTHORS

Each author contributed individually and significantly to the development of this article. LCG: conceived the work, performed the surgeries, selected the patients, collected data, guided the research, wrote and finalized the text; FCGF: performed the surgeries, selected the patients, collected data, analyzed the results, and wrote the article; AMPMF: analyzed the results, presented the study, and wrote the article: LLA, AGDP, VSR: performed the surgeries and selected the patients.

DATA AVAILABILITY DECLARATION

The authors confirm that the data supporting the findings of this study are available in the article itself. Additionally, the datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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FOOTWEAR EFFECT ON THE ORTHOPEDIC INJURY PROFILE IN ANKLE AND FOOT TRAUMA CAUSED BY MOTORCYCLE ACCIDENTS

EFEITO DE CALÇADOS NO PERFIL LESIONAL ORTOPÉDICO EM TORNOZELO E PÉ POR TRAUMA MOTOCICLÍSTICO

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ABSTRACT

Motorcycle accidents represent a significant cause of trauma in developing countries such as Brazil. Within the possible lesions, lower limb injuries are among the most prevalent, with ankle and foot injuries causing a high incidence of morbidity and long-term sequelae. This may partly be due to the low use of protective footwear. Therefore, this study investigated the relationship between the prevalence and severity of lower limb injuries at the ankle and foot level in motorcycle accident victims and the use or non-use of appropriate footwear. To this end, data collection was conducted in the emergency department and inpatient unit of a trauma reference hospital in the interior of the state of Ceará, using a form, clinical images, clinical examinations of injuries, and information from personal medical records over a two-month period. The results showed a significant association between inadequate use of protective footwear and an increase in the frequency and severity of soft tissue injuries. Additionally, the use of closed protective footwear covering the ankle demonstrated a noteworthy protective value. However, no significant relationship was found between footwear use and the presence or severity of fractures, hospitalization, or the need for surgical procedures. ***Level of Evidence II; Retrospective Study.***

Keywords: Lower limbs; Shoes; Wounds and injuries; Traffic accidents; Motorcycles.

RESUMO

Acidentes motociclísticos correspondem a importante causa de trauma em países em desenvolvimento como o Brasil. Dentre traumas possíveis, lesões em membros inferiores estão entre as mais prevalentes, nas quais lesões em tornozelos e pés provocam alta incidência de morbidade e sequelas no decorrer da vida. Parte disso pode estar relacionado com a baixa taxa de uso de calçados protetivos. Assim, este estudo verificou a relação entre a prevalência e gravidade de lesões em membros inferiores ao nível de tornozelos e pés, em pacientes vítimas de acidente de motocicleta e o uso ou não de calçados adequados. Para isto, foi feito levantamento na urgência e enfermaria de um hospital referência em atendimento ao trauma no interior do estado do Ceará, por meio de formulário, imagens e exame clínico de lesões, e de informações de prontuário pessoal durante o período de dois meses. Os resultados mostraram relação importante entre o uso de calçados sem proteção adequada com aumento e gravidade de lesões de partes moles, e valor protetivo relevante com uso de sapatos com proteção fechada e cobertura de tornozelo, mas sem relação significativa com presença e gravidade de fraturas, internamento ou necessidade de procedimentos cirúrgicos. ***Nível de Evidência II; Estudo Retrospectivo.***

Descritores: *Membros inferiores; Calçados; Ferimentos e lesões; Acidentes de trânsito; Motocicletas.*

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INTRODUCTION

Motorcycle accidents are one of the leading causes of trauma that arrive at emergency rooms worldwide. In Iran, motorcycles were involved in 43.4% of accidents.[1] In Africa, motorcycle accidents account for 57% of all traffic accidents.[2]

In Brazil, there is a trend of a linear increase in motorcyclist mortality across all regions, with the greatest annual variation in the Northeast region.[3] Data from the SIH (Hospital Information System) in 2013 showed that among all hospitalizations resulting from traffic accidents, 51.9% were caused by motorcycle accidents.[4]

Data shows that motorcyclists have a higher chance of losing their lives in accidents, and are eight to fourteen times more likely to suffer any type of injury compared to victims of accidents involving cars and other means of transportation.[5,6]

Injuries to the lower limbs are the most common among motorcycle accidents, affecting between 30-70% of victims.[7-9]

Although the most common injuries are to the lower limbs[2], individuals, in general, give little importance to the use of other types of protection besides helmets, as verified in a multicenter African study by Ngunde in 2019,[10] which found a 47.93% prevalence of

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The study was conducted at Hospital São Raimundo, Crato, CE, Brazil.
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lower limb injury (10.66% bilateral), 12.69% in the ankle and feet, 60.29% of the total classified as exposed injuries, and among the victims, little or no protection on extremities was verified.
Previous research has already verified that the use of personal protective equipment, in addition to wearing a helmet, such as appropriate footwear, provides protection against injuries.[11]
Taking this into consideration, the objective was to seek a relationship between the presence and severity of injuries in the lower limbs at the ankle and foot level in individuals who are victims of motorcycle accidents, with the use or non-use of various types of footwear.

METHODOLOGY

Clinical and radiographic data were collected, both in the emergency room and wards, from 72 patients who were victims of motorcycle accidents with injuries to their ankles and/or feet over a period of 2 months, from October to November 2024, treated at a large hospital unit in the state of Ceará (Brazil), a reference in orthopedic trauma. The study was approved by the ethics committee of the Federal University of Cariri (UFCA) on October 1, 2024, under the CAAE (Certificate of Ethical Appreciation Presentation) No. 79386424.4.0000.5698. All participants signed a Free and Informed Consent Term, duly reviewed according to CAAE. Patients who refused to provide information about their footwear at the time of the accident or who refused to sign the consent terms for participation and for information in the medical record were excluded.
The data were organized in a Microsoft Office Excel® spreadsheet, developed by Microsoft Corporation (WA-USA), and analyzed using SPSS software version 24. For qualitative variables, absolute and relative frequencies were calculated. Quantitative variables were summarized using statistics: mean, standard deviation, and quartiles. Qualitative variables regarding the type of footwear were tested using Fisher's exact test, while quantitative variables were tested using Mann-Whitney and Kruskal-Wallis tests. For all inferential procedures, a significance level of 5% was adopted.
It was verified for each patient which footwear was used during the accident through an objective form with images/models of the types of footwear, determining 4 groups: type A – absence of any type of footwear; type B – presence of footwear such as flip-flops or sandals, without protection for the dorsum of the foot and ankle, and without any means of securing to the foot; type C – closed footwear with means of securing to the foot and with protection up to the ankle level; and type D – closed footwear like group C, providing protection above the ankle (Figure 1). Injuries were classified during the first care, and if already hospitalized, in the ward bed, as follows: 1 – Soft tissue injuries according to the Tscherne[12] classification and by AOSTC (AO Soft-Tissue Classification) – IC (Closed Injury) and OI (Open Injury); 2 – Closed fractures by the AO/OTA Fracture and Dislocation Classification (2018);[13] 3 – Open fractures by the Gustillo and Anderson Classification.[14] Radiographic data were collected from the hospital database. Other necessary information was collected from the physical or electronic medical record.

RESULTS

Data were collected from 72 patients with orthopedic injuries related to motorcycle accidents who met the study criteria.
There was a dominance of male patients (77.8%). The average age in the sample was 34.2 years (+/- 14.5). The summaries of the Epidemiological data are available in Table 1.
Regarding footwear, type B was most prevalent (62.5%), followed by type C (22.2%), D (12.5%), and, lastly, 2 participants were without footwear – Type A (2.8%) (Table 2).
There were 49 (68%) participants with closed soft tissue injuries with or without fractures, of which the majority were in group A/B

Figure 1. FORM. A. Barefoot. B. Footwear without covering: Flip-flops, sandals, espadrilles, flat sandals, open-toe high heels, ballet flats without covering. C. Footwear with low cut/covering (up to ankle height): Sneakers, dress footwears, casual footwears, sports footwears, low-cut boots. D. Footwear with high cut/covering (above the ankle): Work boots, motorcycle boots, high-top sneakers.

Table 1. Distribution of frequencies of sex and age group among participants.

Variables	n	%
Gender		
Male	56	77.8
Female	16	22.2
Age range		
15 to 19	11	15.3
20 to 29	22	30.6
30 to 39	16	22.2
40 to 49	10	13.9
50 to 59	9	12.5
60 or more	4	5.6
Mean ± standard deviation	34.2 14.5	
Median (1st - 3rd quartile)	31.0 (22.5 - 45.0)	
Minimum - maximum	15 – 71	

(41.7%), 11 (15.3%) were in group C, and 8 (11.1%) were from group D. There was no significant relationship between the presence of soft tissue injuries and the type of footwear used ($p = 0.335$). Among the type A footwear, all injuries were exposed (Table 3).
Sprains were recorded in 25 participants (34.7%) (Table 3), with patients wearing type A/B footwear showing the highest proportion (40.4%) and the lowest in type D (22.2%), but without a statistically significant difference ($p = 0.458$) (Table 4).
When classified according to Tscherne, type A/B footwears showed a significant relationship with grade 1 injuries (63.3%) and grade 2 injuries (26.7%) ($p < 0.001$) (Table 4), whereas type C and D footwears showed no grade 2 or higher injuries. And when classified according to AO/STC - IC, with the majority of injuries being grade

<< SUMÁRIO

Table 2. Percentage evaluation of footwear type, injury type, injury classifications, hospitalizations, and surgical procedures.

Variables	n	%
Footwear type		
A	2	2.8
B	45	62.5
C	16	22.2
D	9	12.5
Fracture and/or dislocation with/ without open fracture		
Yes	28	38.9
No	44	61.1
Exposed injury with/without fracture		
Yes	23	31.9
No	49	68.1
Closed soft tissue injury with/without fracture		
Yes	49	68.0
No	23	32.0
Fractures and/or dislocations according to location in the participant (n=28)		
Distal tibia	6	21.4
Ankle	5	17.9
Hindfoot	0	0
Midfoot	0	0
Forefoot	17	60.7
Classification of closed soft tissue injuries according to Tscherne (n=49)		
0	10	20.4
1	31	63.3
2	8	16.3
3	0	0
Classification of Fractures according to AO-OTA (n=35)		
Type A	19	54.3
Type B	8	22.9
Type C or greater	8	22.9
Classification of exposed fractures according to Gustillo and Anderson (n=15)		
1	3	20.0
2	7	46.7
3rd	5	33.3
3B	0	0
3C	0	0
Classification of closed soft tissue injuries according to AOSTC - IC (n=49)		
1	11	22.4
2	27	55.1
3	10	20.4
4	1	2.0
5	0	0
Classification of exposed injuries according to AOSTC - IO (n=23)		
1	2	8.7
2	10	43.5
3	5	21.7
4	5	21.7
5	1	4.3
Sprain		
Yes	25	34.7
No	47	65.3
Grade of sprain (n=25)		
Grade 1	9	36.0
Grade 2	16	64.0
Grade 3	0	0
Internment		
Yes	28	38.9
No	44	61.1
Surgical Procedure		
Yes	32	44.4
No	40	55.6

Table 3. Percentage evaluation of the distribution of fractures/dislocations/ soft tissue injuries and surgical procedures by type of footwear.

Groups	N	%
Number of fractures/dislocations by type of footwear		
A/B	16	45.7
C	15	42.8
D	4	5.5
Total	35	
Number of exposed fractures/ dislocations by type of footwear		
A/B	9	50
C	8	44.4
D	1	5.6
Total	18	
Number of surgical procedures according to the type of footwear		
A/B	26	61.9
C	13	30.9
D	3	7.1
Total	42	
Number of closed soft tissue injuries by type of footwear		
A/B	30	41.7
C	11	15.3
D	8	11.1
Total	49	

2 (55.1%), there was a significant relationship (p = 0.004) for a higher number and higher grade of injuries in patients with A/B footwears, while patients with type C and D footwears showed a higher correlation with lower grade injuries (STC - IC 1).

Regarding the presence of fractures and/or dislocations with or without open fracture, a total of 35 fractures and/or dislocations were verified, distributed among 28 (38.9%) of the participants (Table 3). These injuries did not show a significant relationship according to the type of footwear (p = 0.484), as shown in Table 4. Fractures of the forefoot predominated (23.6%), with no fractures of the midfoot and hindfoot observed (Table 2).

The fractures were mostly classified according to AO-OTA as type A (54.3%) (Table 2), and the most affected area among participants was the forefoot (60.7%).

23 patients with exposed injuries (with or without fractures) were classified (31.9%), with a relative predominance of incidence present in the A/B footwear groups, 36.2% (p = 0.388) (Table 4). When classified by AO/STC – IO, there was a predominance of grade 2 injuries (43.5%), with most related to patients with type A/B footwears (47.1%) (p = 0.308). Regarding exposed fractures, 18 were verified among 15 participants, with 9 (50%) verified among patients with type A/B footwears, 8 (44.4%) with type C footwears, and 1 (5.6%) in patients with type D footwears (Table 3). Classified according to Gustillo and Anderson, there was a general predominance of grade 2 injuries (46.7%), and a greater association with type A/B footwears, but not statistically significant (p = 0.895) (See Table 4).

From the sample, 28 patients required hospitalization (38.9%), with no significant relationship verified with the type of footwear (p = 0.393) (Table 4), the highest number of hospitalizations was related to patients with type A/B footwears (38.3%), with the relative value lower for type D patients (22.2%). The length of hospitalization also showed no significant difference between the evaluated groups (p = 0.577) (Table 5).

Additionally, 44.4% (32 patients) of participants required some surgical procedure, totaling 42 procedures, distributed by footwear

Table 4. Statistical evaluation regarding the type and classification of injuries, occurrence of hospitalization and surgical procedure according to the type of footwear of the participants.

Variables	Footwear A/B		Footwear C		Footwear D		p-value
	n	%	n	%	n	%	
Fracture and/or dislocation with or without open fracture							**0.484**
Yes	16	34.0	8	50.0	4	44.4	
No	31	66.0	8	50.0	5	55.6	
Exposed injury with/ without fracture							**0.388**
Yes	17	36.2	5	31.3	1	11.1	
No	30	63.8	11	68.8	8	88.9	
Closed soft tissue injury with/without fracture							**0.335**
Yes	30	63.8	11	68.7	8	88.9	
No	17	36.2	5	31.3	1	11.1	
AOSTC Classification - IC (n=49)							**0.004**
1	2	6.7	6	54.5	3	37.5	
2	17	56.7	5	45.5	5	62.5	
3	10	33.3	0	0.0	0	0.0	
4	1	3.3	0	0.0	0	0.0	
AOSTC Classification - IO (n=23)							**0.308**
1	1	5.9	1	20.0	0	0.0	
2	8	47.1	2	40.0	0	0.0	
3	2	11.8	2	40.0	1	100.0	
4	5	29.4	0	0.0	0	0.0	
5	1	5.9	0	0.0	0	0.0	
Tscherne Classification (n=49)							**<0.001**
0	1	3.3	6	54.5	3	37.5	
1	21	70.0	5	45.5	5	62.5	
2	8	26.7	0	0.0	0	0.0	
Gustillo and Anderson Classification (n=15)							**0.895**
1	2	22.2	1	20.0	0	0.0	
2	4	44.4	3	60.0	0	0.0	
3A	3	33.3	1	20.0	1	100.0	
Sprain							**0.458**
Yes	19	40.4	4	25.0	2	22.2	
No	28	59.6	12	75.0	7	77.8	
Grade of sprain (n=25)							**0.803**
Grade 1	6	31.6	2	50.0	1	50.0	
Grade 2	13	68.4	2	50.0	1	50.0	
Hospitalization							**0.393**
Yes	18	38.3	8	50.0	2	22.2	
No	29	61.7	8	50.0	7	77.8	
Surgical procedure							**0.432**
Yes	22	46.8	8	50.0	2	22.2	
No	25	53.2	8	50.0	7	77.8	

Fisher's exact test.

Table 5. Length of hospitalization and number of surgical procedures by participants' footwear type.

Variables	Footwear A/B	Footwear C	Footwear D	P value
Length of hospitalization				**0.577**
Mean ± standard deviation	2.9 ± 5.2	3.6 ± 5.0	3.2 ± 6.4	
Median (1st - 3rd quartile)	0.0 (0.0 - 3.0)	0.5 (0.0 - 5.5)	0.0 (0.0 - 0.0)	
Number of surgical procedures				**0.355**
Mean ± standard deviation	0.6 ± 0.7	0.8 ± 1.0	0.3 ± 0.7	
Median (1st - 3rd quartile)	0.0 (0.0 - 1.0)	0.5 (0 - 1.5)	0.0 (0.0 - 0.0)	

Kruskal-Wallis test.

type (Table 3). There was a higher number of procedures in participants with type A/B footwears (61.9%).

Regarding the need for surgical procedures, a lower trend was observed among participants with type D footwears (77.8% did not require surgical intervention) ($p = 0.432$) (Table 4). No significant relationship was observed between the number of surgeries and the type of footwear used ($p = 0.355$) (Table 5).

DISCUSSION

After consolidating and analyzing the data, a dominance of male patients (77.8%) was observed, consistent with epidemiological data in the DPVAT report (2018)[15]. The predominant age group was between 20-29 years (30.6%), with an average age in the sample of 34.2 years (+/- 14.5), showing a peak incidence of trauma in young patients, consistent with Brazilian references.[15]

Regarding the use of footwears, there was a predominance of type B (62.5%), with only 2 participants not wearing any footwear (2.78%). It is noteworthy that there was no significant relationship in the analysis of patients with type A footwear due to the limitations of the sample. Despite Article 232 of the Brazilian Traffic Code,[16] which prohibits and fines motorcycle riders who wear footwears that does not secure their feet, category B, which precisely includes these types of footwears, was the most prevalent, highlighting the lack of or low enforcement by competent authorities, as well as the lack of engagement of the population with the rule. However, the same legislation does not determine which protection option is more effective, leaving it to the rider to choose. For cultural and economic reasons, especially in the northeastern region, there is a strong inclination towards the everyday use of espadrilles or sandal-type footwear, which explains the preference for this specific type. Taking this into account, the analyses were conducted by combining the samples from groups A and B, generating group A/B, since the types of protection offered by these two groups are similar.

Approximately 2/3 of the participants presented soft tissue injuries without exposure (68%), with or without fractures, and the highest number of injuries was in group A/B (41.7%), and the lowest was in group D (11.1%). The injuries were predominantly low-grade – 77.5% were AOSTC-IC < 3. A higher frequency and severity of closed soft-tissue injuries were observed among participants using type A/B footwear, with >30% of injuries graded ≥3 ($p = 0.004$). Participants wearing footwears with greater protection, in turn, correlated with a lower number of injuries, and these with a lower grade, with neither of these two groups presenting any injuries classified by AOSTC-IC 3 or higher.

These results were corroborated by categorizing the injuries according to the Tscherne classification, in which a significant difference was observed ($p < 0.001$) in the same direction. Participants with type A/B footwears presented a higher number of soft tissue injuries in closed trauma (61.2%), and with greater severity – 26.7% of the injuries in the group were grade 2. When compared with groups C and D, these presented all their injuries classified as ≤ 1.

Among patients with sprain-type injuries, the majority were grade 2 (64.0%). Although there was a relatively higher frequency of these injuries (76% of the total) and greater severity (68.4% grade 2) with group A/B, it was not possible to verify statistical significance between the occurrence of sprains ($p = 0.458$) or the grade of the injury ($p = 0.803$) according to the type of footwear.

Similarly, exposed injuries with or without fractures showed a relatively higher prevalence in participants from group A/B (36.2%), and the lowest prevalence was in group D (11.1%). However, such values did not show a significant difference ($p = 0.388$). It was also not possible to verify a significant difference in these injuries with the type of footwear, when classified by AOSTC – IO ($p = 0.308$).

The trends observed in both sprains and exposed injuries, although not statistically significant, suggest a possible protective factor that varies by footwear. This explanation is likely due to the low number of individuals participating in the study. This also seems to apply to the other data to be discussed below.

The prevalence of closed and exposed fractures and/or dislocations was higher in patients from groups A/B (42.8% and 50%, respectively) and lower in participants from group D (5.5% and 5.6%, respectively). There was no significant difference in the severity of exposed fractures by type of footwear. Again, with a low statistical correlation of these data, hindered by the sample size.

The data also showed no significant differences in the number and duration of hospitalizations across the groups, as well as in the need for and number of surgical procedures.

The predominance of forefoot fractures over others is likely caused by being the most exposed area of the foot, being more distal and closer to the ground during motorcycle use, and also, because the predominant type of footwear is type B, which does not provide a significant means of staying secured to the foot during an accident/trauma, resembling, in trauma, an individual barefoot, similar to group A.

What can be postulated, considering the predominance of patients using type B footwears with a progressive numerical reduction of types C and D, is that there is a possibility that these individuals (groups C and D) were not even classified with an injury in the lower limb, due to the use of footwear with greater protective power, or that they did not even seek care in the emergency room in cases of lower energy trauma, thus leading to a sampling bias. Another consideration is that groups C and D only seek care in cases of higher energy trauma, making it difficult to identify the protective factor of the footwear. Furthermore, it may be due to low usage for cultural reasons. Such a problem can be rectified and consequently corrected by changing the way participants are selected, including all motorcycle accident victims, and not just those presenting with any injury in the lower limb, and/or differentiating levels of trauma energy.

Another possible bias is that, in high-energy traumas, the use of traditional footwears, regardless of the level of protection, does not provide sufficient protection to alter the degree of injury.

Still, the analysis of the data suggests a progressive relationship between the number of injury severity according to the level of protection at the time of trauma. Individuals who wore footwears without adequate coverage of soft parts and without closed protection at the level of the dorsum of the foot and ankle were relatively more affected. Although no correlating increase was verified in the frequency and duration of hospitalization, as well as in the number of surgical procedures required.

CONCLUSION

The results of the present study showed that the majority of the population uses footwear considered inadequate for riding motorcycles according to current traffic legislation, and that there is a relationship between this type of footwear and a higher prevalence of soft tissue injuries, while patients using footwear with protection above the ankle were the most protected. There was still a trend toward greater protection against sprains, fractures, and open injuries with increasing footwear protection, but it was not statistically significant. Despite the above, there was no statistical significance regarding the need for and duration of hospitalization and surgeries.

CONTRIBUTIONS OF THE AUTHORS

Each author contributed individually and significantly to the development of this article. HLNL: writing, data collection, data organization, and data analysis. MJNLS: writing, data collection, data organization, and data analysis. SMDMPCM: writing, data collection, data organization, and data analysis. MPO: writing, conceptualization, and article review.

DATA AVAILABILITY DECLARATION

The contents underlying the research are available in the manuscript.

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SCAPULAR FRACTURES: COMPARISON OF GLENOPOLAR ANGLE MEASUREMENT USING 3D COMPUTED TOMOGRAPHY AND CONVENTIONAL RADIOGRAPHY

FRATURAS DA ESCÁPULA: COMPARAÇÃO DA MENSURAÇÃO DO ÂNGULO GLENOPOLAR POR TOMOGRAFIA COMPUTADORIZADA 3D E RADIOGRAFIA CONVENCIONAL

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ABSTRACT

Objective: To compare the interobserver and intraobserver reliability of glenopolar angle (GPA) measurement in scapular fractures using conventional radiography (2D) and three-dimensional computed tomography (3D-CT). Methods: This retrospective observational study included 33 patients with fractures of the scapular body or neck treated between 2016 and 2023. Anteroposterior radiographs and 3D-CT scans obtained at the time of diagnosis were included. The GPA was measured by eight independent evaluators, and data were analyzed using the intraclass correlation coefficient (ICC), according to the criteria proposed by Koo and Li, with SPSS software. Results: The mean interobserver ICC for GPA measurement was 0.959 (95% CI: 0.934–0.977) for radiography and 0.971 (95% CI: 0.953–0.984) for 3D-CT, indicating excellent reliability for both methods. Individual intraobserver reliability ranged from 0.598 to 0.869, with five evaluators demonstrating good reliability and three showing moderate reliability. The sample consisted predominantly of males (93.9%), with a mean age of 39.6 years (range: 19–78 years), and 24.2% of patients underwent surgical treatment. Conclusions: GPA measurements obtained by radiography and 3D-CT demonstrated high interobserver reliability, with slight superiority of 3D-CT. Both methods are valid, although 3D-CT may be preferable in cases requiring greater angular precision. ***Level of Evidence: III; Retrospective observational study.***

Keywords: Bone Fracture; Scapula; Shoulder Fractures; Observational Study; Reproducibility of Results.

RESUMO

Objetivo: Comparar a confiabilidade inter e intraobservador da aferição do ângulo glenopolar (AGP) em fraturas da escápula utilizando radiografias convencionais (2D) e tomografias computadorizadas com reconstrução tridimensional (TC-3D). Métodos: Estudo observacional retrospectivo conduzido com 33 pacientes com fraturas do corpo ou colo da escápula atendidos entre 2016 e 2023. Foram incluídas radiografias anteroposteriores e TC-3D obtidas no momento do diagnóstico. O AGP foi aferido por oito avaliadores independentes e os dados foram analisados por meio do coeficiente de correlação intraclasse (CCI), conforme os critérios de Koo e Li, utilizando o software SPSS. Resultados: A média do CCI interobservador para a aferição do AGP foi de 0,959 (IC95%: 0,934–0,977) para a radiografia e de 0,971 (IC95%: 0,953–0,984) para a TC-3D, indicando excelente confiabilidade para ambos os métodos. A confiabilidade intraobservador individual variou de 0,598 a 0,869, com cinco avaliadores apresentando boa confiabilidade e três com confiabilidade moderada. A amostra foi composta majoritariamente por homens (93,9%), com média de idade de 39,6 anos (19–78 anos), sendo 24,2% tratados cirurgicamente. Conclusões: As aferições do AGP por radiografia e TC-3D demonstraram alta confiabilidade interobservador, com leve superioridade da TC-3D. Ambos os métodos são válidos, sendo a TC-3D preferível em casos com necessidade de maior precisão angular. ***Nível de evidência: III; Estudo comparativo retrospectivo.***

Descritores: *Fratura; Escápula; Fraturas do Ombro; Estudo Observacional; Reprodutibilidade dos Testes.*

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INTRODUCTION

The scapula is a flat bone that connects the upper limb to the axial skeleton, providing stable support for muscular action and serving as a dynamic base in maintaining glenohumeral kinematics.[1] Fractures of this bone are rare, accounting for about 1% of all fractures, with approximately 22% of these fractures resulting from high-energy trauma and 21% presenting at least one associated fracture, reinforcing their association with severe clinical conditions.[2] The treatment of these fractures aims to preserve shoulder function and prevent complications such as misalignments that lead to degenerative changes, subacromial impingement, and scapular dyskinesia. Among the criteria used to evaluate fractures of the body and neck of the scapula, the measurement of the glenopolar angle (GPA) stands out, often considered in the decision between conservative and surgical treatment.[3,4]

The concept of the GPA is defined by the angle between two lines: one drawn from the inferior pole to the superior pole of the glenoid, and another from the superior pole of the glenoid to the inferior angle of the scapula (Figure 1), with normal values ranging between 30° and 45°.[5,6]

Romero et al.[7] applied the GPA in the evaluation of fractures of the neck of the scapula, demonstrating that significant deviations in this angle were associated with worse clinical outcomes. Since then, the GPA has become an important parameter in the decision-making process regarding surgical treatment of scapular fractures, especially those involving the neck and body of the scapula.

Traditionally, this measurement is performed using radiographs. However, in environments such as emergency rooms for polytraumatized patients, radiographs are often obtained in inadequate positions or with non-standard projections, which can compromise the accuracy of the measurement and directly impact therapeutic conduct.

In light of this condition, recent studies suggest that computed tomography with three-dimensional reconstruction (CT-3D) yields less inter- and intra-observer variability in measuring the GPA than conventional radiography.[8-10] Therefore, this study aims to compare the inter- and intra-observer reliability of GPA measurement in fractures of the neck and body of the scapula, using radiographs and CT-3D. Our hypothesis is that the measurements performed by CT-3D exhibit greater reproducibility and accuracy than those obtained with conventional radiography.

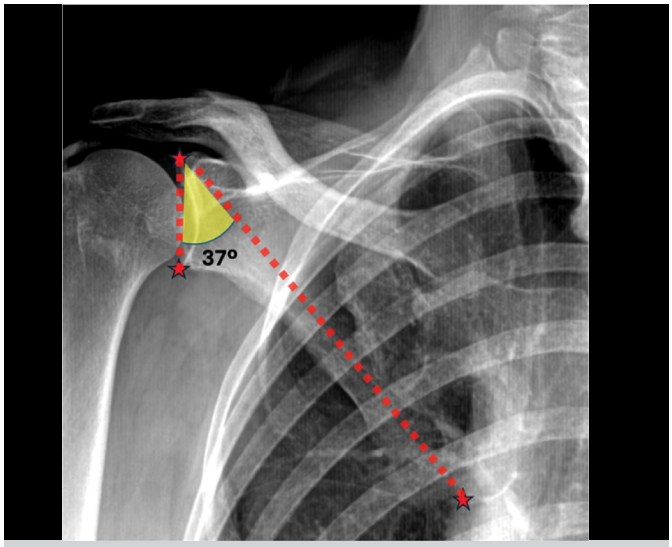

Figure 1. Measurement of the glenopolar angle in a true AP shoulder radiograph.

MATERIALS AND METHODS

An observational retrospective study was conducted, in which medical records and imaging exams of patients with fractures of the body or neck of the scapula (ICD-10: S42.1), treated at a single institution between the years 2016 and 2023, were analyzed. The project was approved by the institution's Research Ethics Committee under number CAAE 73769523.8.0000.5342.

Patients with fractures of the body or neck of the scapula were included, regardless of the treatment performed (surgical or conservative), provided they had an anteroposterior radiograph of the scapula and a CT-3D obtained at the time of diagnosis. Patients who did not undergo both imaging exams, those with isolated fractures of other portions of the scapula (such as the acromion, spine, or coracoid process), cases diagnosed late (more than three weeks after the trauma), images of low quality that hindered adequate angular measurement, and individuals who did not consent to participate in the study were excluded.

After screening, the images were randomized and analyzed by eight independent evaluators (orthopedic surgeons). The evaluators were previously instructed on the measurement method and the parameters used. For standardization, the anteroposterior incidence of the shoulder was used as a radiological reference, and in CT-3D, the reconstruction of the posterior face of the scapula in the plane of the greatest mediolateral diameter was used. (Figure 2)

The GPA measurements were recorded in a spreadsheet (Microsoft Excel, Redmond, WA, USA) and subsequently submitted to statistical analysis using SPSS (Statistical Package for the Social Sciences) software. The intraclass correlation coefficient (ICC) was used to assess measurement reliability across different observers and imaging methods, following the guidelines proposed by Koo and Li.[11] (Table 1)

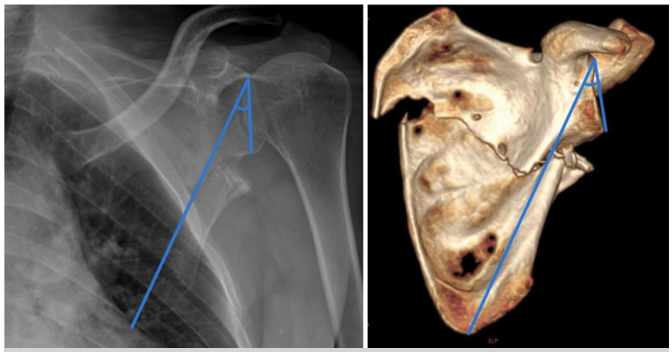

Figure 2. Measurement of the glenopolar angle in an AP radiograph taken in the emergency room and in a CT-3D scan of the same patient.

Table 1. Intraclass correlation coefficient (ICC) according to Koo & Li et al.

Range of CCI	Reliability Classification
< 0.50	Low reliability
0.50 – 0.75	Moderate reliability
0.75 – 0.90	Good reliability
> 0.90	Excellent reliability

RESULTS

Radiographs and CT-3D scans of 33 scapula fractures were evaluated (Table 2). Regarding the epidemiology of the sample, 31 patients (93.9%) were male and 2 (6.1%) were female, with an average age of 39.6 years (ranging from 19 to 78 years) at the time of the trauma. In terms of laterality, 18 fractures (54.5%) affected left scapulae and 15 (45.5%) affected right scapulae. Regarding treatment, 8 patients (24.2%) underwent surgical treatment, while 25 (75.8%) received conservative treatment.

Table 2. Assessment of the GPA of 33 patients (P) by 8 evaluators (AV).

Measurement of the Glenopolar Angle																
	AV1		AV2		AV3		AV4		AV5		AV6		AV7		AV8	
	RX	TC3D	RX	TC3D	RX	TC3D	RX	TC3D	RX	TC3D	RX	TC3D	RX	TC3D	RX	TC3D
P1	24	27.1	22	25.9	20.3	29.9	24.9	26.5	29	39.7	17.1	30.5	24.9	32	25.1	29.2
P2	34.5	37.4	21.5	38.6	22.3	37	29.5	41.8	24.2	30.1	17.8	39.1	13.6	40.1	48.4	39.3
P3	22.4	25.6	23.9	25.3	23.9	30.3	21.2	32.6	22.4	31.2	36.5	35.5	26.9	34.4	31.6	31.4
P4	24.1	15.1	18.1	7.3	16.9	13.4	19.7	16.9	21.1	13.8	23.2	18	17.5	17.3	17.8	13.8
P5	38.5	38.4	39.6	34	43.5	39.4	35	37.5	39.3	37.1	44.6	40.4	36.4	39.5	37.9	40
P6	14.7	24.1	22	18	17.2	32.2	17.9	22.7	17.9	33.8	20	24	18.8	24	15.6	34.1
P7	43.8	43	44	41.4	40.5	39.2	43.4	47.5	40.8	48.4	35.3	45.3	35.5	48	41.2	46.3
P8	32.8	30.5	32.1	30.2	31.3	33.3	25.8	31.6	30.1	32.4	29.8	31.8	26.2	32.3	30.3	32
P9	41	39.9	40.3	38.5	45.3	42	42.1	42.2	41	44.2	43.6	41.1	37	46	48.5	47.7
P10	21.9	30.7	22	28.5	20.6	32.1	22.3	30	21.5	29.6	16.3	30.6	15.9	32.4	21.8	30.2
P11	43.7	47.8	41.5	48.5	47.9	33.5	48.5	41.8	45.8	47	52	45.6	49.8	36.7	62	52.5
P12	22.1	34.5	30.2	30.6	25.2	27.9	18.6	33.9	22.5	33.6	33.1	20.3	36.3	31.1	20.7	32.4
P13	23.1	26.5	13	17.3	25.5	19.2	16.9	24	18.7	16.4	21.2	16.9	20	30.4	22.7	16.1
P14	24	18.4	17.1	12.1	30.1	18.9	22.7	19.6	23.7	19.4	23.3	20.2	23.7	22.8	33.3	17.8
P15	36.8	39.8	30.9	28.8	16.5	39.9	31.3	41	30.4	45.6	36.1	45.2	37.7	40.3	38	44.6
P16	23.1	26.4	27.34	45.3	23.4	29.8	21.6	42.4	40.7	29.7	20.1	28.7	29.5	32	32	28.2
P17	32.9	33.6	34	28.5	34.3	35.8	33.8	36.4	32.8	37	37.9	37.3	37.4	37.3	31.5	41.3
P18	32.5	31.2	25.7	41.5	43.1	32.9	30.6	38.5	17.4	35.6	34.7	42.3	43.1	24.9	31.5	37
P19	38.3	47.4	45.9	40.5	42.5	51.5	43.9	50.3	39.9	46.8	45.9	47.8	44	48	49.2	49.3
P20	18.3	32.4	22.6	25.6	27.6	29.2	24	27.8	26.8	29.9	18.2	30.9	21.7	32.9	43.7	29.6
P21	23	27.8	9.5	19.3	15.3	28.7	27	29.1	16.6	29.9	23.8	29.1	15.1	29.4	17.4	28.6
P22	45	45.5	47.8	44.3	42.6	44.6	40.3	43.5	42	46	41.2	44.4	42.6	45.8	45.2	40.7
P23	26.5	40.8	24.9	28.9	26.3	32.2	25.2	41.2	23	44.2	32.6	50	26.5	42.8	29.7	35.2
P24	29.4	26.8	35.4	32.5	31.2	27.4	26.3	25.8	23.4	25.3	28.5	26.4	35.8	30.3	38.6	26.7
P25	36.1	29.1	34.2	30	32.6	33.9	31.3	33.1	39	35.8	31.1	33.8	34.4	35.1	37.2	30.6
P26	44.8	33.6	36.3	31.5	42.4	33.4	40.4	34.5	40.6	37.8	31.6	40.5	33.6	36	43.1	36.5
P27	27.4	35.3	19.4	23.8	20.8	33.5	25.8	34	24.2	34.9	19.9	38.7	25.9	33	25.5	38.2
P28	26.8	27.6	24	25.6	26.6	29.2	21.3	25.4	24.3	25.8	27.3	24.3	30.6	23.3	31.8	24.3
P29	45.7	42.5	48.5	45.2	46.1	38.1	39.2	45.9	44.6	43	44.9	48.7	37.3	43.4	46.1	42.5
P30	21.3	28.1	21.2	25	25.4	27.5	26.4	25.5	24.5	26.9	20.8	27.7	32	32.2	24.4	29.9
P31	35	37.4	36.3	32.5	31.2	37.7	33.2	35.7	32.5	38.8	34.3	38.5	33.8	39.6	34	37.7
P32	30	32.1	33.5	32.9	31.5	29.7	30.6	30	30.2	30.5	32	33.9	33.9	27.3	36.8	35.8
P33	35.2	43.6	39.4	48.4	40.4	44.4	34.2	47.9	35.7	46.1	41.7	50.8	38.3	46.4	43.6	52.8

Regarding individual variability, we obtained intraclass correlation coefficients (ICCs) ranging from 0.598 to 0.869, as shown in Table 3. Table 3. Individual intraclass correlation coefficient of the evaluators. After analyzing the intraclass correlation coefficient of all evaluators, we obtained an average value for GPA measurement by radiograph of 0.959 (0.934 – 0.977) and GPA measurement by CT-3D of 0.971 (0.953 - 0.984), where "1.0" (absolute/hypothetical) would be the perfect measurement without variability between methods or among evaluators (Table 4).

Table 3. Individual intraclass correlation coefficient of the evaluators.

Evaluator	Mean Value Intraclass Correlation	95% Confidence Interval	
		Lower Limit	Upper Limit
AV1	0.826	0.635	0.915
AV2	0.869	0.736	0.935
AV3	0.68	0.365	0.841
AV4	0.772	0.305	0.907
AV5	0.733	0.337	0.881
AV6	0.766	0.465	0.891
AV7	0.598	0.201	0.799
AV8	0.805	0.604	0.904

Tabela 4 Coeficiente de correlação intraclasse comparativo entre RX e TC-3D.

Método de imagem	Valor médio correlação intraclasse	Intervalo de confiança 95%	
		Limite inferior	Limite superior
Radiografia	0,959	0,934	0,977
TC-3D	0,971	0,953	0,984

We observed that both measurement methods have excellent reliability. According to Koo & Li[11], five of our evaluators achieved good individual reliability in their measurements. The other three evaluators achieved only moderate individual reliability in their measurements. When analyzing the class correlation coefficient by summing the individual measurements, both imaging methods showed good reliability, indicating low interobserver variability.

DISCUSSION

The therapeutic plan for scapular body fractures can be guided by the criteria described by Cole et al., who recommend surgical treatment in the presence of lateral translation >2 cm, angulation >45° in the lateral view, fractures associated with the clavicle or the

acromioclavicular joint, and GPA <22°.[9,12,13] Therefore, the precise measurement of GPA plays a critical role in defining the conduct. In our study, excellent interobserver reliability was observed for GPA measurements using both evaluated methods, with a slight superiority of CT-3D over conventional radiography (CCI: 0.971 vs. 0.959). These findings corroborate the results presented by Anavian et al.[14], who found CT-3D more reproducible for angular measurements of the scapula, and by Suter et al.[10], who demonstrated less interference from rotation in the evaluation of GPA with three-dimensional reconstructions.

It is important to consider that, in emergency situations involving polytraumatized patients, obtaining radiographs may be performed under suboptimal conditions, with variations in positioning that compromise the accuracy of GPA measurement. Tadros et al.[15] and Wijdicks et al.[16] demonstrated that rotational deviations can significantly alter the value of GPA, directly impacting the therapeutic indication. Hong et al.[17] reinforced this finding by reporting an average difference of 6.1° between values obtained on radiographs and those on CT-3D. Labronici et al. [18] demonstrated that scapular rotation of up to 30° – whether internal or external – can substantially reduce the value of GPA, reinforcing the recommendation to measure the scapula in a neutral position. In the present study, the variation of CCI among evaluators (0.598 to 0.869) suggests the influence of technical familiarity and individual experience, highlighting the importance of standardization in measurement.

Regarding functional outcomes, Bi et al.[19], in a review of 669 patients with extra-articular scapular fractures, reported good functional results with both surgical and conservative approaches. Similarly, Morey et al.[20], in a review of floating shoulder treatment, did not identify significant functional differences between therapeutic modalities but observed that restoration of GPA was associated with better clinical scores.

This study presents as its main strengths the methodological standardization in image analysis, the use of multiple independent evaluators, and the direct comparison between two widely used methods in clinical practice for GPA measurement. Additionally, the inclusion of a representative sample of patients treated in a trauma setting enhances the applicability of the results. On the other hand, this is a retrospective study, with inherent limitations of this design, such as dependence on the quality of archived images and possible selection bias. The absence of correlation with clinical or functional outcomes also represents a limitation, preventing the extrapolation of findings for direct prognostic impact. Prospective studies, with functional follow-up and control of clinical variables, are necessary to validate and expand the conclusions presented here.

Finally, although the CT-3D has shown slightly superior reliability, it is necessary to consider its availability, cost, and radiation exposure. When obtained under appropriate conditions, X-rays remain a valid tool for measuring the GPA. Based on our findings, we recommend the complementary use of CT-3D in cases of diagnostic uncertainty or when the therapeutic decision depends on more precise angular measurements.

CONCLUSION

The measurements of the GPA by X-ray and CT-3D demonstrated high interobserver reliability in evaluating fractures of the body and neck of the scapula. Both methods showed low variability among evaluators, with a slight superiority of the CT-3D, which presented a slightly higher intraclass correlation coefficient.

These findings reinforce the use of CT-3D as a tool for greater precision, especially in cases with borderline surgical indications. Standardization of measurement techniques and training of professionals are essential to ensure consistency in evaluations. New studies that associate radiological parameters with clinical and functional outcomes may contribute to more informed and individualized therapeutic decisions.

CONTRIBUTIONS OF THE AUTHORS

Each author contributed individually and significantly to the development of this article. BJA: conceptualization, writing, and data collection; MP: data collection and analysis; AF: data analysis and collection; BJE: data analysis; PP: data collection, article revision, and intellectual concept of the article; LO: article revision and intellectual concept of the article.

DATA AVAILABILITY DECLARATION

Research data will be available upon request from reviewers.

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COMPARISON OF THE USE OF THE SURAL FLAP FOR THE MEDIAL, LATERAL, AND CENTRAL REGIONS OF THE ANKLE

COMPARAÇÃO DO USO DO RETALHO SURAL PARA REGIÃO MEDIAL, LATERAL E CENTRAL DO TORNOZELO

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ABSTRACT

Objective: To evaluate the occurrence of partial or total loss of the reverse-flow sural flap used for coverage failures in the lateral, medial, and central regions of the ankle, as well as factors related to flap loss. Methods: A retrospective cohort study was conducted including data from 32 patients who underwent surgery with reverse sural flaps between February 2012 and September 2023 at the Institute of Orthopedics and Traumatology, HC/FMUSP. Results: In the group of patients requiring coverage in the medial region, 40% had partial flap loss and 30% suffered total loss. In the lateral region, 20% experienced partial loss and 13.3% total loss. In the central area, 57.14% had partial coverage loss, with no cases of total loss. Conclusion: The reverse sural flap proved to be favorable for coverage of defects in the lateral region of the ankle, but showed higher rates of partial or total loss when used for coverage of defects in the medial region of the ankle. A negative effect was observed in the presence of patient comorbidities, in trauma-related cases, and in the early approach to flap construction. ***Level of Evidence II; Retrospective cohort study.***

Keywords: Microsurgery; Surgical Flaps; Risk Factors.

RESUMO

Objetivo: Avaliar a ocorrência de perda parcial ou total do retalho sural de fluxo reverso utilizado nas falhas de cobertura na região lateral, medial e central do tornozelo, assim como fatores relacionados à perda do retalho. Métodos: Foi realizado um estudo de coorte retrospectiva incluindo os dados de 32 pacientes submetidos à cirurgia com retalhos surais reversos entre fevereiro de 2012 a setembro de 2023 no Instituto de Ortopedia e Traumatologia do HC/FMUSP. Resultados: No grupo de pacientes com necessidade de cobertura na região medial, 40% tiveram perda parcial do retalho e 30% sofreram perda total. Na região lateral, foram 20% de perdas parciais e 13,3% de perdas totais. E na área medial, 57,14% tiveram perda parcial da cobertura, sem nenhum caso de perda total. Conclusão: O retalho sural reverso se mostrou favorável para a cobertura de falhas na região lateral no tornozelo e mostrou maiores taxas de perdas parciais ou totais quando foi utilizado para a cobertura das falhas na região medial do tornozelo. Houve um efeito negativo na presença de comorbidades do paciente, nos casos causados por trauma e na abordagem precoce da confecção do retalho. ***Nível de Evidência II; Estudo de coorte retrospectiva.***

Descritores: *Microcirurgia; Retalhos Cirúrgicos; Fatores de Risco.*

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INTRODUCTION

The choice of the best option for skin coverage in the distal leg and hindfoot is a difficult decision for surgeons. The scarcity of local flap tissues and the deficit of adequate vascularization, as seen in cases of severe trauma or arterial diseases (common causes of soft tissue injuries), are some of the factors that create difficulties in treating tissue loss in this region.[1]

Microsurgical flaps are alternatives for these cases, but they require adequate infrastructure and a skilled team for their execution, which is not available in the vast majority of hospital centers.

Donski and Fogdestam[2] described the distal-based sural fasciocutaneous flap in 1983, and Masquelet et al.[3] popularized the reverse sural fasciocutaneous flap in 1992, thus developing an excellent option for local flaps to cover areas in the ankle region.

The reverse sural flap is vascularized by the communicating and perforating branches of the fibular artery, which originate 5 to 6 cm cranially to the lateral malleolus (Figure 1), and due to its lack of technical complexity in execution, it shows good functional and aesthetic results.[4]

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

The study was conducted at Institute of Orthopedics and Traumatology of the Hospital das Clinicas (HC-FMUSP) of the School of Medicine of the Universidade de Sao Paulo, Sao Paulo, SP, Brazil.

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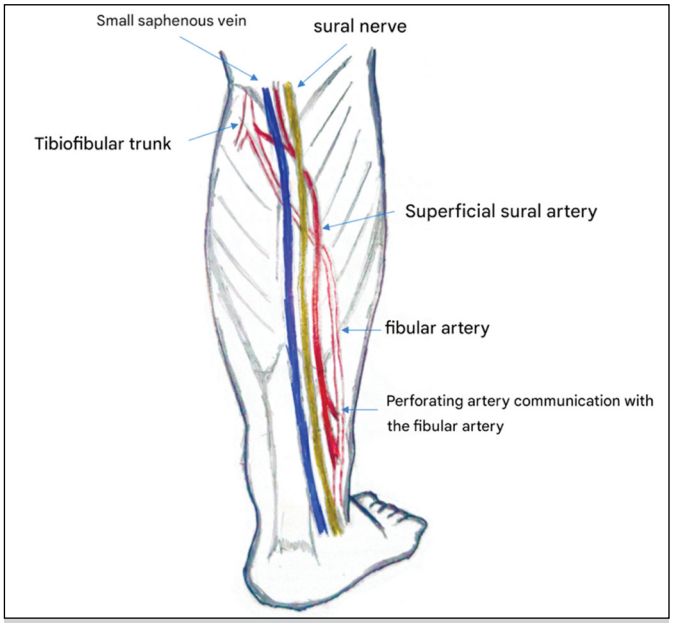

Figure 1. Perforating communicating branches between the superficial sural artery and the fibular artery.

The flap depends on a retrograde arterial blood supply mainly from septocutaneous perforators of the fibular artery.[4] It is also supplied by perforators from the posterior tibial artery, venous perforators associated with the small saphenous vein, and neurocutaneous perforators accompanying the sural artery.[4]

However, even with the ease of execution and the relatively constant anatomy of its pedicle, there are cases where partial or total loss of the flap occurs (Figure 2), which may be related to several factors such as: size of the skin defect, comorbidities, age, mechanism of trauma, time elapsed since the injury, among other factors.[1,5-8]

Furthermore, it is still unknown in which region of the ankle – medial, lateral, or central (Figures 3, 4, and 5) – the highest

Figure 2. Case of total loss of the sural flap for coverage of a defect in the lateral region.

Figure 3. Medial skin failure at the ankle.

Figure 4. Lateral skin failure at the ankle.

Figure 5. Central skin failure at the ankle.

success rate occurs, with a lower risk of complications from the reverse sural flap.[2-4]
Thus, in light of these variables that may influence the success rate of the reverse flow sural flap in different regions of the ankle, we decided to conduct this comparative study.
The primary objective of this study is to evaluate the occurrence of flap loss (partial or total) in coverage defects in the lateral, medial, and central regions of the ankle, and the secondary objective is to assess factors related to flap loss such as: presence of comorbidities, need for postoperative reintervention, etiological factor of skin loss, and the timing of when the patient underwent surgery (immediately after the initial cause, or later).

METHODOLOGY

Retrospective cohort study

Thirty-two patients who underwent surgery with reverse sural flaps from February 2012 to September 2023 at the Institute of Orthopedics and Traumatology of the Hospital das Clínicas of the Faculty of Medicine of the University of São Paulo were included. The study was approved by the Research Ethics Committee under number 64645122.2.0000.0068. All patients included in the study signed the informed consent form.

Inclusion Criteria

• Skin defects in the distal region of the leg/ankle - between the midfoot and the middle third of the leg.

Exclusion Criteria

• Circumferential defects in the ankle region.

Evaluation Criteria

• Location of the skin coverage defect (lateral, medial, or central region of the ankle);
• Surgical outcome (success, partial loss, or total loss of the flap);
• Mechanism of trauma or injury (trauma, infection, dehiscence of previous surgical wound);
• Need for postoperative surgical reintervention;
• Presence of comorbidities: Diabetes Mellitus (DM), smoking (SMK), peripheral vascular disease (PVD);
• Time elapsed until surgery: acute period (up to 48 hours after the initial cause) or later (after 48 hours from the initial cause).
The data were analyzed by descriptive statistical analysis and presented in absolute and relative frequencies, and compared using the chi-square test with its association verified through relative risk. All analyses were performed using SPSS 24.0 software, with a significance level set at 95%.

RESULTS

Of the 32 reverse sural flaps included in the study: ten cases were for coverage of the medial ankle region, fifteen cases for the lateral region, and seven for failures in the central ankle region.
In the group of patients requiring coverage in the medial region, 40% had partial flap loss and 30% suffered total loss. In the lateral region, there were 20% of partial losses and 13.3% of total losses. In the medial area, 57.14% experienced partial loss of coverage, with no cases of total loss (Table 1).
The most common causal indications among all patients were: open fracture (43.75%), infection (37.5%), and dehiscence of previous wounds (18.25%).
Regarding the mechanism of trauma or etiology of the injury in cases of failures in the medial region, 4 cases of open fracture, 1 case of infection, and 2 cases due to dehiscence of previous wounds experienced some degree of loss –partial or total – of the flap (Table 1).
On the lateral side of the leg, 2 skin failures caused by open fracture, 2 caused by infection, and 1 case caused by dehiscence experienced some degree of necrosis (Table 2).
In the central region, 3 cases secondary to open fracture and 1 case of dehiscence of the surgical wound experienced flap loss (Table 3). However, in all these cases, the p-value was not statistically significant.
Of the total patients with failure in the medial region, we had 70% with some type of flap loss, both partial and total. Of these cases, 40% did not require any reintervention procedure, with a 75% lower risk of experiencing any flap loss compared to those who did not need reintervention (RR: 0.25). Additionally, 40% of the patients had some comorbidity, with a risk of experiencing flap losses 5 times greater than patients without comorbidities (RR: 5.00) (Table 1).
Comparatively, in the lateral region, we noted a 33.3% loss rate with 73.3% of patients not undergoing reintervention and a 91%

Table 1. Cases of flaps for medial coverage failures.

	Flap loss			
	Yes (n = 7)	No (n = 3)		
			RR (IC 95%)	Total (n = 10)
Comorbidities				
Yes	2 (20.0%)	2 (20.0%)	5.00 (0.27 – 91.52)	4 (40.0%)
No	5 (50.0%)	1 (10.0%)	0.20 (0.01 – 3.66)	6 (60.0%)
Causes of coverage failure				
Open fracture	4 (40.0%)	0	p 0.52	4 (40.0%)
Infection	1 (10.0%)	3 (30.0%)*		4 (40.0%)
Wound dehiscence	2 (20.0%)	0		2 (20.0%)
Reintervention				
Yes	6 (60.0%)	0		6 (60.0%)
No	1 (10.0%)	3 (30.0%)*	0.25 (0.04 – 1.36)	4 (40.0%)
Chronicity				
Acute	5 (50.0%)	0		5 (50.0%)
Chronic	2 (20.0%)	3 (30.0%)*	2.50 (0.85 – 7.13)	5 (50.0%)

RR: relative risk; 95% CI: 95% confidence interval; *: significant for the chi-square test; $p < 0.05$.

Table 2. Cases of flaps for lateral coverage failures.

	Flap loss			
	Yes (n = 5)	No (n = 10)		
			RR (95% CI)	Total (n = 15)
Comorbidities				
Yes	3 (20.0%)	5 (33.3%)	1.14 (0.56 – 2.33)	8 (53.3%)
No	2 (13.3%)	5 (33.3%)	0.76 (0.17 – 3.32)	7 (46.7%)
Cause of coverage failure				
Open fracture	2 (13.3%)	3 (20.0%)		5 (33.3%)
Infection	2 (13.3%)	6 (40.0%)		8 (53.3%)
Wound dehiscence	1 (6.7%)	1 (6.7%)		2 (13.3%)
Reintervention				
Yes	4 (26.7%)	0*		4 (26.7%)
No	1 (6.7%)	10 (66.7%)*	0.09 (0.01 – 0.58)	11 (73.3%)
Chronicity				
Acute	4 (26.7%)	4 (26.7%)	3.50 (0.50 – 24.41)	8 (53.3%)
Chronic	1 (6.7%)	6 (40.0%)	0.58 (0.27 – 1.24)	7 (46.7%)

RR: relative risk; 95% CI: 95% confidence interval; *: significant for the chi-square test; $p < 0.05$.

lower risk of flap loss compared to those who were readdressed (RR: 0.09). Additionally, 53.3% had some comorbidity, presenting a 1.14 times greater chance of loss (RR: 1.14) (Table 2).
In relation to patients operated on to cover failures in the central region, 57.1% of this total underwent reintervention, resulting in loss in all cases, and all who had some comorbidity experienced some flap loss (Table 3).
Patients operated on for failures in the medial portion during the chronic phase, that is, in a period following the trauma mechanism, had 2.5 times higher chances of losing the flap compared to those operated on in the acute phase (RR: 2.5) (Table 1). In the lateral region, 53.3% were operated on acutely and had a 3.5 times greater chance of loss compared to those operated on in the chronic phase (RR: 3.50) (Table 2). All patients with skin failure in the central region of the leg were operated on in the acute phase (Table 3).

Table 3. Cases of flaps for central coverage failures.

	Flap loss			
	Yes (n = 4)	No (n = 3)		
			RR (95% CI)	Total (n = 7)
Comorbidities				
Yes	4 (57.1%)	0*		4 (57.1%)
No	0	3 (42.9%)*		3 (42.9%)
Cause of coverage failure				
Open fracture	3 (42.9%)	2 (28.6%)	1.20 (0.25 – 5.70)	5 (71.4%)
Wound dehiscence	1 (%)	1 (%)	0.80 (0.13 – 4.61)	2 (28.6%)
Reintervention				
Yes	4 (57.1%)	0		4 (57.1%)
No	0	3 (42.9%)		3 (42.9%)
Chronicity				
Acute	4 (57.1%)	3 (42.9%)		7 (100.0%)
Chronic	0	0		0

RR: relative risk; 95% CI: 95% confidence interval; *: significant for the chi-square test; $p < 0.05$.

DISCUSSION

Acute or chronic skin coverage losses in the distal region of the tibia or ankle have always posed a challenge for the surgeon in deciding the best indicated treatment. The coverage with free flaps is always an option; however, some centers do not offer adequate hospital structure, qualified medical staff, and nursing care for the execution of microsurgery; thus, the reverse sural flap, a locoregional flap, is an effective alternative in the treatment of these injuries.
The performance of the reverse sural flap does not require advanced microsurgical techniques, highly specialized teams, or high-complexity surgical centers compared to free flaps. The procedure requires a relatively short operative time and does not sacrifice any important artery. Additionally, it is capable of covering a wide area of skin failure. It is recommended for many soft tissue defects of the distal third of the leg, ankle, and dorsum of the foot, being capable of covering lateral, medial, or central regions of the lower limb.[8]
The complication rates after reconstruction with the reverse sural flap vary widely in the literature. Some authors point to worse outcomes related to factors such as: timing of surgery, comorbidities, and trauma mechanism.
In our study, of the 32 cases operated on, we obtained a total flap loss rate of around 15.6%, slightly above the average of other studies, which reported rates of 3% to 10%.[1,9-11] The partial flap loss rate was also high, at approximately 34.4%, above the values reported even for free flaps of the lower limb.[1,9-11]
In teaching hospitals and referral centers for complex and emergency cases, the volume of surgeries is large, and patients often require multidisciplinary follow-up with a clinical team, trauma surgery, and microsurgery. As a result, some more severe cases may not be treatable for skin failure in the acute phase, and these cases often present other associated injuries such as fractures, nerve injuries, and vascular injuries. Moreover, since it is a teaching hospital, not all surgeries were performed by the same attending surgeon, which may influence the technical aspect of the procedure. However, all cases were operated on by a team of qualified microsurgeons with technical familiarity for performing the sural flap.
The results of this study differ from those demonstrated in the systematic and analytical review conducted by de Blacam et al.[10] In this study, there was an overall complication rate of 26.4%, and total flap necrosis occurred in 3.2% of patients, mainly associated with DM, PVD and SMK.
Follmar et al.[4] in their systematic review and meta-analysis of 2007 analyzed the results of the reverse sural flap, and 82% of cases healed without complications, with total flap loss in 3.3% and partial flap necrosis in 11% of cases. These loss rates were also associated with DM and PVD in up to 60%.
In our study, these comorbidities reported in the literature also appear to correlate with a higher loss rate, due to vascular diseases and other comorbidities, such as DM, which create unfavorable clinical conditions for flap integration.
Similar to what was found in our study, Johnson et al.[8] found high rates of partial or even total flap loss in patients with comorbidities.[8] However, Daar et al.[1] (2020) found similar rates of complete loss compared to the healthy population; but higher rates of partial loss in the population with comorbidities associated with SMK.
The presence of comorbidity had a negative effect in our study for the three regions of the ankle studied, similar to other studies. However, due to the confidence interval, it was found that the results were not statistically significant, likely due to the small sample size of each group, leading us to believe that having comorbidity only tends to result in flap loss ($p<0.05$).
Regarding the etiological mechanism, skin failures secondary to trauma were more common, representing a rate of 43.75%, similar to the literature that presents rates ranging from 39.4 to 68.8%.[10,11] This data reaffirms that, in hospitals considered reference centers, severe traumas represent a large part of the need for treatments for injuries with skin coverage failures, associated with other injuries.
The highest expected flap loss rate according to location would be for the lateral regions, as the pivot point of the reverse sural flap is located laterally; for coverage failures in the lateral region, the pedicle needs to make a greater curvature for flap rotation, increasing the chances of kinking and compression of the pedicle, generating a higher risk of loss. However, in our study, the procedures designated for covering the medial region presented the highest total loss rate, at 70%. The reach of the flap to the medial region may be greater, which may leave the pedicle under tension, justifying the higher loss rate.
We noted that, in coverage failures in the lateral region, those who required some reintervention procedure, such as surgical cleaning and repositioning of the flap, for example, had a lower tendency to experience any flap loss. In the medial region of the ankle, postoperative reintervention also showed a protective effect.
One of the most common complications of reverse flow flaps is developing congestion, which can be identified with efficient and early monitoring, allowing for a rapid approach in cases of suspected distress. Our study demonstrated that early reintervention in cases of suspected ischemia or congestion in flaps for the medial and lateral regions can maintain flap viability.
The cases of failures in the medial portion operated on during the chronic phase had a 2.5 times higher chance of flap loss. However,

all cases operated on during the acute phase experienced loss, which complicated the risk calculation of loss in this region.
In the lateral region, 43.7% operated in the chronic phase and showed 42% lower chances of loss. In the central region, all operated in the acute phase, with success rates of 57.1% for the flaps.
Patients in some cases were polytraumatized and often required multidisciplinary care, both clinical and surgical, necessitating multiple approaches until definitive treatment. This could hinder the creation of the flap in the early phase, requiring procedures for damage control in this initial phase.
According to Puneky et al.[12], the reduction of time until definitive surgery helps decrease complication rates, with more satisfactory results in patients operated on within 72 hours of the injury. Cases operated on after 7 days of the initial trauma showed an increase in complications, with higher rates of infection and necrosis.[2-14]
Our study indicated a trend towards better outcomes in cases operated on later. The traumas that caused injuries with skin failure in the ankle region were severe, leading to extensive tissue loss. This may have led to a higher rate of necrosis in cases that were operated on during the acute phase, without adequate cleaning, debridement, and local damage control.
Our study has limitations regarding the small number of cases, especially when subdivided into the three major groups evaluated. However, we conducted a novel analysis comparing skin coverage failures in the medial, lateral, and central regions of the ankle, assessing their possible causes and rates of flap necrosis.
There was no statistical significance in the correlations, but we were able to indicate a trend towards better outcomes for failures in the lateral region of the ankle.

CONCLUSION

The reverse sural flap showed a favorable trend for failures in the lateral region of the ankle and exhibited higher rates of partial or total losses in the medial region of the ankle.
A negative effect was observed in the presence of patient comorbidities, in cases caused by trauma, and in the early approach to flap construction.

CONTRIBUTIONS OF THE AUTHORS

Each author contributed individually and significantly to the development of this article. EYW: conceived the work, performed the surgeries, selected the patients and collected data, guided the research, wrote and finalized the text; JAH: performed the surgeries, selected the patients and collected data, analyzed the results and wrote the article; KCSF: analyzed the results, presented the study and wrote the article: LSLRT, JCN, THH, MRR, RMJ: performed the surgeries and selected the patients.

DATA AVAILABILITY DECLARATION

The authors confirm that all data supporting the findings of this study are fully available within the article.

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POSTOPERATIVE STABILITY AFTER VOLAR LOCKING PLATE IN DISTAL RADIUS FRACTURES

ESTABILIDADE PÓS-OPERATÓRIA COM PLACA VOLAR BLOQUEADA EM FRATURAS DE RÁDIO DISTAL

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ABSTRACT

Objective: To evaluate the correction and maintenance of radiographic parameters—volar tilt (VT), radial inclination (RI), and radial height (RH)—from the preoperative period to outpatient discharge in distal radius fractures treated with a volar locking plate (VLP), stratified by AO/OTA, Fernandez, and IDEAL classifications. Methods: Retrospective analytical case series including 135 fractures operated on between January 2023 and August 2024. Standard anteroposterior and lateral radiographs were obtained at three time points: preoperative (PRE), immediate postoperative (IPO), and outpatient discharge (POT). Two independent, mutually blinded raters classified the fractures and measured VT, RI, and RH. The study focused on radiographic outcomes. Results: Significant improvements in VT, RI, and RH were observed from PRE→IPO and PRE→POT ($p<0.001$). Differences from IPO→POT were small and not significant ($p>0.05$), indicating maintenance of parameters until discharge. The same pattern was seen in higher-complexity subgroups (AO type C, IDEAL 3, and Fernandez 5). Conclusion: VLP fixation provided effective initial correction and radiographic maintenance up to discharge in distal radius fractures, particularly in complex patterns. ***Level of evidence IV, case series.***

Keywords: Internal Fixators; Fracture, Distal Radius; Radiographic Image Interpretation, Computer-Assisted; Bone Plates.

RESUMO

Objetivo: Avaliar a correção e a manutenção dos parâmetros radiográficos — inclinação volar (IV), inclinação radial (IR) e altura radial (AR) — do pré-operatório à alta ambulatorial em fraturas distais do rádio tratadas com placa volar bloqueada (PVB), estratificando pelas classificações AO/OTA, Fernandez e IDEAL. Métodos: Estudo tipo série de casos retrospectiva analítica com 135 fraturas operadas entre janeiro/2023 e agosto/2024. Radiografias em anteroposterior e perfil nos momentos pré-operatório (PRE), pós-operatório imediato (POI) e alta (POT). Dois avaliadores independentes, cegos entre si, classificaram as fraturas e mensuraram IV, IR e AR. O estudo concentrou-se em desfechos radiográficos. Resultados: Houve correção significativa de IV, IR e AR entre PRE→POI e PRE→POT ($p<0,001$). Entre POI→POT, as diferenças foram pequenas e não significativas ($p>0,05$), indicando manutenção dos parâmetros até a alta. O padrão repetiu-se nos subgrupos de maior complexidade (AO C, IDEAL 3 e Fernandez 5). Conclusão: A placa volar bloqueada proporcionou correção inicial eficaz e manutenção radiográfica até a alta nas fraturas distais do rádio, sobretudo em fraturas complexas. ***Nível de evidência IV; série de casos.***

Descritores: *Fixadores Internos; Fraturas Distais do Rádio; Interpretação de Imagem Radiográfica Assistida por Computador; Placas Ósseas.*

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INTRODUCTION

Distal radius fractures are common and account for about 15% of all fractures in adults, with a bimodal distribution: in the elderly, due to bone fragility, and in young adults, due to high-energy trauma[1,2]. Standardized radiographic evaluation — radial inclination (RI), radial height (RH), and volar tilt (VT) — is crucial for guiding treatment and follow-up. Reference values (RI ~23°, RH ~11–12 mm, VT ~11°)[3] are often used as postoperative goals, although they vary according to sex, age, and individual characteristics. It is important to emphasize that the relationship between radiographic alignment and function is not linear[4].

Among surgical options, the volar locking plate (VLP) stands out for providing stable angular fixation and allowing early mobilization, with favorable radiographic results even in more complex fractures[5]. However, complications and late loss of reduction may occur, which reinforces the importance of monitoring the maintenance of parameters throughout follow-up — and not just immediate correction[6].

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

The study was conducted at University Hospital of the Universidade Estadual de Ponta Grossa, Ponta Grossa, Parana, Brazil.
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The morphological and mechanical heterogeneity of fractures requires complementary classification systems. The AO/OTA organizes fractures by morphology[7]; Fernandez focuses on the mechanism of injury[8]; and the IDEAL — a Brazilian proposal — integrates aspects of the patient, trauma, and fracture (Instability, Deviation, Joint extension, Association, and Soft tissue injury)[9], offering an expanded view of severity and instability. The interobserver reliability of classifications based solely on X-rays is usually moderate, but it can improve with computed tomography (CT) in intra-articular fractures; nonetheless, routine clinical application must balance accuracy and availability.

Despite the robust literature on initial outcomes VLP, the maintenance of RI, RH, and VT from the immediate postoperative period to outpatient discharge remains underexplored, especially in complex patterns.

The aim of the study is to investigate the correction and stability of radiographic parameters over the postoperative follow-up, stratifying by AO/OTA, Fernandez, and IDEAL, and to verify whether these measures are maintained until outpatient discharge with the use of a locked volar plate, including in fractures of greater complexity.

METHODOLOGY

Analytical retrospective case series study, approved by the Research Ethics Committee (CAAE: 84384024.5.0000.0105).

All cases with a diagnosis of distal radius fracture treated with VLP and aged over 18 years, operated between January 2023 and August 2024 at a tertiary reference hospital in orthopedics in the southern region of Brazil, were included.

Cases with absence of preoperative X-rays or loss of outpatient follow-up were excluded.

The X-rays were standardized in anteroposterior and lateral views at three time points: preoperative (PRE), immediate postoperative (POI), and outpatient discharge (POT).

The surgical indication with locked volar plating followed the institutional protocol for unstable and/or articular fractures: articular displacement >2 mm, volar/dorsal angulation >10°, loss of radial height >3 mm, metaphyseal comminution, and/or articular involvement. All procedures were performed by the same hand surgeon, using the same plate model, via Henry's volar approach.

Fractures were classified by two independent evaluators (one hand surgeon and one third-year resident in orthopedics and traumatology) using the AO/OTA, Fernandez, and IDEAL systems. Discrepancies were resolved by consensus.

For radiographic evaluation, the parameters used were: volar tilt (VT), radial height (RH), and radial inclination (RI). Measurements were made in the Animati PACS system at three time points: PRE (before the surgical procedure), POI (immediate postoperative), and POT (at the time of outpatient discharge), with the evaluators blinded to each other's measurements.

The intraclass correlation coefficient (ICC) was estimated for VT, RH, and RI, interpreted by ranges (low <0.50; moderate 0.50–0.75; good 0.75–0.90; excellent >0.90).

The normality of the distributions was assessed using the Shapiro–Wilk test. Comparisons between the three time points were performed using the Friedman test, with Nemenyi post-hoc test for multiple comparisons. In the descriptive analysis, means, medians, standard deviation (SD), and quartiles (P25–P75) were reported. Significance level $\alpha = 0.05$. Exploratory study, without prior power calculation. The analyses were conducted in R 4.1.3 (R Core Team, 2022). Informed consent was waived as this was a retrospective review of records, without nominal identification.

RESULTS

A total of 135 fractures were analyzed. The sample was predominantly composed of female patients (76 women and 59 men), and the majority (63.7%) were over 50 years old. A predominance of complex patterns was observed in the three classifications: AO type C = 69.63% (A = 17.78%; B = 12.59%), IDEAL 3 = 52.59% (IDEAL 2 = 47.41%) and Fernandez 3/5 = 35.56% each (Table 1). In the preoperative phase (PRE), the volar inclination (VI) predominantly showed dorsal values; after the osteosynthesis with a locked volar plate, there was substantial correction in the immediate postoperative phase (POI), with maintenance at the outpatient discharge (POT). Similar patterns were observed for radial inclination (RI) and radial height (RH) (Table 2).

The greatest variations occurred between PRE→POI and PRE→POT for VT, RI, and RH ($p<0.001$). Between POI→POT, the differences were small and not significant ($p>0.05$) for the three parameters, indicating stability throughout the follow-up (Table 3). Additionally, the comparisons between the differences PRE→POT vs PRE→POI were not significant (VT $p=0.371$; RI $p=0.264$; RH $p=1.000$), while the comparisons involving POI→POT were significant ($p<0.001$), reinforcing the maintenance of the parameters between POI and POT. The same pattern — significant initial correction and subsequent maintenance — was observed in the subgroups AO type C, IDEAL

Table 1. Frequency of fracture types according to each classification system.

				CI (95%)	
Variable		N	%	Inf	Sup
AO	A	24	17.78%	12.25%	25.09%
	B	17	12.59%	8.01%	19.24%
	C	94	69.63%	61.42%	76.75%
Ideal	2	64	47.41%	39.17%	55.79%
	3	71	52.59%	44.21%	60.83%
Fernandez	1	23	17.04%	11.63%	24.27%
	2	16	11.85%	7.43%	18.39%
	3	48	35.56%	27.98%	43.93%
	5	48	35.56%	27.98%	43.93%

N= absolute frequency; = relative frequency; Inf= lower limit of the 95% CI; sup= upper limit of the 95% CI. IC: Confidence interval.

Table 2. Radiographic parameters by moment (mean ± SD).

Variable	PRE (n=135)	POI (n=135)	POT (n=134)
Volar inclination (in degrees)	-13.87 ± 18.06	5.65 ± 5.23	5.89 ± 4.73
Radial inclination (in degrees)	12.67 ± 7.15	18.11 ± 4.55	18.62 ± 4.31
Radial height (in millimeters)	4.26 ± 5.73	10.10 ± 3.33	10.03 ± 3.19

PRE= pre-operative; POI= immediate post-operative; POT= outpatient discharge.

Table 3. Descriptive analysis of the differences between the evaluated moments.

Variable	Δ PRE→POI (mean SD)	Δ PRE→POT (mean SD)	Δ POI→POT (mean SD)	Significance (Friedman + Nemenyi)
Volar inclination (in degrees)	19.51 ± 17.79	19.88 ± 17.81	0.22 ± 4.12	PRE vs POI: p<0.001; PRE vs POT: p<0.001; POI vs POT: p> 0.05
Radial inclination (in degrees)	5.44 ± 7.19	6.01 ± 6.84	0.54 ± 3.60	PRE vs POI: p<0.001; PRE vs POT: p<0.001; POI vs POT: p> 0.05
Radial height (in millimeters)	5.83 ± 5.42	5.84 ± 5.35	-0.04 ± 2.01	PRE vs POI: p<0.001; PRE vs POT: p<0.001; POI vs POT: p> 0.05

PRE = pre-operative; POI = immediate post-operative; POT = outpatient discharge; SD = standard deviation.

3, and Fernandez 5, with no clinically relevant differences between POI and POT. Figure 1 presents the boxplots of the more complex fractures (AO type C, IDEAL type 3, and Fernandez type 5), highlighting the significant change in the measured parameters between the preoperative phase and the other moments, as well as the maintenance of these measures between the immediate postoperative phase and outpatient discharge.

DISCUSSION

The findings align with publications that indicate good radiographic results and the biomechanical advantage of the VLP, favoring early mobilization in unstable/comminuted patterns[5,10,11].

Previous clinical studies describe satisfactory maintenance of alignment after volar fixation, although late variations may occur, especially in the absence of well-positioned subchondral screws[12].

On the other hand, in complex articular fractures, not all parameters always return to physiological ranges by the end of the follow-up[13], which emphasizes the importance of analyzing subgroups by complexity through fracture stratification using classifications.

The simultaneous use of three systems (AO/OTA, Fernandez, and IDEAL) allowed for discussion of the phenomenon of radiographic maintenance from complementary dimensions (morphology, mechanism, and clinical/radiographic instability).

Furthermore, the predominance of complex patterns (e.g., AO C) is consistent with the tertiary setting and provides a demanding test of implant stability; the fact that complex patterns also demonstrate maintenance between POI and POT suggests that the VLP adequately meets this biomechanical demand.

Although alignment and radiographic parameters have clinical relevance, they are not synonymous with full functional recovery. Part of the literature shows a non-linear correlation between radiographic measures and clinical outcomes (pain, grip strength, range of motion, PRWE/DASH scales)[4], especially when there is residual dorsal deviation. Our design did not capture functional outcomes; therefore, one should not automatically infer clinical superiority based solely on radiographic stability.

In practice, the data indicate that, in the absence of clinical signs of failure, reducing late radiographic controls may be considered until outpatient discharge, as POI□POT remained stable. This strategy may optimize workflows and reduce costs/radiation exposure while preserving good clinical follow-up.

The numerically significant consecutive sample, standardization of technique/implant/surgeon, reducing operator variation, the double blind measurement of radiographic parameters with reported ICC, and stratification by three classification systems allow for a multidimensional reading of the results.

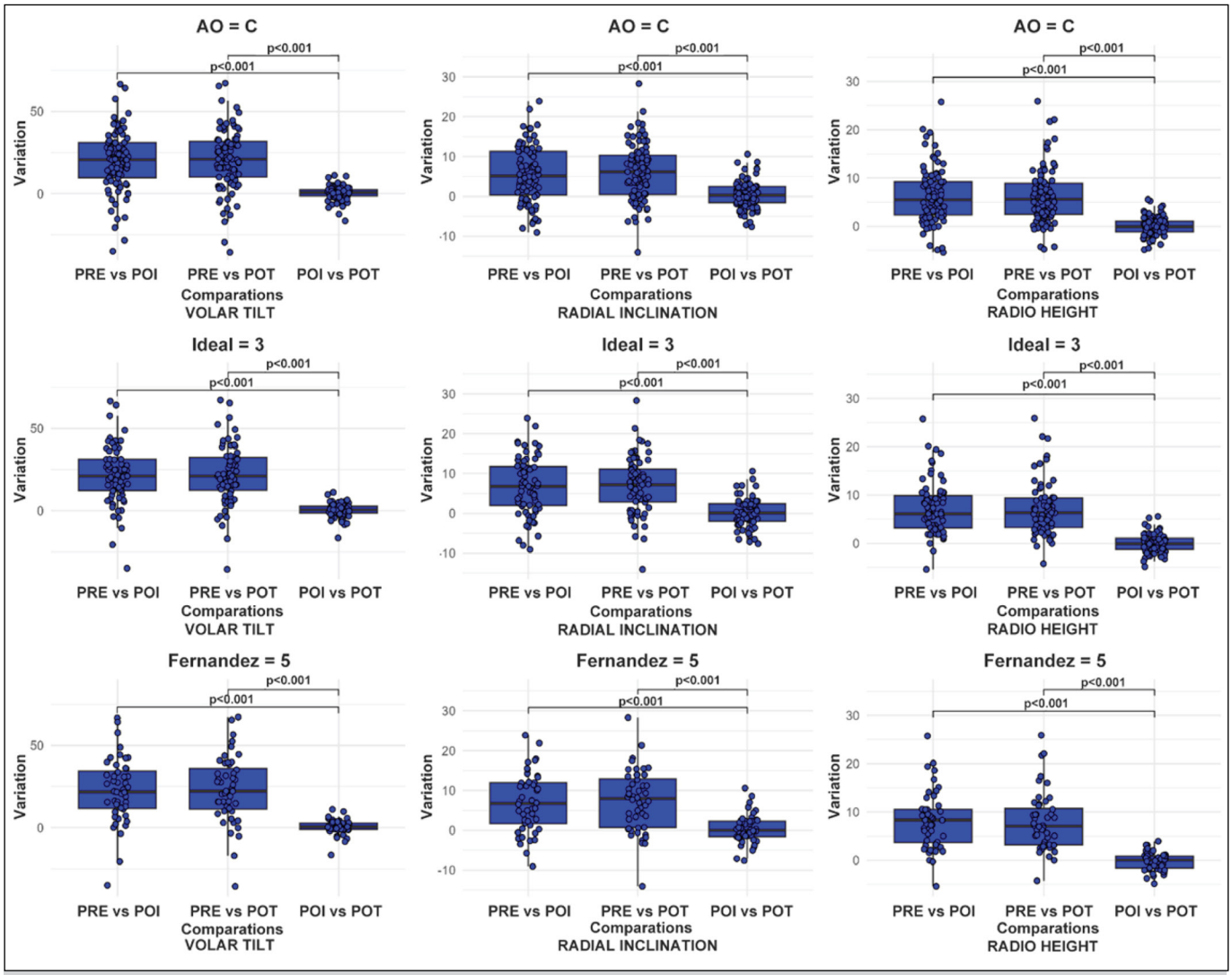

Figure 1. Boxplot of the variation in volar inclination, radial inclination, and radial height between the evaluated times for (AO = C, IDEAL = 3, and FERNANDEZ = 5).

However, the fact that it has a retrospective design in a single center and with a predominance of complex fractures may restrict generalization. The absence of functional outcomes and clinical and demographic covariates reduces the ability to adjust for confounders and reinforces the descriptive nature of the inferences.

The findings suggest that VLP offers effective correction and maintenance of alignment until outpatient discharge, supporting the use of the method in these standards, provided clinical decisions consider function, symptoms, and the individual context of each patient[4,14]. Prospective and multicenter studies, with standardized collection of clinical/demographic variables and inclusion of functional outcomes (PRWE, DASH, strength, range of motion), are necessary to confirm these findings over longer horizons and estimate the clinical impact and cost-effectiveness of follow-up protocols with fewer radiographs when clinical evolution is favorable.

CONCLUSION

Significant correction of VT, RI, and RH was observed from pre-operative to immediate post-operative and maintenance of these parameters until outpatient discharge. This behavior was maintained in the subgroups of greater complexity (AO C, IDEAL 3, and Fernandez 5), suggesting implant stability in the initial follow-up, even in more complex fractures.

VLP presents itself as an effective option for early radiographic correction and maintenance, with therapeutic and follow-up decisions needing to consider individual clinical evolution, symptoms, and patient context. Prospective and multicenter studies, with standardized collection of covariates and inclusion of functional outcomes, are necessary to confirm and expand this evidence.

CONTRIBUTIONS OF THE AUTHORS

Each author contributed individually and significantly to the development of this article. CLHS: Validation, Visualization, Data curation, Formal analysis, Investigation, Methodology, Writing - original draft, review and editing LDB: Validation, Visualization, Data curation, Formal analysis, Writing - original draft. GMA: Validation, Visualization, Data Curation, Formal Analysis, Methodology, Writing - original draft. CRM: Validation, Visualization, Data Curation, Formal Analysis, Methodology, Writing - original draft. RBA: Performing surgeries, Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Validation, Visualization, Writing – Review and Editing.

DATA AVAILABILITY DECLARATION

The contents underlying the research are available in the manuscript.

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THE UNITÉ RHUMATOLOGIQUE DES AFFECTIONS DE LA MAIN (URAM): TRANSLATION INTO PORTUGUESE, CULTURAL ADAPTATION AND VALIDATION

THE UNITÉ RHUMATOLOGIQUE DES AFFECTIONS DE LA MAIN (URAM): TRADUÇÃO PARA A LÍNGUA PORTUGUESA, ADAPTAÇÃO CULTURAL E VALIDAÇÃO

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ABSTRACT

Objective: To translate and culturally adapt the Unité Rhumatologique des Affections de la Main (URAM) scale, a specific instrument for functional assessment in Dupuytren's disease (DD), into Brazilian Portuguese. Methods: Following the methodology of Beaton (2000), the scale underwent five stages: translation, synthesis, back-translation, expert committee, and pre-testing. After adaptation, the Brazilian version of the scale (URAM-BR) was administered to 40 patients with Dupuytren's contracture. Internal consistency was tested using Cronbach's alpha, reproducibility was analyzed using the intraclass correlation coefficient (ICC), and construct validity was analyzed by correlation with the Brazilian version of QuickDASH. Results: The URAM-BR showed excellent internal consistency ($\alpha = 0.930–0.938$), significant reproducibility (ICC > 0.89), and moderate-to-strong construct validity ($r = 0.69$, $p < 0.001$). The adapted version proved to be clear, reliable, and appropriate to the Brazilian cultural context. Conclusion: The URAM-BR is a valid, reliable, and reproducible instrument for functional assessment of patients with DD in Brazil. ***Level of evidence IV; Observational cross-sectional instrument validation study.***

Keywords: Dupuytren Contracture; Surveys and Questionnaires; Validation Study; Hand; Translating.

RESUMO

Objetivo: Traduzir e adaptar culturalmente para o português do Brasil a escala Unité Rhumatologique des Affections de la Main (URAM), instrumento específico para avaliação funcional na Doença de Dupuytren (DD). Métodos: Seguindo a metodologia de Beaton (2000), a escala passou por cinco etapas: tradução, síntese, retrotradução, comitê de especialistas e pré-teste. Após a adaptação, a versão brasileira da escala (URAM-BR) foi aplicada em 40 pacientes com contratura de Dupuytren. A consistência interna foi testada pelo alfa de Cronbach, a reprodutibilidade foi analisada pelo Coeficiente de Correlação Intraclasse (ICC), e a validade de construto pela correlação com a versão brasileira da QuickDASH. Resultados: O URAM-BR apresentou excelente consistência interna ($\alpha = 0,930–0,938$), reprodutibilidade significativa (ICC $> 0,89$) e validade de construto moderada-forte ($r = 0,69$, $p < 0,001$). A versão adaptada demonstrou ser clara, confiável e adequada ao contexto cultural brasileiro. Conclusão: O URAM-BR é um instrumento válido, confiável e reprodutível para avaliação funcional de pacientes com DD no Brasil. ***Nível de evidência IV; estudo observacional transversal de validação de instrumento.***

Descritores: *Contratura de Dupuytren; Inquéritos e Questionários; Estudo de Validação; Mãos; Tradução.*

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INTRODUCTION

Dupuytren's disease (DD) is characterized by the proliferation and thickening of the palmar fascia, which occurs through the differentiation of fibroblasts into myofibroblasts, cells responsible for the excessive production of collagen[1], forming nodules that can evolve into rigid cords, with collagen fibers organized parallel to the lines of tension. About 10% of patients with DD progress to progressive, permanent flexion of the affected fingers, most commonly the ring and little fingers, which characterizes Dupuytren's contracture (DC)[2]. Flexion contractures affect the metacarpophalangeal (MCP) joints, proximal interphalangeal (PIP) joints, and, more rarely, the distal interphalangeal (DIP) joints, which can lead to severe deformities[3].

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

The study was conducted at Hand Surgery discipline of the Hand House of the Paulista School of Medicine at Universidade Federal de São Paulo (UNIFESP).
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The inability to fully open the fingers will affect patients' ability to handle objects, which consequently leads to reports of limitations in work, leisure activities, and self-care, such as using a computer, playing instruments, practicing sports, and performing personal hygiene[4].

Assessing the patient's perception of their limitations is important to clarify and tailor Dupuytren's disease treatment to individual needs and expectations, which can be done using patient-reported outcome measures (PROMs). PROMs questionnaires specific to the affected segment, such as the *Disabilities of the Arm, Shoulder and Hand* (DASH), the *Michigan Hand Questionnaire* (MHQ), and their shortened versions, QuickDASH and the *Brief Michigan Hand Questionnaire* (BMHQ), have been translated into Brazilian Portuguese[5-7] and are widely used in the evaluation of patients and outcomes in clinical studies on various hand-affecting pathologies. However, they are nonspecific to the limitations presented by patients with Dupuytren's disease and are not very sensitive to changes in the range of motion that occur with disease progression and treatment of contractures[8].

The *Unité Rhumatologique des Affections de la Main* (URAM) was the first PROMs developed and validated specifically for Dupuytren's disease, consisting of 9 questions that assess the patient's difficulty in performing some daily living activities commonly affected by finger extension limitations. Its scoring ranges from 0 to 5 for each item, totaling up to 45 points, where higher values represent greater functional limitation[9]. The URAM has validated versions in English, French, Italian, Spanish, German, Dutch, and Korean[10-14], but has not yet been translated into Portuguese.

We developed this study to translate the URAM questionnaire into Portuguese and adapt it to our country's culture for use in the Brazilian population with Dupuytren's disease.

MATERIALS AND METHODS

Research Design

This study is a cross-sectional, observational, primary research study focused on validating a questionnaire for assessing Dupuytren's disease.

Adult patients diagnosed with Dupuytren's contracture were included in the present sample, while those under 18 years of age or who did not agree to sign the Informed Consent Form (ICF) were excluded. The project was approved by the Research Ethics Committee (REC), under opinion number 7.510.123, CAAE: 85528624.1.0000.5505. The translation of the URAM questionnaire was carried out according to the translation, cultural adaptation, and validation protocol proposed by Beaton et al. (2000), which comprises five stages: translation, synthesis, back-translation, expert committee, and pre-testing.[15]

Translation and Cultural Validation Stages

Translation

Two translators fluent in French, with Portuguese as their native language, independently translated the URAM questionnaire from the original French version. One of them was a hand surgery specialist with experience in the clinical management of Dupuytren's disease, while the other was a sworn translator with no prior knowledge of the pathology. The resulting translations were designated T1 and T2, respectively. (see Appendix 1)

Synthesis

The translators gathered to analyze the discrepancies between versions T1 and T2 and synthesize them into a consensual translation. The main divergence was observed in item 1, which originally referred to the term "*toilet bag*", a common object in personal hygiene habits in European countries, but little used by the Brazilian population. Understanding that the question aimed to describe a hygiene action during bathing that requires the use of an open hand to hold an object in contact with the body, it was decided to culturally adapt it to "can you lather up with your open hand?". With this modification, and after consensus among the translators, the unified version of the translation, called T12, was generated. (see Appendix 1)

Back Translation

To verify the consistency between the original French version and version T12, two independent translators, whose native language is French, fluent in Portuguese, not belonging to the medical field, and blind to the original questionnaire, performed the back translation of T12 into French, generating versions RT1 and RT2. Except for item 1, which was modified for cultural adaptation as previously described, all other questions presented semantic equivalence with the original version of the URAM. (see Appendix 1)

Expert Committee

The expert committee was composed of the translators, one hand surgery resident, and three hand surgeons, with different levels of professional experience: one with less than 10 years, two with more than 10 years, and one with over 30 years in the field. The group met to evaluate consistency between the translated and back-translated versions, equivalence relative to the original version, and the cultural appropriateness of the items. Based on this analysis, the version of the questionnaire to be applied to patients was defined.

Pre-Test

The version of the questionnaire obtained after the expert committee was applied to 40 patients who attended for outpatient evaluation at the institution and were diagnosed with DC, all of whom had previously agreed to participate by signing the ICF.

Demographic data were collected, including sex and age, degree of contracture of the affected rays using a goniometer, time required to complete the questionnaire, and identification of unanswered or incorrectly filled items. The degree of patients' understanding of each item was also assessed, and any doubts were recorded. Based on this preliminary stage, we reviewed the translated version and finalized the instrument in Brazilian Portuguese, called URAM-BR.

Statistical Analysis

The collected data were organized in Microsoft Excel spreadsheets and analyzed using IBM SPSS Statistics software (IBM Corp. Released 2023. IBM SPSS Statistics for Windows, Version 29.0.2.0. Armonk, NY: IBM Corp). For all analyses, a significance level of 5% ($p < 0.05$) was adopted.

The reproducibility of the URAM questionnaire was assessed through interviews with patients, by comparing responses obtained in the pre-test and retest, using the Intraclass Correlation Coefficient (ICC), which measures the stability of responses over time, as well as the observed integrity.

The internal reliability of the questionnaire was assessed using Cronbach's alpha, which evaluates the internal consistency of responses across items for different patients. Additionally, a construct validity analysis was conducted, comparing the URAM scores with those of the QuickDASH scale, which has already been validated for functional assessment in Dupuytren's disease, to assess convergence between the instruments and the ability of the new questionnaire to produce equivalent results.

RESULTS

The clinical and demographic characteristics of the patients are presented in Table 1. The average age was 64 years. Of the 40 participants, 32 (80%) were male, 37 (92.5%) were right-handed,

Table 1. Patient characteristics.

Characteristics	n (%) mean (SD)
Age	64.93 (6.45)
Sex	
Male	32 (80%)
Female	8 (20%)
Dominant side	
Right-handed	37 (92.5%)
Left-handed	3 (7.5%)
Comorbidity count	
1	23 (57.5%)
2	8 (20%)
3	5 (12.5%)
4	3 (7.5%)
5	1 (2.5%)
Hands affected by Dupuytren	
Right	8 (20%)
Left	3 (7.5%)
Bilateral	29 (72.5%)
Disease status	
Pre-operative	10 (25%)
Conservative	4 (10%)
Post-operative	26 (65%)
URAM Sum (1st application)	20.78 (12.85)
URAM Sum (2nd application)	20.83 (12.77)
QuickDASH Score	41.02 (23.05)

Values indicated in count (% of the group) or average (standard deviation). as appropriate. N=40

Table 2. Evaluation of the questions by the patients.

Item	n (%)
1) Do you wash with an open hand?	
Clear	39 (97.5)
Not clear	1 (2.5)
2) Do you wash your face?	
Clear	39 (97.5)
Not clear	1 (2.5)
3) Can you pick up a bottle with one hand?	
Clear	39 (97.5)
Not clear	1 (2.5)
4) Can you shake someone's hand?	
Clear	39 (97.5)
Not clear	1 (2.5)
5) Can you pet something or someone?	
Clear	38 (95)
Not clear	2 (5)
6) Can you clap your hands?	
Clear	40 (100)
Not clear	0 (0)
7) Can you open your hand by spreading your fingers?	
Clear	37 (92.5)
Not clear	3 (7.5)
8) Can you lean on your hand?	
Clear	39 (97.5)
Not clear	1 (2.5)
9) Can you pick up small objects between your thumb and index finger?	
Clear	38 (95)
Not clear	2 (5)

Values indicated in count (% of the group). N=40.

and 29 (72.5%) had bilateral involvement of Dupuytren's disease. All patients reported at least one comorbidity, and the majority (n = 26; 65%) were in postoperative follow-up.

Table 2 presents patients' evaluation of the clarity of the questions. At least 92.5% of participants considered each questionnaire item clear. The greatest difficulty was observed in question 7, regarding the movement of opening the hand by spreading the fingers, which three patients (7.5%) marked as unclear. On the other hand, question 6, "clap your hands?", was the only one considered clear by all 40 participants, demonstrating total understanding. The scale in Portuguese is presented in Figure 1.

The analysis of internal consistency, presented in Table 3, revealed a Cronbach's alpha coefficient of 0.930 in the first application of the test, indicating excellent internal reliability of the instrument.

In the second application of the URAM, the analysis of internal consistency yielded a Cronbach's alpha coefficient of 0.938, reinforcing the instrument's high reliability (Table 4).

Table 5 presents the reproducibility analysis, with the ICC calculated for each questionnaire item. All values were equal to or greater than 0.897, indicating at least good reproducibility for all items. Most questions showed an ICC above 0.90, indicating excellent reproducibility and supporting the stability of responses between the two applications of the URAM-BR.

Table 6 presents the correlation analysis of the URAM and QuickDASH scores. A statistically significant correlation was observed in both applications of the URAM ($p < 0.001$ in both cases). The Spearman correlation coefficients were 0.690 in the first application and 0.695 in the second, indicating a moderate-to-strong correlation. QuickDASH was applied only once.

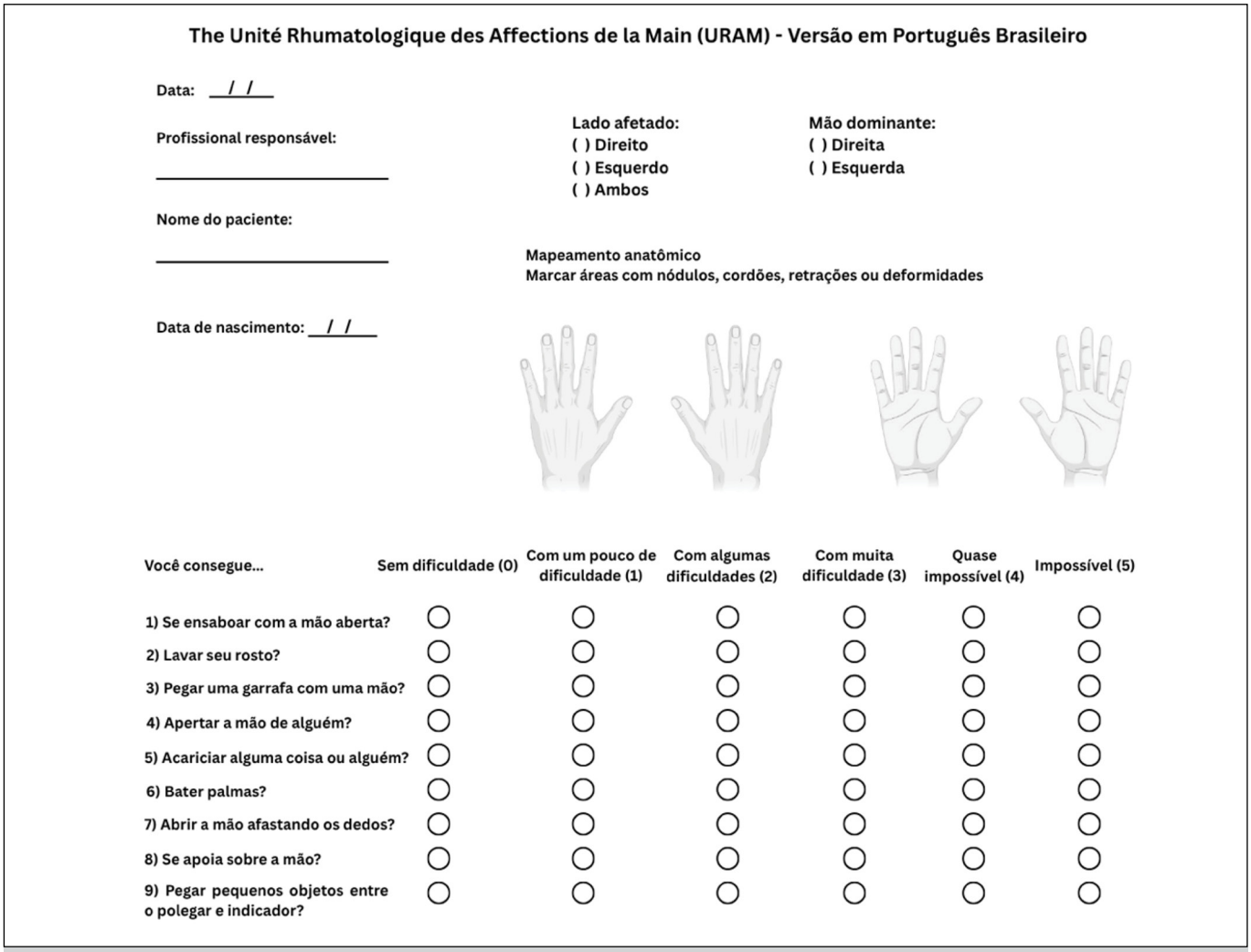
DISCUSSION

The use of appropriate instruments to assess patients with Dupuytren's disease is essential for systematically documenting disease progression and treatment outcomes. In this context, patient-reported outcome measures (PROMs) provide a more sensitive and patient-centered perspective on the functional impact of the disease, overcoming the limitations of isolated objective measures, such as the degree of contracture in specific joints[16].

The literature has pointed out the lack of standardization among the instruments used in clinical studies with patients with Dupuytren's disease, which compromises the comparability of findings and hinders the consolidation of scientific evidence[17]. The cultural adaptation and validation of already established instruments, such as the URAM, following rigorous protocols like those of Beaton et al.[15], ensure that their psychometric properties are preserved in new linguistic and cultural contexts.

The URAM is, to date, the only PROM developed specifically to assess functionality in patients with Dupuytren's disease. Previous studies have validated this instrument in languages such as English, German, Dutch, Korean, Spanish, and Italian[9-14]. The present study was the first to adapt the URAM for Brazilian Portuguese, with results that attest to its conceptual, cultural, and statistical equivalence to the original version.

Figure 1 presents the final version of the URAM-BR, developed in simple language and with a standardized structure, facilitating its clinical application. The instrument comprises nine items related to daily manual activities, scored from 0 (no difficulty) to 5 (impossible), according to the degree of perceived functional limitation. Auxiliary anatomical representations for mapping nodules and retractions reinforce the practical and patient-centered nature of the adapted version.


The Unité Rhumatologique des Affections de la Main (URAM) - Versão em Português Brasileiro

Data: __/__/__

Profissional responsável:

_____

Nome do paciente:

_____

Data de nascimento: __/__/__

Lado afetado:
( ) Direito
( ) Esquerdo
( ) Ambos

Mão dominante:
( ) Direita
( ) Esquerda

Mapeamento anatômico
Marcar áreas com nódulos, cordões, retrações ou deformidades

Você consegue...	Sem dificuldade (0)	Com um pouco de dificuldade (1)	Com algumas dificuldades (2)	Com muita dificuldade (3)	Quase impossível (4)	Impossível (5)
1) Se ensaboar com a mão aberta?	○	○	○	○	○	○
2) Lavar seu rosto?	○	○	○	○	○	○
3) Pegar uma garrafa com uma mão?	○	○	○	○	○	○
4) Apertar a mão de alguém?	○	○	○	○	○	○
5) Acariciar alguma coisa ou alguém?	○	○	○	○	○	○
6) Bater palmas?	○	○	○	○	○	○
7) Abrir a mão afastando os dedos?	○	○	○	○	○	○
8) Se apoia sobre a mão?	○	○	○	○	○	○
9) Pegar pequenos objetos entre o polegar e indicador?	○	○	○	○	○	○

Figure 1. URAM-BR, URAM's brazilian versions (*Unité Rhumatologique des Affections de la Main*).

Table 3. Internal consistency of URAM responses in the first test.

Item	Mean (SD)	Alfa de Cronbach	
		When excluding the item*	General
1) Do you wash with an open hand?	2.42 (1.796)	0.920	0.930
2) Do you wash your face?	2.42 (1.852)	0.919	
3) Can you pick up a bottle with one hand?	2.00 (1.649)	0.919	
4) Can you shake someone's hand?	2.20 (1.757)	0.923	
5) Can you pet something or someone?	2.00 (1.769)	0.926	
6) Can you clap your hands?	2.85 (1.875)	0.919	
7) Can you open your hand by spreading your fingers?	3.05 (1.880)	0.923	
8) Can you lean on your hand?	3.00 (1.974)	0.929	
9) Can you pick up small objects between your thumb and index finger?	0.83 (1.299)	0.942	

Mean and standard deviation of the responses to each of the questions on the *URAM* scale. The scale ranges from 1 to 5. N=40. *Describes the adjusted Cronbach's Alpha coefficient if the respective item is excluded from the construct.

Table 4. Internal consistency of URAM responses (second test).

Item	Mean (SD)	Alfa de Cronbach	
		When excluding the item*	General
1) Do you wash with an open hand?	2.42 (1.767)	0.929	0.938
2) Do you wash your face?	2.40 (1.851)	0.928	
3) Can you pick up a bottle with one hand?	2.08 (1.623)	0.929	
4) Can you shake someone's hand?	2.20 (1.667)	0.929	
5) Can you pet something or someone?	2.03 (1.747)	0.935	
6) Can you clap your hands?	2.78 (1.819)	0.929	
7) Can you open your hand by spreading your fingers?	3.10 (1.823)	0.932	
8) Can you lean on your hand?	3.03 (1.874)	0.940	
9) Can you pick up small objects between your thumb and index finger?	0.80 (1.224)	0.953	

Mean and standard deviation of the responses to each of the questions on the *URAM* scale. The scale ranges from 1 to 5. N=40. *Describes the adjusted Cronbach's Alpha coefficient if the respective item is excluded from the construct.

Table 5. Reproducibility analysis.

Item	Mean (SD)		ICC
	1st test	2nd test	
1) Do you wash with an open hand?	2.42 (1.796)	2.42 (1.767)	0.968
2) Do you wash your face?	2.42 (1.852)	2.40 (1.851)	0.960
3) Can you pick up a bottle with one hand?	2.00 (1.649)	2.08 (1.623)	0.958
4) Can you shake someone's hand?	2.20 (1.757)	2.20 (1.667)	0.897
5) Can you pet something or someone?	2.00 (1.769)	2.03 (1.747)	0.955
6) Can you clap your hands?	2.85 (1.875)	2.78 (1.819)	0.952
7) Can you open your hand by spreading your fingers?	3.05 (1.880)	3.10 (1.823)	0.956
8) Can you lean on your hand?	3.00 (1.974)	3.03 (1.874)	0.956
9) Can you pick up small objects between your thumb and index finger?	0.83 (1.299)	0.80 (1.224)	0.945

Reproducibility analysis of the URAM test by *Intraclass Correlation Coefficients* - ICC) intra-observer. Results of the questions expressed as mean and standard deviation for the 1st and 2nd application of the test. The parameters for the ICC test were established, the mixed model of two factors, with single measures.

Table 6. Construct analysis, comparative between URAM and QuickDASH.

Item	Mean (SD)	p	R
URAM Sum (1st application)	20.78 (12.85)	<0.001	0.690
URAM Sum (2nd application)	20.83 (12.77)	<0.001	0.695
QuickDASH Score	41.02 (23.05)	-	1.000

Assessment of the construct of URAM by correlation with the QuickDASH scale. Results indicated as mean (standard deviation). N=40. *r* = Spearman's coefficient.

The Brazilian version of the URAM demonstrated excellent internal consistency, with Cronbach's alpha coefficients of 0.930 and 0.938. According to Landis and Koch[18], this coefficient indicates very high consistency among the construct's responses. Such values indicate high homogeneity among the items and suggest that the questions coherently assess the same construct: functional limitation related to Dupuytren's disease. These findings are comparable to those of international studies: the Italian version presented a Cronbach's alpha coefficient of 0.94[10], the Spanish version 0.85[11], while the German[12], Dutch[13], and Korean[14] versions presented an alpha of 0.91, corroborating the stability of the instrument across different cultures.

The reproducibility of the URAM-BR was also excellent. The intra-class correlation coefficients ranged from 0.897 to 0.968 across the questions, confirming the stability of responses over time. According to the criteria of Koo and Li[19], ICC values above 0.90 are considered indicative of excellent reproducibility, while values between 0.75 and 0.90 are good. These results support the use of URAM-BR in clinical and research contexts that require stable responses over time. The reproducibility demonstrated in this study was superior to that of the Dutch version, which presented an ICC of 0.76 (0.64-0.87)[13], and was comparable to the Korean version, with an ICC of 0.89 (0.78-0.95)[14], to the Spanish version, with an ICC of 0.93 (0.88–0.96)[11], and to the Italian version, with an ICC of 0.96 (0.94–0.98)[10]. The German version[12] did not present ICC values for comparison.

Construct validity was evidenced by a statistically significant correlation with the Brazilian version of the QuickDASH scale, a widely used instrument that is not specific to Dupuytren's disease (DD)[8]. The Spearman correlation coefficients were 0.690 and 0.695 for the first and second applications of the URAM, respectively, both statistically significant ($p < 0.001$). According to Cohen's classification, these values indicate a moderate-to-strong correlation, demonstrating that URAM-BR comparably measures the functional aspects of the upper limb, with the advantage of specifically capturing the limitations imposed by the progressive digital contracture of DD[20].

The Spanish version also used QuickDASH as a comparative instrument and found a slightly higher Spearman correlation coefficient, $r = 0.716$[11]. In contrast, the Korean and Italian versions employed Pearson correlation with the PRWHE-I and K-PRWE, presenting values of $r = 0.60$ [10] and $r = 0.56$ [14], respectively. The German validation demonstrated a higher inverse correlation between URAM and the reduced total score of the MHQ, $r = -0.76$[12], while the Dutch version found $r = -0.65$ in comparison with the MHQ[13].

The qualitative analysis of item comprehension indicated a high clarity rate in all items (≥ 92.5%). This high understanding rate attests to the effectiveness of the cultural adaptation process, especially in modifying item 1, which originally referred to the use of *gant de toilette*, an object that is not common in Brazil, and was adapted to washing with an open hand, respecting functional and semantic equivalence[15].

Despite the promising results, this study has relevant limitations. Firstly, the sample size was small (n = 40), which limits the generalizability of the findings. Additionally, there was a predominance of postoperative patients (65%), limiting comparisons across clinical stages of the disease, such as the pre-treatment and conservative follow-up phases. No sensitivity-to-change analysis (responsiveness) was conducted, an essential criterion for the instrument's use in longitudinal studies of therapeutic efficacy. Finally, the application of URAM-BR has not yet been tested in different regional and socioeconomic contexts in Brazil, which would be fundamental to ensure its external validity and national applicability.

Ultimately, URAM-BR emerges as a valuable tool for both clinical practice and scientific research in hand rehabilitation and surgery. Its brief format, accessible language, clarity in questions, and ability to capture the specific functional limitations of DD make it ideal for routine application. The availability of a validated version in Brazilian Portuguese fills an important gap in the functional assessment of DD.

CONCLUSION

The URAM questionnaire was translated and culturally adapted, and its psychometric properties were tested in the Brazilian population, resulting in the URAM-BR, a clear, easy-to-use instrument with excellent internal consistency, reproducibility, and construct validity.

CONTRIBUTIONS OF THE AUTHORS

Each author made a personal and significant contribution to the development of this article. SRG: study conception, data collection and analysis, and writing; DVYC: data collection, statistical analysis, and writing; LLGS: statistical interpretation of data, methodological review, and critical content review; SJBG: partial writing and final review; BJC: partial writing and final review; FF: partial writing and final review.

DATA AVAILABILITY DECLARATION

Data will be made available upon request.

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Appendix 1.

T1:						
Can you...	**Without difficulty (0)**	**With a little difficulty (1)**	**With some difficulties (2)**	**With a lot of difficulty (3)**	**Almost impossible (4)**	**Impossible (5)**
1) Wash yourself with a hand towel?	☐	☐	☐	☐	☐	☐
2) Wash your face?	☐	☐	☐	☐	☐	☐
3) Pick up a bottle with one hand?	☐	☐	☐	☐	☐	☐
4) Shake someone's hand?	☐	☐	☐	☐	☐	☐
5) Pet something or someone?	☐	☐	☐	☐	☐	☐
6) Clap your hands?	☐	☐	☐	☐	☐	☐
7) Completely separate your fingers?	☐	☐	☐	☐	☐	☐
8) Support oneself with one hand?	☐	☐	☐	☐	☐	☐
9) Pick up small objects between the thumb and index finger?	☐	☐	☐	☐	☐	☐

T2:						
Can you...	**Without difficulty (0)**	**With very little difficulty (1)**	**With some difficulties (2)**	**With a lot of difficulty (3)**	**Almost impossible (4)**	**Impossible (5)**
1) Wash oneself with a bath glove?	☐	☐	☐	☐	☐	☐
2) Wash the face?	☐	☐	☐	☐	☐	☐
3) Pick up a bottle with one hand?	☐	☐	☐	☐	☐	☐
4) Shake someone's hand?	☐	☐	☐	☐	☐	☐
5) Caress anything or anyone?	☐	☐	☐	☐	☐	☐
6) Clap?	☐	☐	☐	☐	☐	☐
7) Spread the fingers apart?	☐	☐	☐	☐	☐	☐
8) Lean on the hand?	☐	☐	☐	☐	☐	☐
9) Grab small objects between the thumb and index finger?	☐	☐	☐	☐	☐	☐

T12:						
Can you...	**Without difficulty (0)**	**With a little difficulty (1)**	**With some difficulties (2)**	**With a lot of difficulty (3)**	**Almost impossible (4)**	**Impossible (5)**
1) Lather oneself with an open hand?	☐	☐	☐	☐	☐	☐
2) Wash your face?	☐	☐	☐	☐	☐	☐
3) Pick up a bottle with one hand?	☐	☐	☐	☐	☐	☐
4) Shake someone's hand?	☐	☐	☐	☐	☐	☐
5) Pet something or someone?	☐	☐	☐	☐	☐	☐
6) Clap your hands?	☐	☐	☐	☐	☐	☐
7) Open the hand by spreading the fingers apart?	☐	☐	☐	☐	☐	☐
8) Lean on the hand?	☐	☐	☐	☐	☐	☐
9) Pick up small objects between the thumb and index finger?	☐	☐	☐	☐	☐	☐

RT1:						
Pouvez-vous...	**Sans difficulté (0)**	**Avec un peu de difficulté (1)**	**Avec une certaine difficulté (2)**	**Avec beaucoup de difficulté (3)**	**Presque impossible (4)**	**Impossible (5)**
1) Vous savonner avec la main ouverte?	☐	☐	☐	☐	☐	☐
2) Vous laver le visage?	☐	☐	☐	☐	☐	☐
3) Prendre une bouteille d'une main?	☐	☐	☐	☐	☐	☐
4) Serrer la main de quelqu'un?	☐	☐	☐	☐	☐	☐
5) Caresser quelque chose ou quelqu'un?	☐	☐	☐	☐	☐	☐
6) Applaudir?	☐	☐	☐	☐	☐	☐
7) Ouvrir la main en écartant les doigts?	☐	☐	☐	☐	☐	☐
8) Prendre appui sur la main?	☐	☐	☐	☐	☐	☐
9) Prendre de petits objets entre le pouce et l'index?	☐	☐	☐	☐	☐	☐

RT2:						
Pouvez-vous...	**Sans difficulté (0)**	**Avec un peu de difficultés (1)**	**Avec une certaine difficultés (2)**	**Avec beaucoup de difficultés (3)**	**Presque impossible (4)**	**Impossible (5)**
1) Vous savonner avec la main ouverte?	☐	☐	☐	☐	☐	☐
2) Laver votre visage?	☐	☐	☐	☐	☐	☐
3) Prendre une bouteille avec la main?	☐	☐	☐	☐	☐	☐
4) Serrer la main de quelqu'un?	☐	☐	☐	☐	☐	☐
5) Caresser quelque chose ou quelqu'un?	☐	☐	☐	☐	☐	☐
6) Applaudir?	☐	☐	☐	☐	☐	☐
7) écarter les doigts les uns des autres?	☐	☐	☐	☐	☐	☐
8) Vous appuyer sur la main?	☐	☐	☐	☐	☐	☐
9) Prendre de petits objets entre le pouce et l'index?	☐	☐	☐	☐	☐	☐

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UPDATES ON THE TREATMENT OF ANTERIOR TIBIAL TUBEROSITY AVULSION FRACTURES IN ADOLESCENTS

ATUALIZAÇÕES NO TRATAMENTO DAS FRATURAS POR AVULSÃO DA TUBEROSIDADE ANTERIOR DA TÍBIA EM ADOLESCENTES

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ABSTRACT

Anterior tibial tuberosity avulsion fracture (ATF) is a rare injury in adolescents, usually associated with sports activities, ranging from mild to complex cases. Early diagnosis and appropriate treatment are essential to recover knee function and avoid complications. This study analyzed updates and innovations in the treatment of ATF in adolescents, highlighting recent therapeutic approaches and their efficacy. A narrative review of the literature was performed in the Lilacs, PubMed and Capes Periodicals databases. Treatment should be individualized, with a conservative approach for stable fractures and surgical fixation for severe cases. Advances such as fluoroscopy-guided percutaneous fixation have optimized recovery, allowing better joint assessment and less invasiveness. Postoperative management emphasizes early mobilization and physiotherapeutic rehabilitation, favoring functional recovery and a safe return to sports. The prognosis is generally favorable, provided the diagnosis is accurate and the follow-up is rigorous. Rehabilitation is essential to restore muscle strength and prevent relapses. Despite advances, the scarcity of long-term studies highlights the need for more research to standardize protocols and improve clinical outcomes. ***Level of Evidence II, Review Study.***

Keywords: Fractures, Avulsion; Tibia; Adolescent; Treatment Outcome.

RESUMO

A fratura-avulsão da tuberosidade anterior da tíbia (FATAT) é uma lesão rara em adolescentes, geralmente associada a atividades esportivas, variando de casos leves a complexos. O diagnóstico precoce e o tratamento adequado são fundamentais para recuperar a função do joelho e evitar complicações. Este estudo analisou as atualizações e inovações no tratamento da FATAT em adolescentes, destacando abordagens terapêuticas recentes e sua eficácia. Foi realizada uma revisão narrativa da literatura nas bases Lilacs, PubMed e Periódicos Capes. O tratamento deve ser individualizado, com abordagem conservadora para fraturas estáveis e fixação cirúrgica para casos graves. Avanços como a fixação percutânea guiada por fluoroscopia têm otimizado a recuperação, permitindo melhor avaliação articular e menor invasividade. O manejo pós-operatório enfatiza mobilização precoce e reabilitação fisioterapêutica, favorecendo a recuperação funcional e o retorno seguro ao esporte. O prognóstico é geralmente favorável, desde que o diagnóstico seja preciso e o acompanhamento rigoroso. A reabilitação é essencial para restaurar a força muscular e prevenir recidivas. Apesar dos avanços, a escassez de estudos de longo prazo evidencia a necessidade de mais pesquisas para padronizar protocolos e aprimorar os resultados clínicos. ***Nível de Evidência II, Estudo de Revisão.***

Descritores: *Fratura Avulsão; Tíbia; Adolescente; Resultado do Tratamento.*

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INTRODUCTION

Anterior tibial tuberosity avulsion fractures (ATF) are rare but clinically significant injuries that predominantly occur in adolescents during the skeletal growth phase. These fractures are characterized by the displacement of the bony fragment from the tibial tuberosity due to excessive traction from the patellar tendon, usually during high-intensity physical activities such as jumping or running. The incidence is higher in boys aged 14 to 16, coinciding with the period of closure of the proximal tibial physis, which makes the area more vulnerable to traction forces.[1]

ATF occurs when the tension exerted by the patellar ligament exceeds the combined resistance of the underlying physes, the surrounding perichondrium, and the adjacent periosteum. This injury can result from two main mechanisms: abrupt and intense contraction of the quadriceps muscle against a fixed tibia, usually observed during explosive jumps, or sudden passive flexion of

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The study was conducted at Universidade Estadual do Piaui (UESPI), Departamento de Ortopedia e Traumatologia, Teresina, PI, Brazil.
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the knee while the quadriceps remains contracted. Additionally, associated injuries may occur that affect the surrounding ligaments, the menisci, and, in rare cases, the tibial plateau.[2]

It is also noteworthy that ATF is frequently associated with pre-existing conditions, such as Osgood-Schlatter disease, which can weaken the patellar tendon's insertion at the tibial tuberosity. Although the relationship between these conditions is not completely causal, the presence of Osgood-Schlatter may increase the risk of avulsion during sports activities.[3] Furthermore, the classification of these fractures has evolved over the years, with contributions from Watson-Jones, Ogden, Tross, and Murphy, and more recently by Ryu and Debenham, who proposed the inclusion of type IV fractures, involving the proximal epiphysis of the tibia and the posterior metaphysis.[1,4]

The treatment of ATF depends on the classification of the fracture, the extent of displacement, and the presence of complications, such as compartment syndrome. Less severe fractures (types IA, IB, and IIA) can be treated conservatively with immobilization and load restriction, while more complex fractures (types III, IV-A, and IV-B) require open reduction and internal fixation with cannulated screws to ensure stability and proper consolidation.[4]

Post-operative rehabilitation plays a crucial role in functional recovery, with intensive programs aimed at restoring range of motion, muscle strength, and the ability to return to daily and sports activities. Recent studies highlight that, with appropriate treatment, most patients achieve excellent functional outcomes, with a low impact on quality of life.[5]

Given the clinical relevance of ATF and the potential complications associated with inadequate diagnosis and treatment, it becomes essential to conduct studies that systematize and critically analyze the available therapeutic strategies. The evolution of surgical techniques, combined with the improvement of rehabilitation protocols, reinforces the need for updated reviews that guide clinical decision-making. Thus, this study is justified by the importance of understanding innovations in the management of these injuries, contributing to the optimization of functional outcomes and the improvement of the quality of life of affected adolescents.

METHODOLOGY

This research consists of a narrative review of the literature, a suitable format for describing and examining the evolution of a specific topic. As it is a qualitative approach, it provides the reader with the opportunity to deepen and update their knowledge on the subject. This type of study does not require a methodology that allows for data reproduction or quantitative analysis.[6]

Research strategy in databases

The narrative review on the treatment of avulsion fractures of the anterior tibial tuberosity was developed through research in the databases Latin American and Caribbean Literature in Health Sciences (LILACS), *Scientific Electronic Library Online* (SciELO), and PubMed. The study was conducted in January and February 2025. For the selection of articles, the descriptors "*Avulsion Fractures of the Anterior Tibial Tuberosity", "Adolescent"* were combined with the boolean operator "AND."

Eligibility criteria

The established inclusion criteria were articles published in Portuguese and English that had a direct relationship with the topic addressed and that had been published in the period from 2018 to 2024. In contrast, the exclusion criteria included studies that were not aligned with the proposed subject, publications in languages other than those specified, and articles that were only partially available.

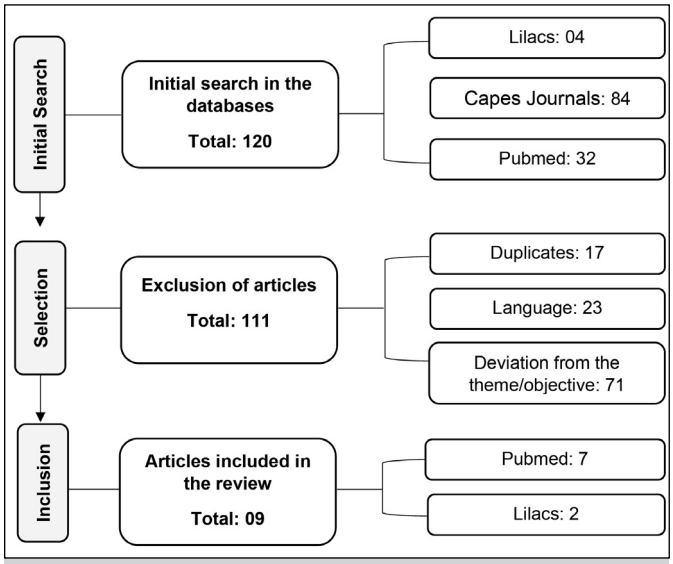
Data organization

After the search stage, the articles were classified and structured according to the main themes, being organized by areas of knowledge. During the analysis, the publications chosen to compose the review were segmented into four central axes, which will be explored throughout the study, namely:

1. Definition, Etiology, and Classification of Anterior Tibial Tuberosity Avulsion Fractures;
2. Diagnostic Methods and Clinical Assessment;
3. Conventional Treatments and Current Approaches;
4. Innovations and Future Trends in Fracture Management.

Selection of studies

Initially, a total of 120 articles were located in the selected databases, with 4 from Lilacs, 32 from PubMed, and 84 in the Capes Periodicals Portal. Based on the eligibility criteria, 111 articles were excluded, leaving 9 for review and inclusion in the narrative review (Figure 1).



Source: Author (2025).

Figure 1. Review and selection of the articles included in the review.

RESULTS AND DISCUSSION

The results of this narrative review explore fundamental aspects of ATF, covering its definition, etiology, and classification, in addition to the main diagnostic methods used in clinical practice. The analysis includes a review of conventional therapeutic approaches, from conservative treatment to surgical techniques indicated for different degrees of injury severity. Furthermore, recent innovations in the management of these fractures are discussed, focusing on advances in bone fixation, new rehabilitation strategies, and future perspectives to optimize clinical and functional outcomes for patients.

Nine studies were highlighted, most of which addressed adolescents aged 14 to 15 years, with ages ranging from 12 to 18 years. All participants were male, and the use of cannulated screw fixation was emphasized as a prior technique.

General aspects of anterior tibial tuberosity avulsion fractures

The tibial tuberosity originates from a secondary ossification center located in the proximal portion of the tibia. Unlike the proximal epiphysis of the tibia, which forms under compressive forces, the tibial tuberosity is classified as an apophysis and develops under tension. The process of tubercle formation is divided into four stages: cartilaginous, apophyseal, epiphyseal, and osseous. The closure of

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the proximal epiphysis of the tibia occurs progressively, advancing distally towards the tuberosity apophysis, creating a period of greater mechanical vulnerability, which may favor the occurrence of avulsion fractures. This characteristic partly explains the rarity of recurrences of this type of injury, although they may occur, especially in pre-adolescent patients aged between 9 and 12 years.[4]

According to Kunis et al.[7], the ATF are traumatic injuries that predominantly occur in adolescents, characterized by the displacement of the bone fragment from the tibial tuberosity due to excessive traction of the patellar tendon. This region is particularly vulnerable during the skeletal growth period, when the proximal tibial physis is in the process of closing. The ATF is considered a rare injury, with reported incidence between 0.4% and 2.7% of pediatric fractures, being more common in boys aged between 14 and 16 years.

The etiology of ATF is directly related to mechanisms of indirect trauma, such as the violent contraction of the quadriceps muscle against a fixed foot, common in sports activities involving jumps, such as basketball and soccer. Another frequent mechanism is the abrupt flexion of the knee against a vigorous contraction of the quadriceps, as occurs during the landing of a jump.[2]

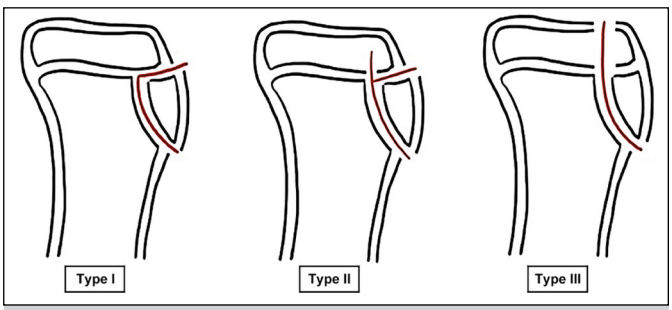
Predisposing factors include the presence of conditions such as Osgood-Schlatter disease, which weakens the insertion of the patellar tendon at the tibial tuberosity, increasing the risk of avulsion during high-intensity activities.[3] Additionally, the developmental phase of the tibial tuberosity, which occurs under tension (in contrast to the proximal tibial epiphysis, which develops under compression), makes the region more susceptible to injuries during the closure period of the physis.[7]

The classification of ATF has evolved over the years, with significant contributions from various authors. The original classification by Watson-Jones[8] describes three types of fractures:

- Type I: Avulsion of a small portion of the tibial tuberosity, distal to the proximal physis.
- Type II: Fracture that extends through the physis but does not involve the knee joint.
- Type III: Fracture that extends proximally to the physis, involving the knee joint.

Figure 2 presents the Watson-Jones classification (1974), which categorizes fractures into three types: I, II, and III.

Subsequently, Ogden et al.[9] expanded this classification to include subtypes (A and B) that consider the degree of displacement and comminution, which explain: IA: fracture through the center of ossification, without displacement; IIB: fracture through the center of ossification, with minimal displacement; IIA: separation of the anterior tuberosity of the tibia; IIB: comminution of the center of ossification; IIIA: trans-epiphyseal articular fracture without comminution; IIIB: trans-epiphyseal articular fracture with comminution. Ryu and Debenham[10] proposed the addition of Type IV, which involves the avulsion of the proximal tibial epiphysis and the posterior metaphysis, creating a more complex configuration.



Source: Adapted from Kunis et al. (2021).

Figure 2. Watson-Jones classification system.

More recently, Frankl et al.[11] suggested the inclusion of a Type C, which encompasses fractures associated with the avulsion of the patellar ligaments, while McKoy and Stanitski[12] proposed Type V, characterized by a "Y" fracture that combines elements of Types III and IV.

This evolution in classification reflects the anatomical complexity and diversity of fracture patterns, allowing for a more precise and individualized therapeutic approach.[7]

Diagnostic methods and clinical assessment

The diagnosis of ATF is based on a combination of clinical assessment and imaging, aimed at identifying the extent of injury, the degree of displacement, and possible associated complications.[4]

The clinical presentation of ATF is generally acute, with a history of indirect trauma during sports activities, such as jumping or running. Patients often report intense pain in the anterior region of the knee, accompanied by local swelling and an inability to actively extend the leg. On physical examination, visible deformity may be observed at the tibial tuberosity, tenderness to palpation, and, in severe cases, an inability to ambulate.[13]

The conventional assessment of avulsion fractures of the anterior tibial tuberosity is performed through radiographs in anteroposterior (AP) and lateral views of the knee. Since the tibial tuberosity is not perfectly aligned with the midline of the tibia, a slight internal rotation of the leg can position it perpendicular to the radiographic film, providing a more accurate view of the injury. Additionally, the presence of a high patella can be identified in lateral images, aiding in the analysis of the clinical picture.[14]

According to Zaizi et al.[15], plain radiography is the initial method of choice, while Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) are reserved for complex cases or when there is suspicion of associated injuries. Early and accurate identification of the fracture is crucial to guide treatment and prevent complications, such as compartment syndrome or loss of knee function.

Conventional treatments and current approaches

The treatment of ATF is determined based on the classification of the fracture, the degree of displacement, and the presence of associated complications. Therapeutic approaches range from conservative methods to surgical interventions, with the main objective of restoring the integrity of the extensor mechanism and, when necessary, preserving the articular surface.[4]

Fractures with minimal displacement (types IA, IB, and IIA) can be treated conservatively. Treatment includes immobilization with a cast or brace in full extension of the knee for four to six weeks, followed by progressive rehabilitation. Load restriction is recommended until there is radiographic evidence of bone consolidation.[14]

The conservative approach is primarily indicated for patients with stable fractures and no compromise of the knee joint. However, it is essential to regularly monitor fracture alignment and consolidation with serial X-rays to avoid complications such as nonunion or loss of reduction.[14]

In less severe cases, conservative treatment involves closed reduction of the fracture, followed by immobilization with a long or cylindrical cast for approximately four weeks until bone consolidation is confirmed on imaging. Fractures with greater displacement or joint involvement require open reduction with internal fixation, using screws, tension band wires, Kirschner wires, Steinmann pins, or periosteal sutures, followed by a period of immobilization of three to four weeks.[4]

Fractures with significant displacement (types III, IV-A, IV-B, and V) or involvement of the knee joint generally require RAFI. RAFI allows for direct visualization of the fracture, ensuring anatomical reduction and stable fixation. Cannulated screws are often used to fix the fractured fragment, while plates and Kirschner wires may be employed in more complex cases.[15]

Regarding the treatment of associated complications, it is noteworthy that compartment syndrome is a potentially serious complication of ATF and requires immediate diagnosis and treatment. Fasciotomy is the procedure of choice to relieve intracompartmental pressure and prevent irreversible damage to soft tissues.[16,17]

Furthermore, the importance of postoperative rehabilitation is emphasized, as it is a critical component of ATF treatment, regardless of the chosen approach. Physical therapy programs are initiated early to restore the range of motion, muscle strength, and knee function. Partial weight-bearing is gradually allowed, with a full return to sports activities after 3 to 6 months, depending on clinical and radiographic progress.[1,18,19]

Postoperative management generally follows protocols that prioritize initial immobilization, early weight support, and gradual progression of range of motion. Symptomatic pain control and physiotherapeutic rehabilitation are essential for the recovery of muscle strength and joint stability. The choice of treatment should be individualized, taking into account the specific characteristics of the fracture and the patient. The advancement of minimally invasive techniques and the development of bioabsorbable materials have contributed to better functional outcomes and a lower incidence of complications, demonstrating significant progress in the treatment of ATF.[7]

Therapeutic approaches used in recent studies

In recent years, various therapeutic approaches have been explored and refined in the management of tibial tuberosity avulsion fracture, a rare but significant injury that primarily affects adolescents during sports activities. Recent studies highlight advances in both conservative treatments, indicated for minimally displaced cases, and surgical treatments, recommended for unstable fractures or with significant displacement. Additionally, new fixation techniques, such as cannulated screws and tension wires, have been developed to improve fracture stability and accelerate rehabilitation. The personalization of treatment, considering factors such as fracture pattern, patient skeletal maturity, and functional demand, has become an essential principle in clinical decision-making. In this way, the analysis of current therapeutic strategies allows for understanding their efficacy and safety, as well as identifying trends and gaps that require further investigation to improve specific outcomes and prevent complications.

In this perspective, the study by Pacífico Júnior et al.[1] reports the case of an adolescent with an avulsion fracture of the tibial tuberosity, where the diagnosis was confirmed by imaging tests, and the treatment performed was surgical fixation with screws, which showed good results regarding the treatment used, with adequate stabilization of the bone fragment and allowed for progressive rehabilitation. The postoperative follow-up reported good clinical evolution, with bone lesions recovered and complete functional recovery of the knee, reinforcing the efficacy of surgical treatment in this condition.

Zhao et al.[3] reported a case of an adolescent with an avulsion fracture of the anterior tibial tuberosity associated with Osgood-Schlatter disease, a condition that weakens the patellar tendon insertion and increases susceptibility to this type of injury. The patient presented with intense pain and swelling in the knee after a sudden contraction of the quadriceps during a sports activity, and the diagnosis was confirmed by imaging tests, which revealed the displacement of the bone fragment. The treatment involved open reduction under epidural anesthesia, surgical fixation with cannulated screws, and reinforcement with sutures, ensuring stabilization of the fracture. After two weeks, the stitches were removed, and healing was completed, with the knee kept immobilized for four weeks before starting exercises for restoring range of motion and muscle strengthening. At the three-month follow-up, joint mobility had already reached 0° to 120°, and the implants were removed after 12 months, allowing the patient to resume activities without pain or functional limitations.

In the study by Pedrazzini et al.[18], a 13-year-old adolescent suffered a ATF during a basketball game, presenting with intense pain and inability for active extension of the knee. The diagnosis was confirmed by X-rays and CT scans, which revealed lateral displacement of the patella and possible injury to the lateral ligamentous retinacula. Classified as Type IB according to Ogden, the fracture was treated with RAFI using cannulated screws to ensure anatomical restoration and mechanical stability. The procedure was performed 10 days after the trauma, through an anterior approach with an incision centered on the tibial tuberosity. The postoperative period followed a structured rehabilitation protocol, beginning with physical therapy to restore joint mobility, followed by muscle-strengthening exercises. After three months, the patient showed no pain, limping, or local tenderness, being cleared for a progressive return to sports activities, including basketball, without complications or functional sequelae.

Similarly, in the case report by Zaizi et al.[15], an adolescent suffered an ATF during a school sports activity, characterizing a mechanism of injury associated with sudden and intense contraction of the quadriceps muscle. The diagnosis by imaging tests revealed the displacement of the bone fragment. Given the fracture pattern and degree of displacement, surgical treatment was chosen using the RAFI technique with cannulated screws, aiming for anatomical restoration and stability of the extensor mechanism. In the postoperative period, the patient followed a protocol of temporary immobilization, followed by progressive physical therapy to restore mobility and muscle strength. The evolution was satisfactory, with adequate bone consolidation, absence of complications, and complete functional return to sports activities after rehabilitation.

In addition to these, in the study by Giunchi et al.[19], the authors described two rare cases of simultaneous bilateral avulsion of the anterior tibial tuberosity in adolescents occurring during sports activities. Both patients presented with severe pain, swelling, and inability to actively extend their knees after jumping during basketball practice. The diagnosis was confirmed by X-rays and CT scans, which revealed avulsion fractures classified as Type III according to Watson-Jones. The treatment consisted of RAFI with cannulated screws in both knees, performed in a single surgical session. The fixation was supplemented with absorbable sutures to reinforce the insertion of the patellar tendon. Postoperatively, the patients were immobilized with braces and kept non-weight bearing for 6 weeks, followed by a progressive rehabilitation protocol. After 3 months, both patients showed complete radiographic consolidation, recovery of range of motion, and return to sports activities without complications.

In the study by Bombah et al.[14], the authors reported two cases of ATF among Cameroonian adolescents occurring during sports activities. Both patients were boys and sustained the injury after a violent contraction of the quadriceps during sports (high jump and soccer). The fractures were classified as Type IV according to Ryu and Debenham (case 1) and Type IA according to Ogden (case 2). The treatment for the first case was surgical, with internal fixation through double screw fixation, while the second case was treated conservatively, with immobilization using a cast brace. Both patients achieved excellent functional outcomes, with complete fracture consolidation, recovery of range of motion, and return to sports activities without complications.

Therefore, it is emphasized that these cases highlight the importance of an individualized approach, considering the classification of the fracture and the degree of displacement, and reinforce the effectiveness of both surgical and conservative treatments, when appropriately indicated, to ensure good clinical and functional results.

CONCLUSION

According to the analyzed data, it was found that simultaneous bilateral avulsion of the anterior tubercle of the tibia in adolescents is a rare condition, with a lack of consensus on the ideal therapy. The management of these fractures should be individualized, taking into account the severity of the injury, the degree of bone displacement, and the presence of associated injuries. Early diagnosis and appropriate treatment choice, whether conservative or surgical, are essential to ensure effective recovery and minimize complications. Surgical approaches, such as internal fixation with cannulated screws, have demonstrated effectiveness in restoring extensor mechanism stability, allowing a gradual return to functional activities. Furthermore, postoperative rehabilitation is crucial for restoring muscle strength and preventing recurrences. Despite advances in treatment, the lack of long-term studies on this condition highlights the need for further research to establish more standardized protocols and improve clinical outcomes.

CONTRIBUTIONS OF THE AUTHORS

Each author contributed individually and significantly to the development of this article. FFRNN: Conception and design of the work, analysis and interpretation of the data, writing of the work, final approval of the version of the manuscript to be published; SCMGC: analysis and interpretation of the data, writing of the work, final approval of the version of the manuscript to be published; VDN: Writing of the work and critical review of its intellectual content, final approval of the version of the manuscript to be published; SJA: Writing of the work and critical review of its intellectual content; BAA: Conception and design of the work, critical review of its intellectual content, final approval of the version of the manuscript to be published; PNOC: Conception and design of the work, critical review of its intellectual content, final approval of the version of the manuscript to be published.

DATA AVAILABILITY DECLARATION

The authors confirm that all data supporting the findings of this study are available within the article.

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KIRSCHNER WIRES *VERSUS* SCREW FIXATION FOR LATERAL HUMERAL CONDYLE FRACTURES IN CHILDREN: A SYSTEMATIC REVIEW AND META-ANALYSIS

FIOS DE KIRSCHNER *VERSUS* FIXAÇÃO COM PARAFUSO PARA FRATURAS DO CÔNDILO LATERAL DO ÚMERO EM CRIANÇAS: UMA REVISÃO SISTEMÁTICA E META-ANÁLISE

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ABSTRACT

Objective: Lateral condyle fractures of the humerus are the second most common elbow fracture in children. Both Kirschner wires (K-wires) and cannulated screws are widely used for fixation, but the optimal technique remains debated. This study aimed to compare these methods in terms of functional outcomes and complications. Material and Methods: A systematic review and meta-analysis were conducted in accordance with PRISMA guidelines. Results: Thirteen comparative studies involving 1,230 pediatric patients were included. Outcomes were analyzed using random-effects models, with risk ratios (RRs) and 95% confidence intervals (CIs). Meta-regression and prediction intervals (PIs) were applied to explore heterogeneity. Screw fixation significantly reduced the risk of postoperative infection (RR = 0.27; 95% CI: 0.12–0.60) and was associated with better functional outcomes (RR = 1.09; 95% CI: 1.01–1.18). No significant differences were observed in overall complications (RR = 0.89; 95% CI: 0.66–1.20), lateral overgrowth, range of motion limitation, or nonunion. Meta-regression did not identify age or fracture severity as effect modifiers. Conclusion: Cannulated screw fixation may be preferable for reducing infection and improving outcomes, but individualized clinical decisions and further high-quality research remain essential. ***Level of Evidence III; Systematic Review.***

Keywords: Humeral Fractures; Fracture Fixation, Internal; Elbow Joint; Bone Screws; Kirschner Wires; Pediatrics.

RESUMO

Objetivo: A fratura do côndilo lateral do úmero é a segunda mais comum do cotovelo da criança. Os fios de Kirschner e os parafusos canulados são amplamente utilizados para sua fixação, mas o dispositivo ideal ainda é discutível. Este estudo teve como objetivo comparar esses métodos considerando os resultados funcionais e as complicações. Material e Métodos: Foi realizada uma revisão sistemática e uma metanálise, seguindo as diretrizes PRISMA. Resultados: Treze estudos comparativos envolvendo 1.230 pacientes pediátricos foram incluídos. Os resultados foram analisados usando modelos de efeitos aleatórios, com razões de risco (RRs) e intervalos de confiança (ICs) de 95%. Meta-regressão e intervalos de predição (PIs) foram aplicados para explorar a heterogeneidade. A fixação com parafuso reduziu significativamente o risco de infecção pós-operatória (RR = 0,27; IC 95%: 0,12–0,60) e foi associada a melhores resultados funcionais (RR = 1,09; IC 95%: 1,01–1,18). Nenhuma diferença significativa foi observada considerando: complicações gerais (RR = 0,89; IC 95%: 0,66–1,20), supercrescimento lateral, limitação da amplitude de movimento ou não-união. A meta-regressão não identificou idade ou gravidade da fratura como modificadores de efeito. Conclusão: A fixação com parafuso canulado é preferencial para reduzir infecções e melhorar os resultados, mas decisões clínicas individualizadas e pesquisas futuras de alta qualidade continuam sendo essenciais. ***Nível de Evidência III; Revisão Sistemática.***

Descritores: *Fraturas do Úmero; Fixação Interna de Fraturas; Articulação do Cotovelo; Parafusos Ósseos; Fios de Kirschner; Pediatria.*

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INTRODUCTION

Fractures of the lateral condyle of the humerus represent the second most common type of elbow fracture in the pediatric population, accounting for approximately 12% to 20% of these injuries. These fractures predominantly affect children aged 5 to 10 years and are typically the result of a fall with the hand extended, leading to an avulsion injury at the lateral condyle due to traction on the extensor muscles.[1]

Involvement of the growth plate increases the risk of disturbances to this structure, while intra-articular extension may lead to bone

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The study was conducted at Department of Orthopedics and Traumatology, Paulista School of Medicine, Universidade Federal de Sao Paulo, Sao Paulo, SP, Brazil.
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incongruence if not managed properly. Consequently, accurate diagnosis and appropriate treatment are critical to prevent complications such as non-union, malunion, angular deformities, and long-term functional impairment.[2]

Surgical intervention is generally indicated for fractures that exhibit displacement greater than 2 mm, especially when there is disruption of the articular surface or instability on stress testing.[2] The two main methods of surgical fixation are the use of Kirschner wires (K-wires) and cannulated screws. K-wire fixation is a traditional technique that involves the percutaneous insertion of wires to stabilize the fracture, often requiring prolonged immobilization and carrying a risk of pin-tract infections.[3] On the other hand, cannulated screw fixation provides stable internal stabilization, allowing for early mobilization and reducing the risk of superficial infections.[4] However, screw fixation generally requires a second surgical procedure for removal, similar to K-wires. The choice between these methods remains a topic of debate, as each has its own advantages and potential complications, and the current literature presents inconclusive results regarding their efficacy and safety profiles.

We found a systematic review that included studies up to 2023, where several important limitations were reported.[5] This review failed to incorporate all available studies comparing K-wire fixation and screw fixation for pediatric lateral condyle fractures. Additionally, several new studies have been published since then, providing updated data that may potentially alter the previously observed conclusions.[5] Therefore, the present systematic review and meta-analysis aims to provide a more comprehensive, updated, and methodologically rigorous synthesis of the comparative outcomes between K-wire fixation and cannulated screw fixation. Our primary objective is to assess the functional aspect and complication rates associated with each technique. We also explore the influence of patient age and fracture classification on treatment outcomes.

MATERIALS AND METHODS

This systematic literature review was conducted according to the PRISMA guidelines *(Preferred Reporting Items for Systematic Reviews and Meta-Analyses)*.[6] The main objective is to compare the clinical and functional outcomes of fixation with K-wires versus fixation with screws in the treatment of lateral condyle humeral fractures in children. The study population consisted of patients under 18 years of age diagnosed with lateral condyle humeral fractures. The intervention of interest was fixation using Kirschner wires, compared to fixation with screws. The primary outcomes assessed were functional recovery and postoperative infection rates. The secondary outcomes included lateral overgrowth, nonunion or malunion, and avascular necrosis (AVN) after surgical treatment. The included study designs were randomized clinical trials (RCTs) and cohort studies (prospective or retrospective).

This review was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO) under registration number CRD420251012187. The review protocol, including eligibility criteria and outcome definitions, was established and submitted before initiating the systematic database search.

Eligibility criteria

The eligibility criteria encompassed full-text RCTs published in English from inception to April 2025 and indexed in PubMed, Scopus, Embase, and Cochrane CENTRAL. The studies directly compared fixation with K-wires and screws in pediatric patients with lateral condyle humeral fractures and reported relevant clinical outcomes, including functional recovery and postoperative complications.

We excluded articles not available in full text via institutional or open-access platforms, conference abstracts, preprints, letters to the editor, case reports, case series, reviews, cross-sectional studies, and case-control studies. Studies that did not report sufficient information on the outcomes of interest were also excluded. In cases of duplicate publication, only the most complete and recent version of the study was retained for analysis.

Search strategy

For the database search, descriptors related to "Lateral Condyle of the Humerus," "Fracture," "Screw Fixation," "K-wire," and "Children" were used. The descriptors were obtained from the *Medical Subject Headings* (MeSH), accessed at www.ncbi.nlm.nih.gov/mesh/. The Boolean operators "AND" and "OR" were used for term searches on the mentioned platforms, adhering to the articles' inclusion and exclusion criteria.

Study selection

Two independent reviewers, blind to each other's evaluations, jointly screened the titles and abstracts of all retrieved articles to identify those that met the predefined inclusion criteria. Studies deemed potentially eligible were then read in full to confirm their inclusion in the review. In cases of disagreement, a senior reviewer, who had access only to the disputed articles, made the final decision. The selection of studies was conducted using the Rayyan application.[7]

To ensure comprehensive coverage of the available literature, a snowballing strategy[8] was also employed: the reference lists of all relevant systematic reviews identified through the initial search were screened to identify additional eligible primary studies, and the references of the included full-text articles were likewise reviewed after full reading to detect any potentially overlooked studies in the database search.

Data synthesis

Data extraction was performed independently and in duplicate to ensure accuracy and reliability. Two reviewers extracted data from the included studies using a pre-designed data extraction form created in Microsoft Excel® (2025 version). The form captured comprehensive details about the study characteristics, including population size, specifics of the intervention and control groups, methodological approaches, and the outcomes assessed. Any discrepancies between the reviewers were resolved through discussion or consultation with a senior reviewer to reach a consensus.

Quality assessment

The risk of bias was assessed using two Cochrane tools, selected according to the study design: cohort studies were evaluated with the ROBINS-I *(Risk Of Bias In Non-randomized Studies of Interventions)*[9], while RCTs were assessed using the revised RoB 2 tool *(Risk of Bias tool for randomized trials)*.[10] All assessments were conducted independently by two reviewers, and any disagreements were resolved through discussion and consensus. Publication bias was assessed using a funnel plot with enhanced contours, which displays point estimates against study weights and highlights areas of statistical significance to aid interpretation of the asymmetry.[11]

Statistical analysis

Functional and complication outcomes, given their event-based nature, were analyzed using relative risks (RRs), with corresponding 95% confidence intervals (CIs). Heterogeneity among studies was assessed using Cochran's Q test and the I^2 statistic. A p-value < 0.10 and $I^2 > 25\%$ were considered indicative of significant heterogeneity. A random-effects model was applied to account for potential methodological variability among studies, despite statistical heterogeneity. The Restricted Maximum Likelihood (REML) method was the primary estimator for variance among studies. However, for the infection outcome, the REML method failed to converge due

to the data characteristics; therefore, the Der Simonian and Laird model estimator was employed as an alternative.

Subgroup analyses were conducted based on study design (RCTs vs. cohort studies). A sensitivity analysis was conducted to assess the influence of individual studies on the pooled estimates. Although pre-specified in the protocol, the sensitivity analysis, which included only studies with low risk of bias, was not performed because none of the included studies met this criterion. Meta-regression analyses were conducted to explore the impact of two study-level covariates: mean patient age and the proportion of participants classified as Milch type II. These regressions aimed to investigate potential moderators of effect size. All statistical analyses were performed using RStudio (version 764), employing the 'meta' and 'metafor' packages.

RESULTS

A comprehensive search of the literature across multiple databases initially yielded 1,286 records. After the removal of duplicates, 1,003 unique articles remained for title and abstract screening. Based on the predefined eligibility criteria, 25 studies were selected for full-text review, resulting in the inclusion of 9 articles.[12-20] To complement the database search, a search was conducted using the reference lists of the included studies and six additional systematic reviews on the same topic[5, 21-25], thereby identifying 411 additional records. After screening these, 33 full-text articles were reviewed, of which 2 additional studies met the inclusion criteria[26-27]. In total, 11 studies were included in the systematic review and meta-analysis.[12-20,26,27] The complete study selection process, including reasons for exclusion, is detailed in Figure 1.

Characteristics of the studies

Of the eleven included studies[12-20,26,27], four were open-label randomized clinical trials[12,19,26,27] and seven were retrospective cohort studies[13-18,20]. None of the trials were blinded. The study populations consisted of children with lateral condyle humeral fractures, typically indicated for surgery when displacement exceeded 2 mm, which was the common inclusion criterion across all studies. In total, 1,820 patients were included, of whom 514 were treated with cannulated screws and 1,306 with K-wires. Males represented approximately 51.15% of the total sample; however, two studies did not specify the sex distribution of their participants.[14,16] The average age of the patients was approximately 7.8 years. The follow-up periods varied among the studies, ranging from 10 weeks to 4.8 years (on average), with seven studies reporting at least 12 months of follow-up.[12-15,20,26,27] More details about the included studies are provided in Table 1.

Metanalysis of function

A total of seven studies evaluated postoperative functional outcomes in the included patient population.[12,17-20,26,27] However, only five were eligible for inclusion in the meta-analysis, as they used the same measurement tool, the Hardacre criteria.[12,17,18,20,26] This scale categorizes functional recovery into four levels: excellent, good, fair, and poor, based on criteria such as pain, range of motion, and return to activity. For the purposes of this meta-analysis, only patients classified as having "excellent" function were considered to have experienced a positive outcome.

In total, 286 patients were included in the analysis. The pooled results demonstrated a favorable association for the cannulated screw group (RR = 1.37; 95% CI = 1.02 to 1.85; PI = 0.57 to 3.27; p = 0.606; I^2 = 64.7%) (Figure 2). Although the association suggests a benefit of cannulated screws, the wide prediction interval and moderate-to-high heterogeneity suggest that future studies could modify the overall conclusion. The sensitivity analysis revealed that this association remained statistically significant only when the study by Li et al. was excluded.

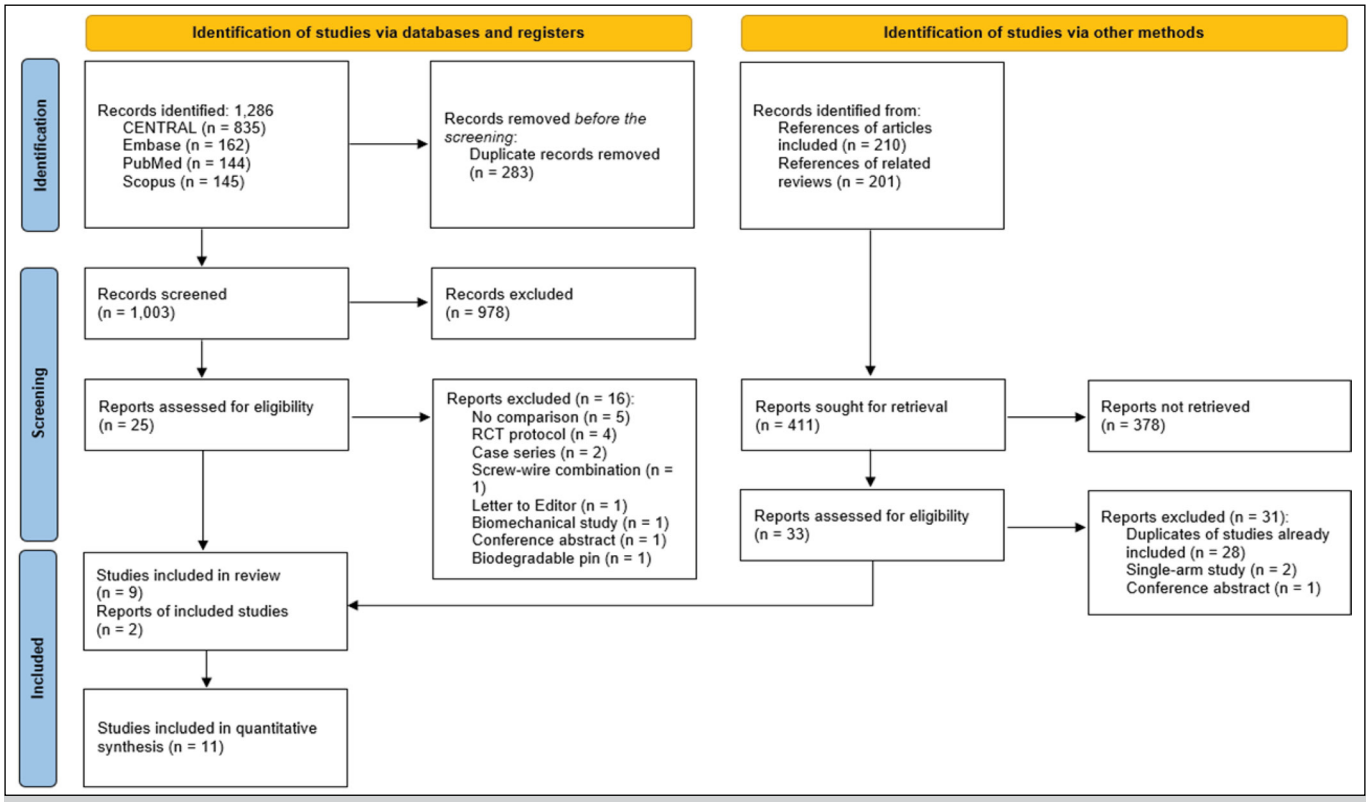

Figure 1. PRISMA flow diagram of the study selection and inclusion process.

Table 1. The main characteristics of the included studies.

Authors/Year	Country	Study Design	Follow-up	Included Patients		Mean Age (years)*		Gender†		Milch Classification	
				Screw	Kirshner Wire	Screw	Kirshner Wire	Screw	Kirshner Wire	Screw	Kirshner Wire
Afaque and Singh 2020	India	Open trial	18 mo‡	21	19	7.5a	7.9a	15 / 8	13 / 4	Type I: 8 Type II: 13	Type I: 7 Type II: 12
Cummings et al. 2023	United States	Retrospective cohort	12 mo	209	553	7.81 ± 3.61	8.78 ± 3.63	350 / 203	126 / 83	Type I: 102b Type II: 646	
Ganeshalingam et al. 2018	Canada	Retrospective cohort	4.8 y‡	101	235	7.15 ± 3.17	5.84 ± 2.77	62 / 39	143 / 92	Type I: 11 Type II: 89	Type I: 80 Type II: 154
Gilbert et al. 2016	United States	Retrospective cohort	6.8 mo‡	41	43	6.2 ± 3.03	5.2 ± 2.33	29 / 12	30 / 13	-	-
Gupta et al. 2023	India	Open trial	12 mo	23	23	6.26a	6.87a	15 / 8	19 / 4	Type I: 7 Type II: 16	Type I: 5 Type II: 18
Li et al. 2011	China	Retrospective cohort	39.4 mo‡	32	30	7.02a	6.83a	18 / 14	24 / 6	Type I: 9 Type II: 23	Type I: 5 Type II: 25
Pace et al. 2018	United States	Retrospective cohort	10 w‡	14	318	-	-	-	-	-	-
Stein et al. 2017	United States	Retrospective cohort	7.3 mo‡	26	22	5.9 ± 2.73	5.1 ± 1.73	20 / 6	13 / 9	Type I: 0 Type II: 26	Type I: 0 Type II: 22
Thapa et al. 2019	Nepal	Open trial	12 mo	23	23	6.26a	6.87a	15 / 8	19 / 4	Type I: 7 Type II: 16	Type I: 5 Type II: 18
Vergara and Fretes 2023	Paraguay	Open trial	6 mo	11	19	7.27 ± 2.80	6.42 ± 1.50	7 / 4	13 / 6	Type I: 5 Type II: 6	Type I: 7 Type II: 12
Wendling-Keim et al. 2020	Germany	Retrospective cohort	18 mo	13**	21	6.91 ± 2.83	5.67 ± 3.47	-	-	-	-

Legend: y = years; mo = months; w = weeks. *Mean ± Standard Deviation; **4 patients in the group used screw + K wire; †Male/Female; ‡The authors reported the average follow-up; aThe author did not provide the standard deviation; bThe author did not stratify the classification for the groups.

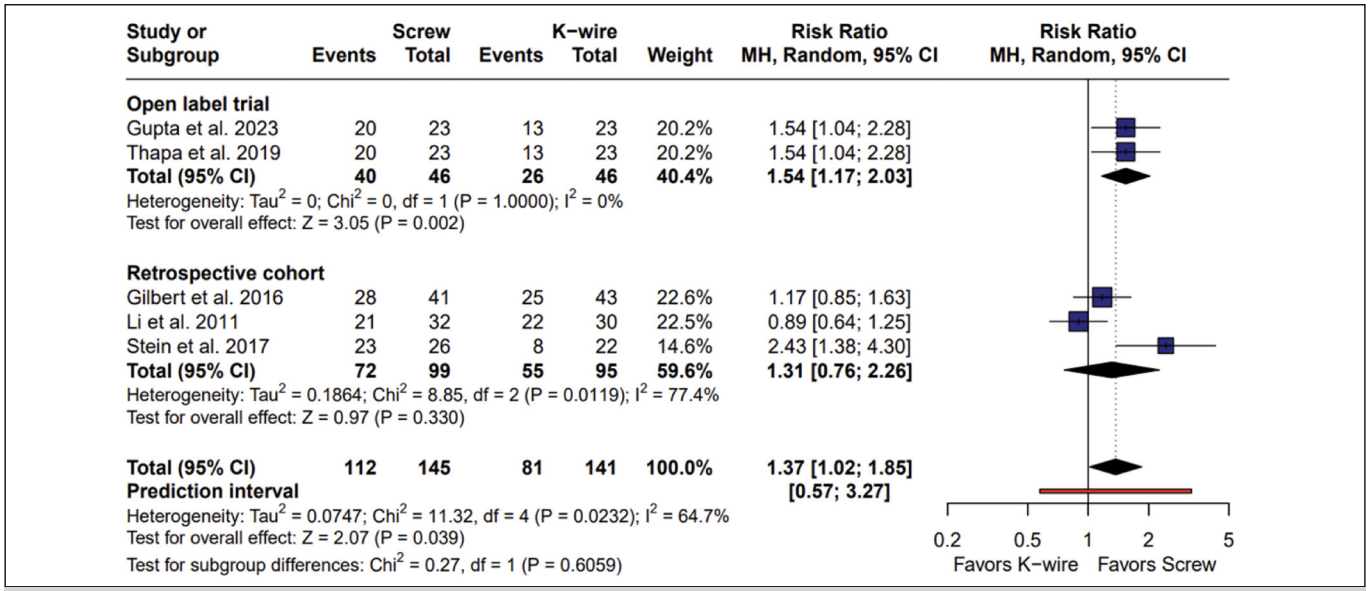

Figure 2. Forest plot showing the risk ratio for functional outcome based on the proportion of patients classified as "excellent" according to the Hardacre criteria, comparing cannulated screws with K-wires.

Meta-regression analyses did not show a significant relationship between functional outcome and the average age of participants (β = -0.32, p = 0.27) or the proportion of type II Milch fractures (β = 0.02, p = 0.25). Residual heterogeneity remained high, with a significant test for unexplained variance, suggesting that other unmeasured covariates may contribute to variability in functional outcomes. More details of the meta-regression are presented in Figure 3.

Metanalysis of complications

The included studies reported postoperative complications inconsistently. Overall, the most commonly assessed and frequently observed complications were infection, malunion, nonunion, lateral overgrowth, and reduced range of motion. Less frequently reported complications included partial loss of fixation, nerve injury, and various adverse events. No serious complications or patient deaths were reported in any of the included studies.

A general meta-analysis was conducted, grouping all reported complications, regardless of type. A total of 1,488 patients were included. The study by Pace et al. (2018) was excluded from this analysis, as the authors did not stratify the total number of complications by treatment group, reporting only the non-union rates separately. No statistically significant difference was observed

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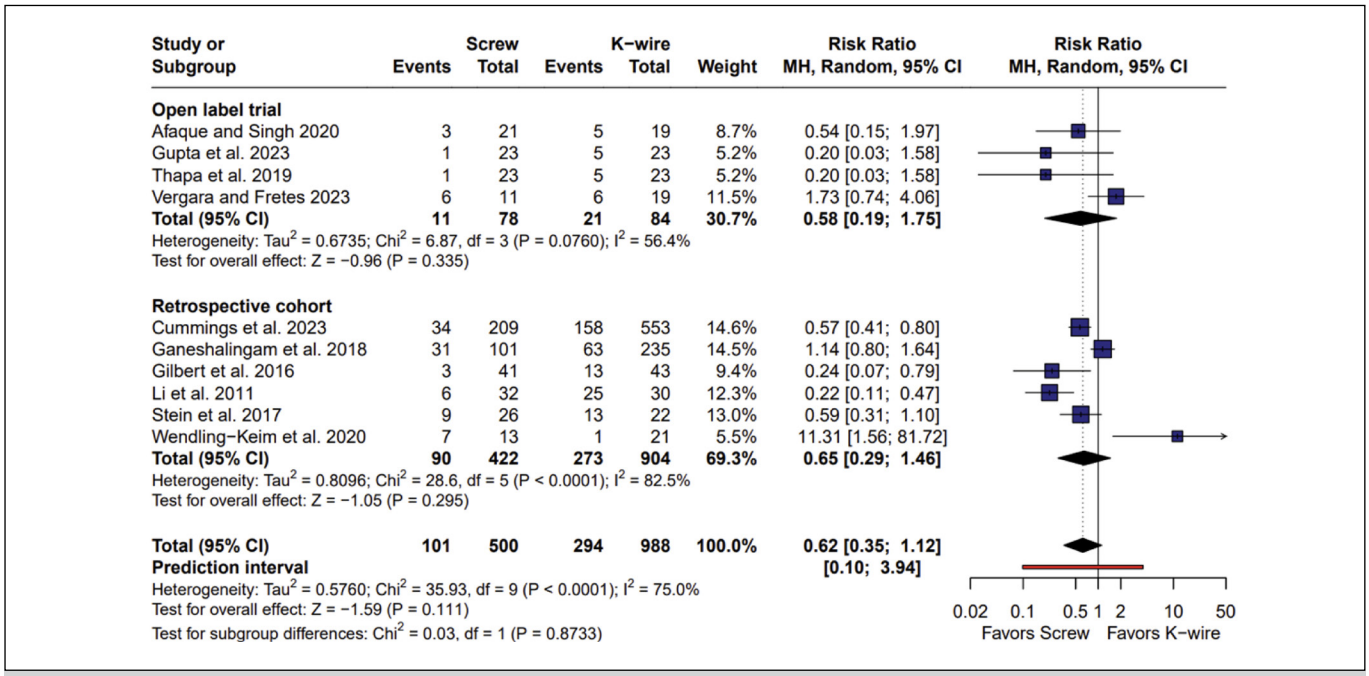

Figure 3. Forest plot showing the risk ratio for overall complication rates in patients treated with cannulated screws versus K-wires.

between the groups regarding the overall risk of complications (RR = 0.62; 95% CI = 0.35 to 1.12; PI = 0.10 to 3.94; p = 0.111; I^2 = 75.0%) (Figure 4).

The meta-regression analyses did not show a significant association between complication rates and the average age of study participants (β = -0.12, p = 0.72) or the proportion of Milch type II fractures (β = -0.01, p = 0.60). Residual heterogeneity remained high, and the significant test for unexplained variance suggests that other unmeasured covariates may be influencing the observed results. More details of the meta-regression analysis are provided in Table 2.

Infection

A total of 1488 patients were included in this analysis, which primarily involved infections managed conservatively with antibiotic therapy only. Only a few patients required surgical reinterventions; however, stratified data distinguishing between conservative and surgical management were reported in few studies. The remaining studies provided only overall infection rates, preventing a stratified meta-analysis. The risk of infection was significantly lower in the group treated with cannulated screws (RR = 0.23; 95% CI = 0.10 to 0.52; PI = 0.08 to 0.64; p < 0.001; I^2 = 0%) (Figure 5). The narrow prediction interval suggests that future studies are unlikely to substantially alter these results.

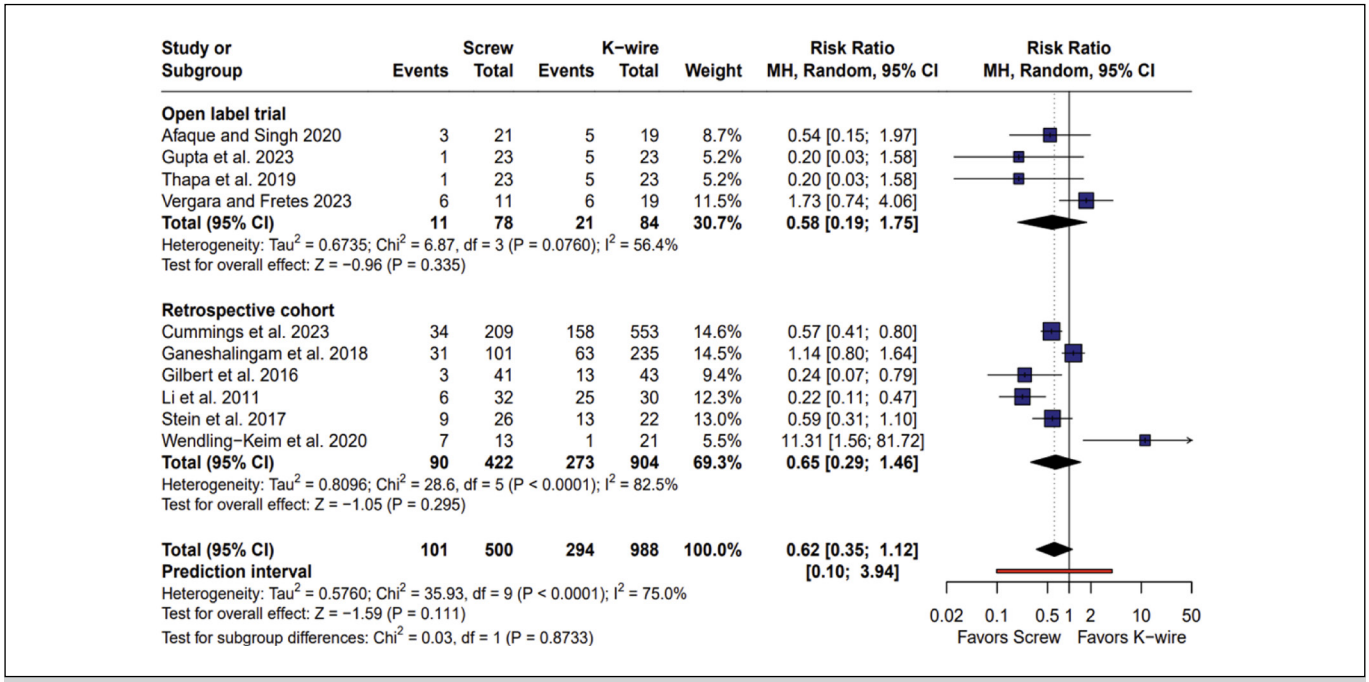

Figure 4. Forest plot showing the risk ratio for overall complication rates in patients treated with cannulated screws versus K-wires.

Table 2. Meta-regression analysis of the relationship between covariates (average age and proportion of Milch type II) and outcomes (function and complications).

	Effect estimates	P-value	I (%)	Residual heterogeneity test
Average Age (Function)				
Intercept	2.31	0.21	65.83	P=0.0300
Average Age	-0.32	0.27		
Proportion of Milch type II (Function)				
Intercept	-1.40	0.37	74.07	p = 0.0175
Milch type II	0.02	0.25		
Middle Ages (Complications)				
Intercept	0.33	0.88	79.73	p < 0.0001
Average Age	-0.12	0.72		
Milch type II ratio (Complications)				
Intercept	0.12	0.92	78.02	p < 0.0016
Milch type II	-0.01	0.60		

Lateral overgrowth

Lateral overgrowth in 1488 patients was observed through clinical evaluation and radiographic comparison of the affected limbs. The outcome was typically identified by asymmetry in the length or alignment of the operated limb in follow-up images and physical examination, as reported by the included studies. No statistically significant difference was observed between the groups (RR = 0.66; 95% CI = 0.31 to 1.43; PI = 0.19 to 2.35; p = 0.295; I^2 = 5.6%) (Figure 6).

Mobility reduction

The reduction in mobility was assessed in 1448 by measuring the postoperative range of motion (ROM) of the affected elbow, typically during follow-up after bone consolidation. These measurements were compared both to the expected physiological ROM for the pediatric population and to the ROM of the contralateral, unaffected limb. No statistically significant difference was found between the groups (RR = 0.98; 95% CI = 0.35 to 2.76; PI = 0.04 to 22.05; p = 0.967; I^2 = 65.4%) (Figure 7).

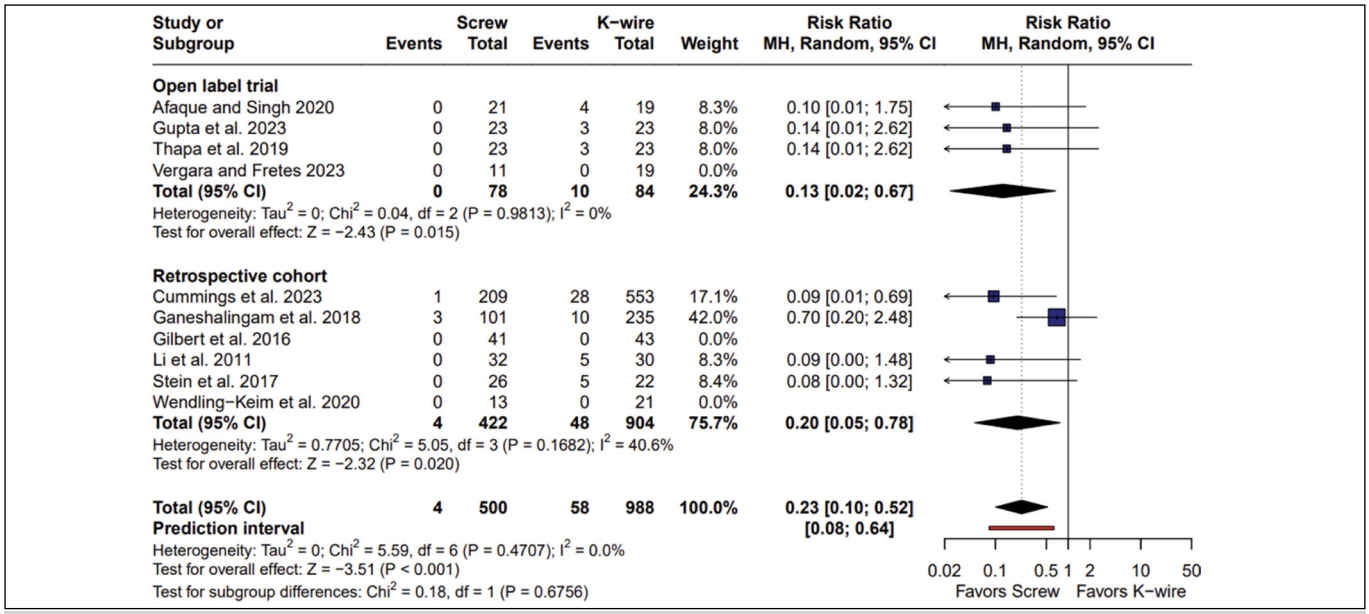

Figure 5. Forest plot showing the hazard ratio for infection in patients treated with cannulated screws versus K-wires.

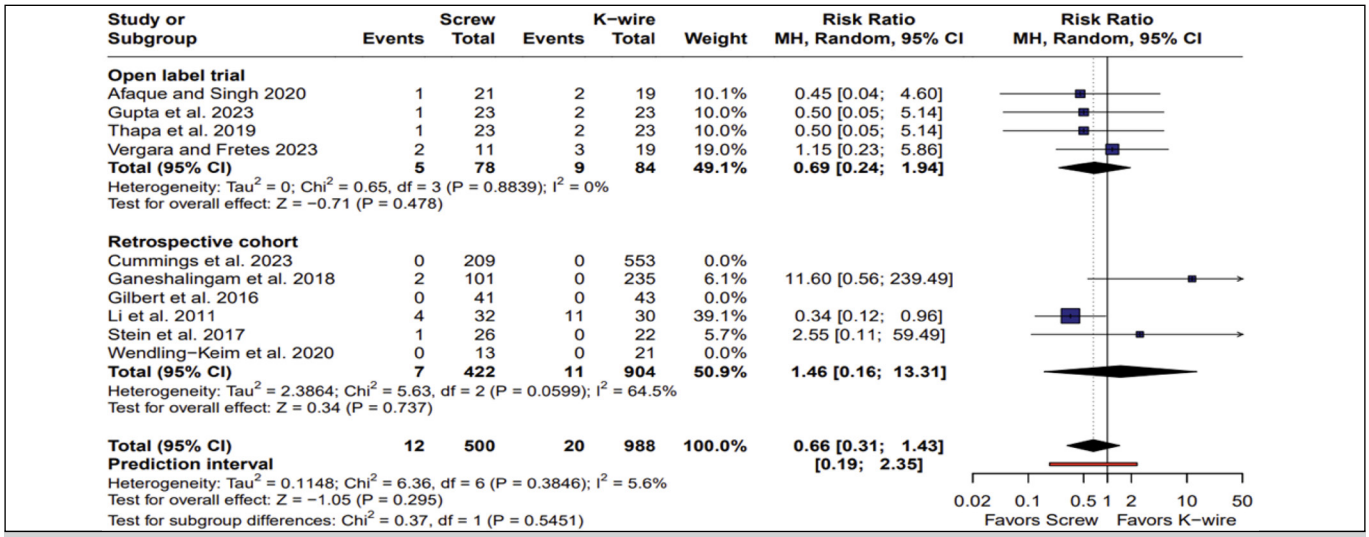

Figure 6. Forest plot showing the hazard ratio for lateral overgrowth in patients treated with cannulated screws versus K-wires.

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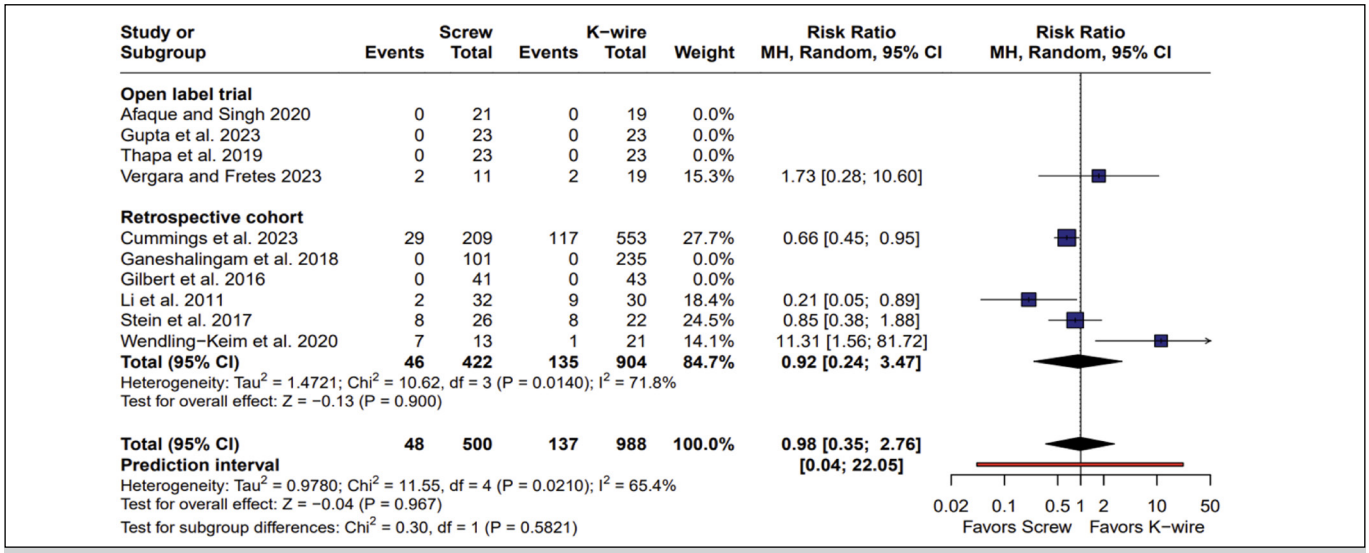


Figure 7. Forest plot showing the risk ratio for reduced range of motion in patients treated with cannulated screws versus K-wires.

Non-union and vicious consolidation

A total of 1,820 patients were included in this analysis. Non-union and vicious consolidation were typically assessed through a combination of clinical and radiographic criteria during follow-up. This included evidence of incomplete or delayed bone consolidation on imaging, persistent pain or dysfunction, angular deformity, or the need for surgical revision due to inadequate fracture consolidation or alignment. In the combined analysis, no statistically significant difference was observed between the groups (RR = 0.73; 95% CI = 0.32 to 1.64; PI = 0.19 to 2.72; p = 0.439; I^2 = 6.0%) (Figure 8).

Risk of bias of included studies

The risk of bias of the included studies is summarized in Figures 9 and 10.

Risk of bias in randomized studies

All four studies raised some concerns regarding the randomization process (Domain 1). Although some authors described the use of random number tables and opaque envelopes to allocate patients, the details on whether the allocation sequence was concealed were not sufficiently reported, leaving the possibility of selection bias.[12,19,26] In the study by Afaque and Singh (2020), the methodological information regarding this process was particularly limited. Regarding deviations from intended interventions (Domain 2), most studies adhered to the allocated treatments[12,19,26], but in the case of Afaque and Singh (2020), patients without adequate follow-up were excluded from the assessment, and no intention-to-treat analysis was applied, which increased the risk of bias in this domain. Concerning missing outcome data (Domain 3), most studies had complete follow-up or minimal loss, while Afaque and Singh (2020) excluded approximately 15% of participants without accounting for these losses in the analysis. In Domain 4, related to outcome measurement, none of the studies blinded their assessors, and all used subjective measures such as pain and functional scores, leading to some general concerns.[12,19,26,27] In Domain 5, none of the included trials had a published protocol or registered analysis

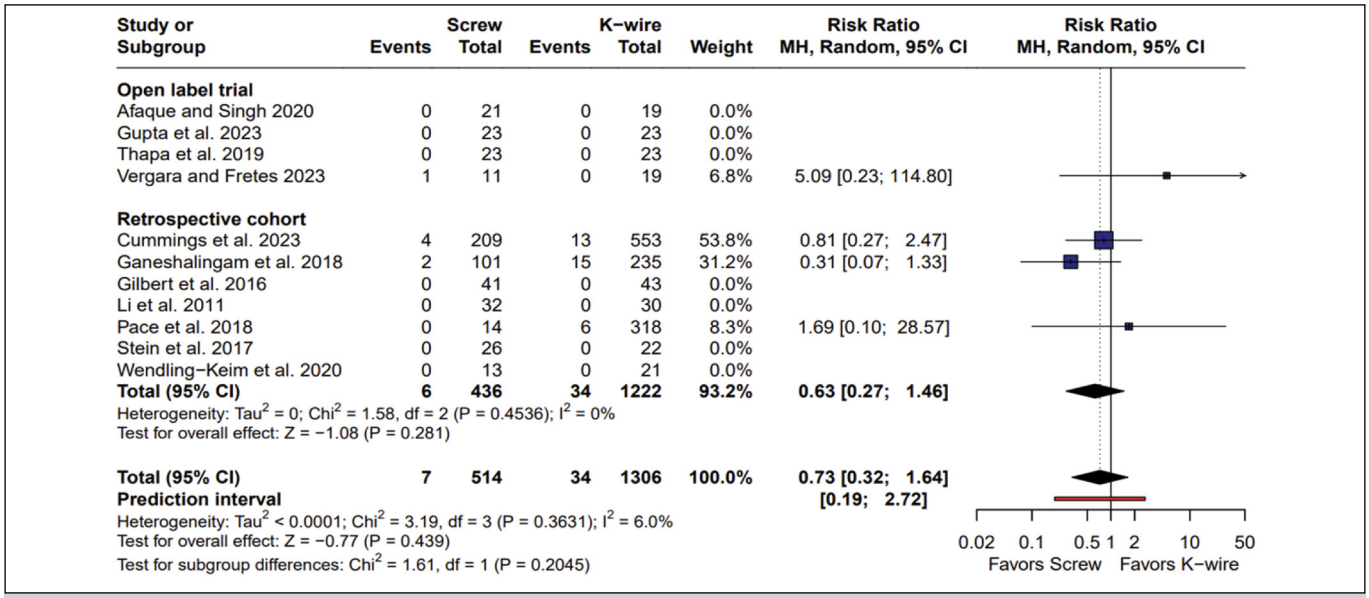
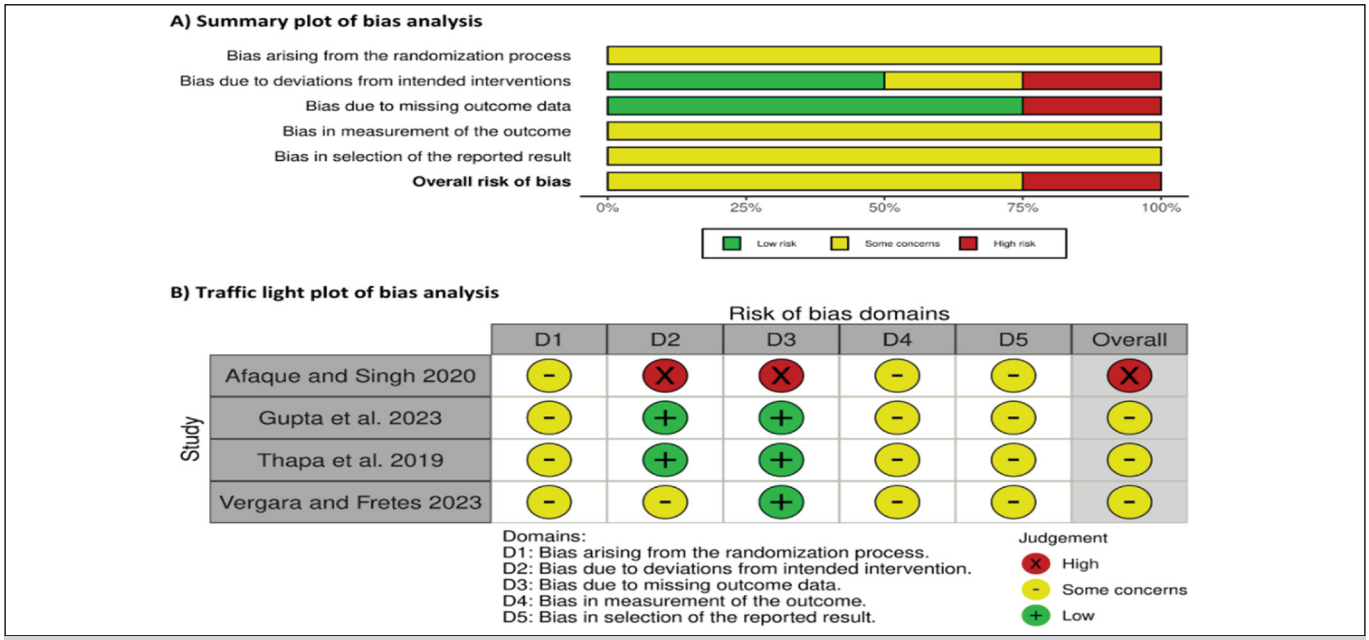
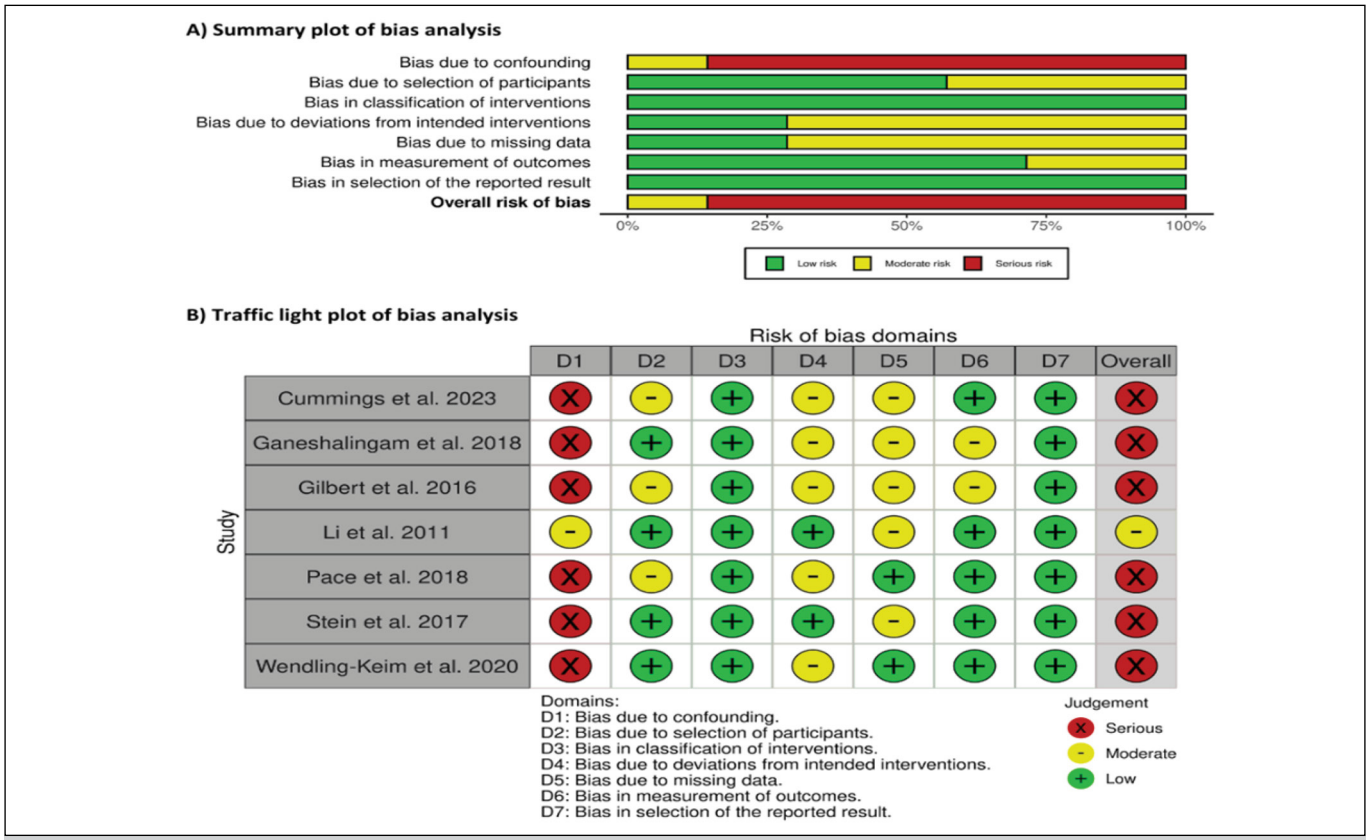


Figure 8. Forest plot showing the risk ratio for non-union/vicious consolidation in patients treated with cannulated screws versus K-wires.



A) Summary plot of the bias analysis. B) Traffic light plot of the bias analysis.

Figure 9. Assessment of the risk of bias of the included randomized clinical trials using the RoB 2.0 tool.



A) Summary plot of the bias analysis. B) Traffic light plot of the bias analysis.

Figure 10. Assessment of the risk of bias in the included non-randomized studies using the ROBINS-I tool.

plan, which hindered verification of outcome reporting decisions and contributed to concerns in all cases.[12,19,26,27]

Risk of bias in cohort studies

The most frequent and serious concerns were related to confounding factors (Domain 1). Six studies were classified with serious risk in this domain due to allocation driven by institutional practice, time, or clinical severity at presentation. The study by Li et al. (2011) was considered to have a moderate risk, mainly due to treatment choice likely influenced by the surgeon's preference or fragment morphology. In Domain 2 (participant selection), most studies were classified as low risk, although moderate concerns were identified in

three cases where inclusion was limited to patients with complete follow-up, potentially excluding more severe or complex cases.[13,15,16,20] For missing outcome data (Domain 3), all studies were considered low risk, with no substantial attrition or differential follow-up.[12-20,26,27] In deviations from intended interventions (Domain 4), moderate risk was presented in four studies due to limitations in describing whether all patients received the initially planned technique or if intraoperative decisions altered the intervention.[13-16,18] In bias due to handling of missing data (Domain 5), moderate concerns were observed in five studies that lacked detailed information on the impact of incomplete follow-up or did not conduct appropriate sensitivity analyses.[13,15-18] For Domain 6 (outcome measurement), most studies were low risk, although Ganeshalingam et al. (2018) and Gilbert et al. (2016) raised moderate concerns due to the lack of blinding and inconsistent assessment methods. All studies were judged to be at low risk in Domain 7 (selection of reported outcomes).[12-20,26,27]

DISCUSSION

This systematic review with meta-analysis demonstrated a statistically significant association between cannulated screw fixation and superior functional outcomes compared to K-wires in pediatric lateral condyle humeral fractures. Additionally, screw fixation was associated with a significantly lower risk of postoperative infection, while no significant difference was identified between the two techniques in overall complication rates, lateral overgrowth, range of motion reduction, or nonunion and malunion. These findings highlight potential advantages of screw fixation, particularly in reducing superficial infections, but also emphasize the need for cautious interpretation of functional outcomes.

Stable fixation with cannulated screws allows for early mobilization, potentially reducing the risk of joint stiffness and facilitating a quicker return to function. In contrast, fixation with K-wires often requires prolonged immobilization due to less rigid stabilization, which may contribute to higher rates of elbow stiffness and superficial infections, as the wires remain exposed through the skin and can serve as entry points for pathogens.[13] This heterogeneity suggests that, although the average effect favors screw fixation, the results of individual studies vary, and in some cases, fixation with K-wires may produce comparable outcomes. The broad PI highlights the uncertainty and potential influence of factors such as surgical technique, patient age, fracture pattern, and postoperative rehabilitation protocols on the effectiveness of the fixation method. Therefore, although current evidence leans towards the benefits of screw fixation, clinicians should interpret these findings with caution, considering the specific clinical context and patient characteristics. We conducted meta-regression analyses to explore potential sources of heterogeneity, with particular focus on patient age and fracture classification. These factors are important in the prognosis of pediatric fractures. Younger children may have different healing capacities and risks than older children, and the degree of fracture displacement may affect treatment decisions and outcomes. However, our analyses did not identify a significant moderating effect of age or fracture severity on functional outcomes. This suggests that the observed heterogeneity in functional outcomes may be attributed to other unmeasured variables, such as variations in surgical technique, postoperative care protocols, or patient adherence to rehabilitation. Therefore, although our meta-regression did not point to specific factors influencing variability, it highlights the complexity of treatment outcomes and the need for individualized clinical assessments.

Previous systematic reviews have also explored comparative functional outcomes between Kirschner wire fixation and screw fixation in pediatric lateral condyle fractures. The study by Haghighi et al. (2025) reported a slightly higher rate of excellent functional outcomes in the screw group (82.2%) compared to the K-wire group (75.3%) using Hardacre criteria, suggesting a favorable trend towards screw fixation. Similarly, Cho et al. (2023)[5], in a meta-analysis including a randomized clinical trial and three cohort studies, found a significantly lower risk of postoperative range of motion limitation in the screw group (RR = 3.75; 95% CI: 1.54–9.18; $P < 0.01$), reinforcing the notion of superior functional recovery with screws. The work of Birkett et al. (2020) also demonstrated higher rates of excellent outcomes with screw fixation (95%) than with K-wire fixation (86%), although their analysis was narrative due to heterogeneity in outcome measures. In contrast, our systematic review included a larger set of studies and patients and applied a more comprehensive, statistically rigorous approach. By incorporating the prediction interval (PI), we were able to quantify the expected variability in functional outcomes in future scenarios, revealing that the effect size favoring screws, while significant, is not universally consistent. Furthermore, through meta-regression analyses, we investigated potential moderators such as patient age and Milch classification, enhancing the depth of our interpretation. These advanced methods enabled a more cautious, context-sensitive understanding of functional outcomes, going beyond simple aggregate effects and addressing heterogeneity among studies that previous meta-analyses did not adequately explore.

Several previous systematic reviews assessed the complication profiles associated with K-wire and screw fixation. The article by Sinha et al. (2023) found no statistically significant differences in overall complication rates between the two methods, reporting complications in 23.7% of K-wire cases and 20.4% of screw fixations, although union was more common in the screw group (93.2% vs. 91.1%). Similarly, Eckhoff et al. (2022) observed high union rates across all techniques (> 99%) in their comparison of K-wire under the skin and K-wire through the skin and screws. They highlighted that the K-wires, especially when not kept under the skin, had a shorter union time and better postoperative range of motion, although with higher rates of superficial infection. Tan et al. In 2018, in a review of 2,440 pediatric cases, they identified a wide spectrum of complications, such as valgus/varus deformities, loss of motion, prominence of the lateral condyle, and osteonecrosis. Infection occurred in approximately 4.8% of cases, and pain caused by the implants occurred in 22% of cases, regardless of fixation type. When compared with our systematic review, these findings were consistent in showing no major differences in overall complication rates. We found a significantly lower risk of postoperative infection in the screw group, while other complications, such as limited range of motion, non-union, and lateral overgrowth, did not differ significantly.

Regarding postoperative infection, most studies reported higher rates with the use of K-wires, especially when the wires were left outside the skin.[5,21,22] Our work corroborated this association by demonstrating a significantly lower risk of infection with screw fixation. Exposed K-wires through the skin create a direct pathway for bacterial entry, increasing the risk of contamination.[21] These factors, together, help explain why screw fixation consistently shows better outcomes in terms of infection prevention.

Limitations of the study

This study has some limitations that must be acknowledged. Most of the included studies were retrospective cohort designs, which are inherently susceptible to selection bias and confounding factors, particularly regarding treatment allocation based on institutional protocols or surgeon preference. Secondly, the definitions of outcomes, especially for complications such as lateral overgrowth, vicious consolidation, and reduced range of motion, were not fully

standardized across studies, which may introduce measurement bias and limit the comparability of results. Although subgroup analyses and meta-regression were performed to explore heterogeneity, several potentially relevant covariates, such as the exact surgical technique, duration of postoperative immobilization, or time to hardware removal, were not consistently reported and could not be analyzed. Furthermore, the inability to blind outcome assessors in all included trials and the absence of intention-to-treat analyses in at least one study may have inflated effect estimates. Finally, although publication bias was formally assessed, the limited number of studies for some outcomes may reduce the power of funnel plot analysis, and the observed asymmetry in the complication outcome suggests that reporting bias cannot be entirely ruled out.

CONCLUSION

Based on the current body of evidence, cannulated screw fixation appears to be associated with better functional outcomes and a lower risk of infection than Kirschner wire fixation for the management of lateral condyle fractures in children. However, the observed functional benefit may change as new evidence emerges. No significant difference was identified between the techniques regarding other postoperative complications. These findings should be interpreted with caution due to the predominantly observational nature of the included studies. Therefore, while screw fixation may offer advantages in clinical contexts where infection prevention is a priority, the current evidence does not support its overall superiority.

CONTRIBUTIONS OF THE AUTHORS

Each author made a personal and significant contribution to the development of this article. Conceptualization: DSJG; Data curation: DSJG, NAS, CIQ; Methodology: DSJG, NAS, DET; Original draft writing: SMG, TFA, CIQ; Supervision: DET; Review and editing of the manuscript: TFA, SMG, DET.

DATA AVAILABILITY DECLARATION

The underlying content of the research text is contained in the manuscript.

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