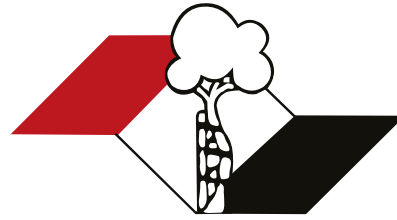


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





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

































































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Marcela dos Santos Martins, Janaina Bosso da Silva Ricciardi, Allan de Oliveira Santos, Margareth Castro Ozelo, Rodrigo Gonçalves Pagnano, Emerson Taro Inoue Sakuma

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KNEE

UTILIZATION OF ROBOTIC ARM ASSISTANCE FOR REVISION OF PARTIAL TO TOTAL KNEE ARTHROPLASTY: A CASE REPORT**UTILIZAÇÃO DA ASSISTÊNCIA DO BRAÇO ROBÓTICO PARA REVISÃO DA ARTROPLASTIA PARCIAL PARA ARTROPLASTIA TOTAL DE JOELHO: RELATO DE CASO**

Eduardo Frois Temponi, Felipe Santiago de Almeida, Lúcio Honório de Carvalho Júnior, Matheus Braga Jacques Gonçalves, Ricardo Leão Carmo, Vitor Rodrigues Miranda

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ORTHOPEDIC TRAUMA

COMPARATIVE STUDY OF DISTAL RADIUS FRACTURE FIXATION WITH A VOLAR PLATE VERSUS KIRSCHNER WIRES**ESTUDO COMPARATIVO DA FIXAÇÃO DE FRATURAS DO RÁDIO DISTAL COM PLACA VOLAR VERSUS FIOS DE KIRSCHNER**

Karina Seabra de Oliveira, Karen Cristina Barbosa Chaves, Paola Augusto Gomes, Gabriel Kosurian de Souza Sayegh, Vitor Augusto Queiroz Mauad, Fernando Nogueira Zambone Pinto, Rafael Saleme Alves, Edson Pereira de Lima Júnior, Paulo Cesar Vieira dos Santos

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PEDIATRIC ORTHOPEDIC

EPIDEMIOLOGICAL ANALYSIS OF FEMUR FRACTURES IN THE PEDIATRIC POPULATION IN A REFERENCE SERVICE IN THE STATE OF SERGIPE**ANÁLISE EPIDEMIOLÓGICA DAS FRATURAS DE FÊMUR NA POPULAÇÃO PEDIÁTRICA EM UM SERVIÇO DE REFERÊNCIA DO ESTADO DE SERGIPE**

Gustavo Henrique Cavalcanti Pereira Paixão, Thassyo Oliveira Sales, Gabriel Borges Paixão, Marcela Tavares Machado, Henrique de Sousa Monteiro, Mário Augusto Ferreira Cruz

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SHOULDER AND ELBOW

EVALUATION OF THE QUALITY AND RELIABILITY OF INFORMATION ON ADHESIVE CAPSULITIS (FROZEN SHOULDER) ON THE SOCIAL MEDIA PLATFORM INSTAGRAM

AVALIAÇÃO DA QUALIDADE E CONFIABILIDADE DAS INFORMAÇÕES SOBRE CAPSULITE ADESIVA (OMBRO CONGELADO) NA PLATAFORMA DE MÍDIA SOCIAL INSTAGRAM

Douglas Hideo Higuchi, Fabio Teruo Matsunaga, Guilherme Satake, Augusto Yassuo Mathuy, Marcel Jun Sugawara Tamaoki

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WRIST AND HAND

THERMOGRAPHY ACCURACY IN THE DIAGNOSIS OF CARPAL TUNNEL SYNDROME

ACURÁCIA DA TERMOGRAFIA NO DIAGNÓSTICO DA SÍNDROME DO TÚNEL DO CARPO

Maria Fernanda Franco de Oliveira dos Anjos, Sérgio Murilo Georgeto, Maycon Anderson Guedes Maciel Moreira, Rodrigo Antônio Carvalho Andraus

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REVIEW ARTICLE

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TREATMENT OF INFERIOR POLE FRACTURE OF THE PATELLA IN ADULTS: SYNTHESIS OF CLINICAL EVIDENCE

TRATAMENTO DA FRATURA DO POLO INFERIOR DA PATELA EM ADULTOS: SÍNTESE DE EVIDÊNCIAS CLÍNICAS

João Pedro de Melo, Stephanie Brandão, Diego David Vilte Martinez, Alessandra Masi, Carlos Gorios

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SYSTEMATIC REVIEW ARTICLE

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USE OF PERONEUS LONGUS AS A GRAFT FOR ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION: A META-ANALYSIS

USO DO FIBULAR LONGO COMO ENXERTO PARA RECONSTRUÇÃO DO LIGAMENTO CRUZADO ANTERIOR: UMA METANÁLISE

Yesmin Najj Sola, Joao Vitor de Souza Ribeiro, José Dutra Neto, Helder Rocha da Silva Araújo, Marcelo Rodrigues Torres, Halley Paranhos Junior

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SPINE

SPINAL DISORDERS IN PROFESSIONAL ESPORTS ATHLETES: PROTOCOL FOR A SYSTEMATIC REVIEW





DISTÚRBIOS DA COLUNA VERTEBRAL EM ATLETAS PROFISSIONAIS DE ESPORTS: PROTOCOLO DE REVISÃO SISTEMÁTICA

Newton Yukio Miachiro, Marcelo Diniz de Menezes, Mariana Demétrio de Sousa Pontes, Carlos Fernando Pereira da Silva Herrero

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EVALUATION OF THE RADIOISOTOPIC SYNOVECTOMY PROTOCOL IN PATIENTS WITH HEMOPHILIA

AVALIAÇÃO DO PROTOCOLO DE SINOVIOTOMIA RADIOISOTÓPICA EM PACIENTES COM HEMOFILIA

MARCELA DOS SANTOS MARTINS¹ , JANAINA BOSSO DA SILVA RICCIARDI¹ , ALLAN DE OLIVEIRA SANTOS¹ , MARGARETH CASTRO OZELO¹ , RODRIGO GONÇALVES PAGNANO¹ , EMERSON TARO INOUE SAKUMA¹ 

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ABSTRACT

Introduction: Hemophilia is an inherited hemorrhagic disorder in which the most common musculoskeletal manifestation is intra-articular hemorrhage. Successive hemarthroses result in chronic synovitis, joint surface destruction, and chronic hemophilic arthropathy. When conservative treatment cannot halt an already established synovitis, removing the synovium may interrupt the process of joint destruction, and radioisotopic synovectomy (RS) becomes one of the treatments of choice. **Objective:** To evaluate the safety and effectiveness of the RS protocol in reducing the incidence of hemarthrosis in patients with hemophilia. **Materials and Methods:** This retrospective study is based on a review of medical records. We compared the number of bleeding events one year before and one year after RS. Results were submitted to statistical analysis and compared using the Wilcoxon signed-rank test. **Results:** 65 RS procedures were performed between 2008 and 2018 in patients followed at our institution. The number of bleeding events recorded in the joints submitted to intervention in the year preceding the procedure was 367. In contrast, the number in the following year was 203, a reduction of 44.68% ($P < 0.001$). There were no complications related to the procedure during the analyzed period. **Conclusion:** The RS protocol was safe and effective in reducing the number of bleeding events. **Level of Evidence IV; Case Series.**

Keywords: Hemophilia; Synovectomy; Radioisotopes; Joint diseases.

RESUMO

Introdução: A hemofilia é um distúrbio hemorrágico hereditário cuja manifestação musculoesquelética mais comum é a hemorragia intra-articular. Sucessivas hemartroses resultam em sinovite crônica, destruição da superfície articular e artropatia hemofílica crônica. Nos casos em que o tratamento conservador não controla a sinovite já instalada, a remoção da sinóvia interrompe o processo de destruição articular, sendo a sinovectomia radioisotópica (SR) um dos tratamentos de escolha. **Objetivo:** Avaliar a eficácia e segurança do protocolo de SR adotado em nossa instituição na redução da incidência de hemartroses em pacientes hemofílicos. **Métodos:** Estudo retrospectivo baseado em revisão de prontuários. Foi comparado o número de episódios de sangramento um ano antes e um ano após a SR. Os resultados foram submetidos a análise estatística e comparados de acordo com o Wilcoxon signed rank test. **Resultados:** Foram avaliadas 65 SR entre os anos de 2008 a 2018. O número de sangramentos nas articulações submetidas à intervenção no ano que a antecedeu foi de 367. O número de sangramentos no ano seguinte ao procedimento foi de 203, uma redução de 44,68% ($P < 0,001$). Não houve complicações relacionadas ao procedimento no período analisado. **Conclusão:** O protocolo de sinovectomia radioisotópica adotado foi seguro e eficaz na redução do número de eventos hemorrágicos intra-articulares. **Nível de Evidência IV; Série de Casos.**

Descritores: Hemofilia; Sinovectomia; Radioisótopos; Artropatia.

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INTRODUCTION

Hemophilia is an inherited bleeding disorder linked to the X chromosome, classified into hemophilia A (factor VIII deficiency) and hemophilia B (factor IX deficiency). Hemophilia A affects between 1 in 5,000 to 10,000 men, while hemophilia B affects 1 in 25,000 to 30,000 men.¹ The main symptom is bleeding, with up to 90% of

episodes occurring in joints and muscles, often spontaneously.² Repeated episodes of hemarthrosis result in chronic synovitis, joint destruction, and the development of chronic hemophilic arthropathy (CHA), with pain, loss of mobility, and deformity.^{3,4} Prophylactic treatment with factor replacement is the standard to prevent bleeding and avoid joint damage. However, in cases of

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Page 1 of 4



<< SUMÁRIO

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chronic synovitis refractory to conservative treatment, synovectomy is indicated to interrupt the progression of CHA.⁵ Among the modalities of synovectomy, radioisotopic (RS) stands out for being a minimally invasive, effective, and safe procedure, indicated for target joints that present chronic synovitis.⁶

In RS, radioisotopes such as yttrium-90 and samarium-153, both with favorable properties for synovial ablation, are widely used.⁷ Yttrium-90 and samarium-153 are coupled to larger particles, such as hydroxyapatite, to minimize the risk of the radiopharmaceutical leaking out of the joints, ensuring that its action is restricted to the application site and reducing possible adverse effects.⁸

Studies show that RS significantly reduces the joint inflammatory process and the frequency of hemarthroses, relieving pain and improving the quality of life of patients.^{9,10} This study aimed to evaluate the efficacy and safety of the RS protocol adopted in our institution in reducing the incidence of hemarthroses in hemophilic patients.

MATERIALS AND METHODS

This retrospective cohort study was approved by the Research Ethics Committee in Human Beings of our institution (CAAE: 15464619.6.0000.5404). Medical records and diaries of patients with hemophilia who underwent radioisotopic synovectomy (RS) between 2008 and 2018 were evaluated using our protocol. Demographic data, type and severity of hemophilia, number of hemarthroses recorded in the year before and after RS, as well as associated comorbidities, were collected.

The RS protocol included the use of yttrium-90 labeled hydroxyapatite (Y90-HYP) and samarium-153 (153Sm-HYP), both provided by the Institute of Energy and Nuclear Research-IPEN (São Paulo, SP), divided into three phases: pre, intra, and post-procedure. In the pre-procedure phase, clinical, radiographic, and scintigraphic evaluations were performed. The procedure was performed with aseptic technique, local anesthesia, and administration of coagulation factor. In the post-procedure phase, care such as analgesia, anti-inflammatories, joint immobilization, and outpatient follow-up were adopted.

Patients with hemophilia A or B who underwent RS at our institution were included, while patients with loss of follow-up, those followed at other centers, and cases of advanced arthropathy were excluded. The number of bleedings was recorded in the patients' charts and diaries. The statistical analysis was performed using the Wilcoxon test for dependent samples, with significance of $p < 0.05$. The Real Statistics program for Microsoft Excel 2010 was used for the analysis.

SR Protocol:

Pre-procedure phase: Clinical, radiographic, and scintigraphic evaluation of the affected joint. Patients received a dose of coagulation factor (FVIII or FIX) to prevent hemarthrosis during the procedure. **Procedure phase:** The radiopharmaceutical, hydroxyapatite labeled with yttrium-90 (Y90-HYP) or samarium-153 (153Sm-HYP), was injected into the joint under aseptic technique and local anesthesia, followed by the injection of corticosteroid to irrigate the needle path during its withdrawal, thus preventing the leakage of radioactive material to the skin. Before the patient was discharged, monitoring of radioactivity presence on the skin at the puncture site was performed using a swab with gauze, monitored by portable Geiger Müller radiation meters and/or in a curiometer. The procedure was guided by ultrasound in the smaller joints (elbow and ankle) and, when necessary, there was aspiration of synovial fluid to confirm the correct location. The joint was immobilized for 48 hours with compressive bandaging.

Post-procedure phase: Patients were clinically followed on days 2, 4, 7, 14, and 30, with monthly follow-up during the first 12 months. Analgesia (Ibuprofen) and coagulation factor were administered according to protocol. In addition, patients underwent scintigraphy

to evaluate the distribution of the radiopharmaceutical and any joint leakage within 72 hours after the intervention. All procedures were performed by the same professionals.

RESULTS

102 SR were recorded between the years 2008 and 2018 in our service. Sixty-five procedures ($n=65$) were performed on 42 patients followed at the institution, with regular records in the chart. The other procedures, performed on patients followed by other services, were excluded due to lack of sufficient data.

All 65 treated joints achieved technical procedural success, with no adverse responses described in the medical records. The average age of the patients was 20 years. Most procedures were performed on male patients ($n=41$), and severe Hemophilia A was the most prevalent subtype of the disease ($n=38$), followed by severe Hemophilia B ($n=3$) and moderate Hemophilia A ($n=1$). Of the procedures, 52.30% were performed on patients who were already on prophylaxis with regular doses of coagulation factor ($n=34$). Among the comorbidities associated with multiple blood transfusions, six cases of hepatitis C were identified (9.09%).

The joints subjected to SR included: knees ($n=32$), elbows ($n=21$), and ankles ($n=12$) (Table 1), being: left knee ($n=20$), right knee ($n=12$), left ankle ($n=5$), right ankle ($n=7$), left elbow ($n=15$), and right elbow ($n=6$).

The total number of bleedings recorded in the year prior to radioisotopic synovectomy was 650, considering all joints. In the year after the RS, 475 bleedings were recorded, a reduction of 26.92% ($P = 0.00927$) (Figure 1).

Considering only the treated joints, the number of bleedings reduced from 367 in the previous year to 203 in the following year, a reduction of 44.68% ($P = 0.000367$) (Figure 2).

Table 1. Demographic data of the patients.

Characteristic	Value
Sex	
Male	41
Female	1
Type of hemophilia	
Hemophilia A	39
Hemophilia B	3
Age (average)	20 years
Target joint	
Knee	32
Elbow	21
Ankle	12

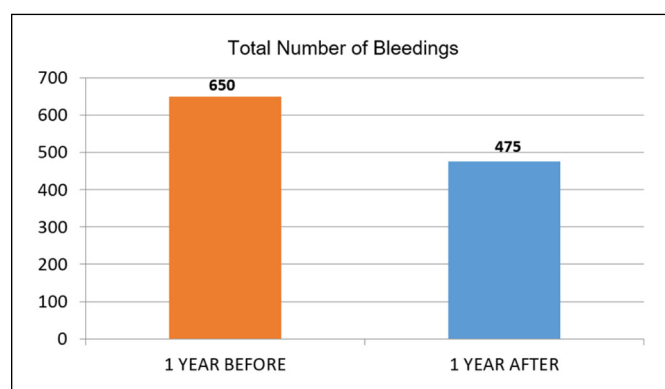


Figure 1. Comparison of the total number of bleedings one year before and one year after the RS.

The average total number of bleedings per patient pre-procedure was 10.0 ± 8.066 , while post-procedure it was 7.3 ± 6.995 , a reduction of 27.0%. In the treated joints, the average number of bleedings per patient fell from 5.6 ± 5.188 to 3.1 ± 4.072 , a reduction of 44.6%.

In patients treated in the knee (n=32), the number of bleeding episodes pre-RS was 202 (average of 6.31) and post-RS was 120 (average of 3.75), a reduction of 40.57% (P=0.0110). In patients treated in the elbow (n=21), there was a reduction of 46%, from 106 bleeding episodes to 57 (P=0.0328). For the ankle (n=12), the reduction was 55.93%, from 59 to 26 episodes (P=0.0391) (Figure 3 and Table 2).

Patients treated with prophylaxis (n=23) showed a reduction of 32.91% in bleeding in the treated joint (P=0.02) (Figure 4). For patients treated with factor on demand (n=19), the reduction was 53.58% (P=0.001) (Figure 5).

The joints treated with Yttrium-90 were compared to those treated with Samarium-153. Of the 65 joints studied, 32 were treated with Samarium-153 (7 knees, 7 ankles, and 18 elbows) and 30 were treated with Yttrium-90 (23 knees, 4 ankles, and 3 elbows). No records were found regarding the radiopharmaceutical used in 3 joints (2 knees and 1 ankle) of the studied patients.

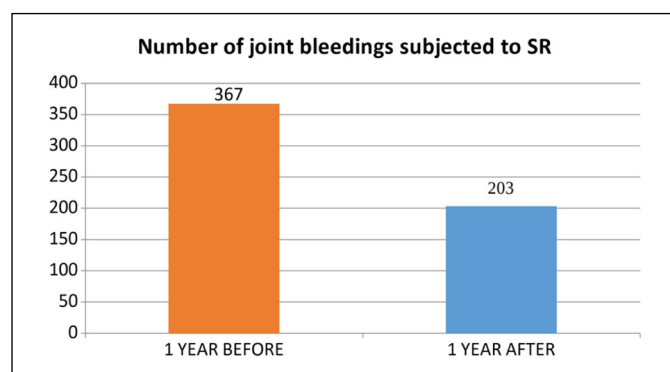


Figure 2. Comparison of the number of bleedings before and after the RS in the treated joints.

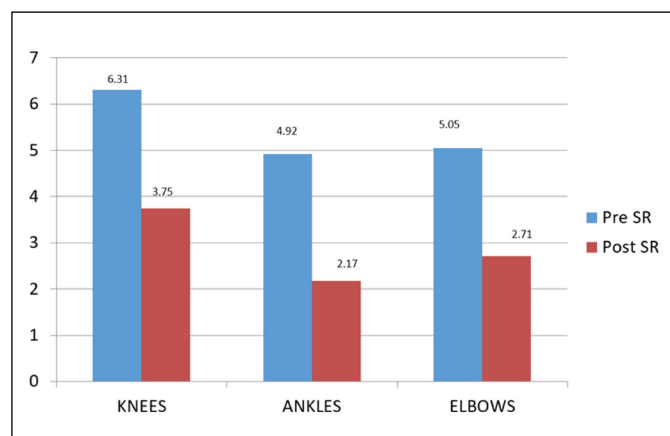


Figure 3. Average bleedings per joint.

Table 2. Bleeding events per joint, in the period of one year before and one year after the RS.

Joint	Bleedings pre-rs	Bleedings post-rs	Decrease	P
Knee (32)	202	120	40.57%	0.011
Ankle (12)	59	26	55.93%	0.039
Elbow (21)	106	57	46.34%	0.032

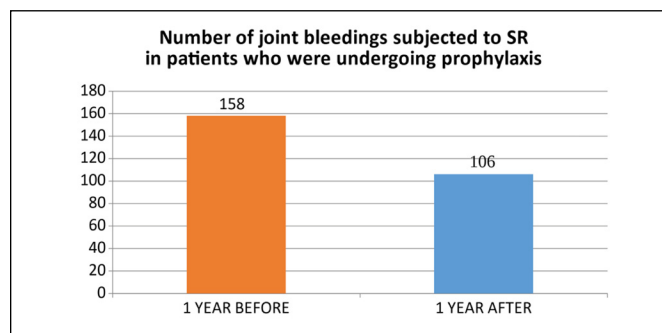


Figure 4. Comparison of bleeding in patients with prophylaxis.

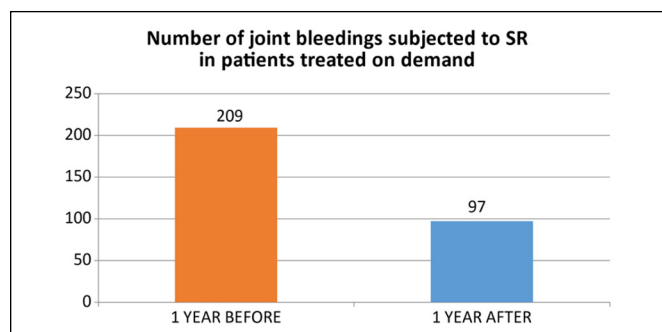


Figure 5. Comparison of bleeding in patients treated with factor on demand.

Among the joints treated with Yttrium-90 (n=30), the number of bleedings was reduced from 200 to 117 (41.5%, P=0.030). In the joints treated with Samarium-153 (n=32), there was a reduction of 45.1%, from 155 to 85 (P=0.006)

DISCUSSION

Radioisotopic synovectomy (RS) is widely recognized for its safety and efficacy. In addition to the management of hemophilia, its use also extends to the control of synovitis caused by other conditions, such as pigmented nodular synovitis, rheumatoid arthritis, psoriasis, lupus, gout, and ankylosing spondylitis.¹¹ After injection, the radiopharmaceutical particles are quickly phagocytized by synovial macrophages and deposited in the outermost layers of the synovial membrane. These particles, due to their size, cannot penetrate the capillary fenestrations, remaining in the joint.¹² The emission of beta radiation continues for weeks, inducing synovial apoptosis through the production of reactive oxygen species.¹¹

The emitted radiation has low penetration power, being mostly absorbed by the synovium, synovial fluid, and superficial layers of cartilage and joint capsule. Adjacent tissues, such as subchondral bone, receive insignificant doses of radiation, which theoretically ensures the safety of the procedure.¹²

Complications related to SR, such as skin necrosis due to extravasation of radiopharmaceuticals, arthritis, and infections, are rarely reported. In the literature, there are reports of two cases of lymphocytic leukemia in children who underwent SR with higher energy tracers, such as gold-198 and phosphorus-32, isotopes that are no longer in current use.¹² However, the causal relationship between these tracers and the neoplasia has not been well established. Studies with more modern radioisotopes, such as yttrium-90, do not show an increase in the incidence of neoplasms in treated patients.¹³

In our study, no evidence of serious adverse effects, such as skin necrosis or chemical synovitis post-procedure, was found in the

reviewed records. These findings suggest that the SR protocol adopted by the Hemocenter of Unicamp is safe, with no early treatment failures identified.

The results of this study also demonstrated the effectiveness of SR in reducing the incidence of hemarthroses in knee, elbow, and ankle joints that underwent SR. It was also possible to compare the effectiveness of SR between patients who received regular prophylaxis and those who received factor on demand. In both groups, SR proved effective in reducing bleeding episodes in the treated joint.

When comparing treatment with different isotopes, yttrium-90 and samarium-153, we observed that both resulted in a reduction in the number of bleedings, demonstrating the effectiveness of both radioisotopes in the treatment of chronic synovitis.

This study has some limitations inherent to retrospective cohorts, such as the absence of a control group, failures in medical record keeping, and the subjectivity of records maintained by the patients themselves. In addition, there is a lack of information on the long-term effects of SR.

It is possible that there was an observation bias, as patients undergoing SR may have paid more attention to the number of bleedings in the treated joint. However, the results indicate that SR promoted a significant reduction in the incidence of hemarthroses in hemophilic patients and proved to be a safe method, with no serious adverse effects reported.

CONCLUSION

The adopted radioisotopic synovectomy protocol proved to be safe and effective in reducing the number of intra-articular hemorrhagic events over the studied period. No procedure-related adverse events were observed during the follow-up. There was a significant reduction in the number of bleedings in all groups of patients analyzed after the procedure.

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CONTRIBUTIONS OF THE AUTHORS

Each author contributed individually and significantly to the development of this article: MSM: Conception and design of the work, acquisition and analysis of data, writing of the manuscript; JBSR: Data acquisition and follow-up of participants, participation in the review process, final approval of the manuscript version; ETIS: Participation in procedures, participation in the review process, final approval of the manuscript version; AOS and MCO: Conception and planning of the activities that led to the study, participation in procedures, participation in the review process, final approval of the manuscript version; RGP: Study guidance, participation in procedures, critical review of intellectual content, final approval of the manuscript version.

DATA AVAILABILITY DECLARATION

The contents underlying the research are available in the manuscript.

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UTILIZATION OF ROBOTIC ARM ASSISTANCE FOR REVISION OF PARTIAL TO TOTAL KNEE ARTHROPLASTY: A CASE REPORT

UTILIZAÇÃO DA ASSISTÊNCIA DO BRAÇO ROBÓTICO PARA REVISÃO DA ARTROPLASTIA PARCIAL PARA ARTROPLASTIA TOTAL DE JOELHO: RELATO DE CASO

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ABSTRACT

Introduction: The introduction of robotic-assisted total knee and hip arthroplasty in Brazil since 2021 has demonstrated benefits, including greater precision in bone cuts and reduced tissue trauma. However, there is a lack of studies on the use of this technology in TKA revisions. This report presents the first robot-assisted TKA performed in Brazil, representing an innovative and pioneering approach. **Case report:** A 61-year-old female patient presenting with pain and limited flexion in her left knee, who underwent unicompartmental knee arthroplasty (UKA) in 2015. After conservative treatment with physical therapy and injections proved ineffective, it was decided to proceed with robot-assisted total knee arthroplasty. The procedure followed the Mako protocol, which included robotic anatomical marking, removal of the previous components, and ligament adjustments. Precise bone cuts were made using the robotic arm, followed by the cementation of prosthetic components. The surgery went smoothly, with a favorable postoperative course. **Conclusion:** The use of robotic assistance in revision anterior cruciate ligament surgery has proven promising, yielding good postoperative results. However, further studies are needed to standardize the technique and establish specific protocols. **Level of Evidence IV; Case Report.**

Keywords: Review; Robotics; Arthroplasty, Total Knee; Arthroplasty, Partial Knee.

RESUMO

Introdução: A introdução da assistência robótica em artroplastias total de joelho (ATJ) e quadril no Brasil, desde 2021, tem demonstrado benefícios como maior precisão nos cortes ósseos e menor impacto tecidual. No entanto, há uma escassez de estudos sobre o uso dessa tecnologia em revisões de ATJ. Este relato apresenta a primeira revisão de ATJ assistida por robô realizada no Brasil, representando uma abordagem inovadora e pioneira. **Relato de caso:** Paciente feminina, 61 anos, com dor e limitação de flexão no joelho esquerdo, submetida a artroplastia unicompartmental (AUJ) em 2015. Após falha no manejo conservador com fisioterapia e infiltrações, optou-se por conversão para ATJ assistida por robô. O procedimento seguiu o protocolo Mako, com marcação anatômica robótica, remoção dos componentes prévios e ajustes ligamentares. Foram realizados cortes ósseos precisos utilizando o braço robótico, seguidos pela cimentação de componentes protéticos. A cirurgia ocorreu sem intercorrências, com boa evolução pós-operatória. **Conclusão:** O uso da assistência robótica na revisão de AUJ para ATJ demonstrou ser uma técnica promissora, com bons resultados pós-operatórios. Contudo, são necessários estudos adicionais para padronizar a técnica e estabelecer protocolos específicos. **Nível de Evidência IV; Relato de Caso.**

Descritores: Revisão; Robótica; Artroplastia do Joelho; Artroplastia Parcial do Joelho.

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INTRODUCTION

The use of robotic-assisted total knee and hip replacements has been gaining popularity worldwide¹ and, since 2021, in Brazil. Recent data have shown a significant increase in the use of robotics for joint replacement procedures. According to Stryker data, approximately

1,400 total knee replacements assisted by the Mako robotic arm have been performed in Brazil since 2021. Mako-assisted TKAR provides preoperative planning and precise execution, with validated surgical outcomes.^{2,3} However, these data cannot be extrapolated to TKA revision cases.

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

The study was conducted at Hospital Madre Teresa IPMMI, Belo Horizonte, Minas Gerais, Brazil.

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Page 1 of 4



<< SUMÁRIO

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With the growing number of total knee arthroplasties (TKA) performed worldwide, there has also been an increase in TKA revisions.⁴ Among the challenges faced in TKA revisions, issues such as malalignment of components, instability, excessive bone loss, and damage to non-bony soft tissue structures are particularly notable.⁵ However, despite the growing demand for interventions in this context, the available literature on robot-assisted rTKA is scarce.^{4,7} This scarcity of specific studies on the application of robotics in Total Knee Arthroplasty revisions (rTKA) highlights a gap in the expansion of this technology, especially considering the complexity of these interventions.

It is important to note that, to date, robotic surgery with the Mako robot for joint replacement procedures has not been approved for revision surgeries. The application of robotic technology in robotic total knee arthroplasty (rTKA) presents significant challenges that must be addressed in the medium and long term.^{4,6} This case report stands out as the first documented instance of robotic rTKA surgery in Brazil, marking a pioneering shift toward this approach.

Case report

This is a 61-year-old female patient who came to our institution for evaluation regarding total knee arthroplasty (TKA) of the left lower limb. The patient was referred to our clinic in 2017, complaining of pain and limited flexion in her left knee following a unicompartmental knee arthroplasty (UKA) performed at another institution in 2015. Initially, the patient underwent a diagnostic workup, including imaging and laboratory tests, to rule out infection or loosening of the UKA components. These possibilities were ruled out, and, given the persistence of symptoms, a conservative management approach was chosen, involving physical therapy and a series of injections, which brought the condition under control until early 2022. However, the patient's condition worsened, with persistent pain and functional limitations that did not respond to the measures taken. Figure 1 shows the patient's preoperative AP and lateral radiographs and MRI slices. Neither the X-ray nor the MRI revealed any findings that, on their own, would indicate the need for revision of the UKA. However, the failure of conservative treatment was the main factor in the decision to proceed with surgical treatment.



Figure 1. Preoperative X-rays in AP and lateral views (A, B) and coronal and sagittal sections (C, D) from MRI

After a thorough discussion of the risks and benefits, the patient was selected to proceed with the conversion from unicompartmental knee arthroplasty to total knee arthroplasty, using the Mako robotic system. A Stryker Triathlon total knee arthroplasty system was selected based on a preoperative CT scan sent to the United States. An expert in Robot-Assisted Surgical Planning (MPS) provided valuable insights into the use of computed tomography (CT) for preoperative planning. The CT protocol remained similar; however, segmentation to create the three-dimensional (3D) model proved more challenging due to image artifacts caused by the implant. The 3D model was meticulously constructed, taking the implants into account, since the subsequent registration would be based on these devices. During the registration process, only polyethylene was excluded, as it becomes invisible on CT scans. The surgical plan aimed to preserve as much bone as possible by using prior knowledge of the implant dimensions to determine cut thickness. The primary objective of the initial planning was to selectively remove the first layer of bone and cement without additional procedures. On June 15, 2022, the patient underwent robot-assisted total knee arthroplasty (TKAr) under spinal anesthesia. The flowchart in Figure 2 outlines the step-by-step surgical procedure performed in this case. The incision was made along the midline of the left knee, using a medial parapatellar approach. Following the Mako protocol, femoral and tibial guides and checkpoints were placed, and anatomical

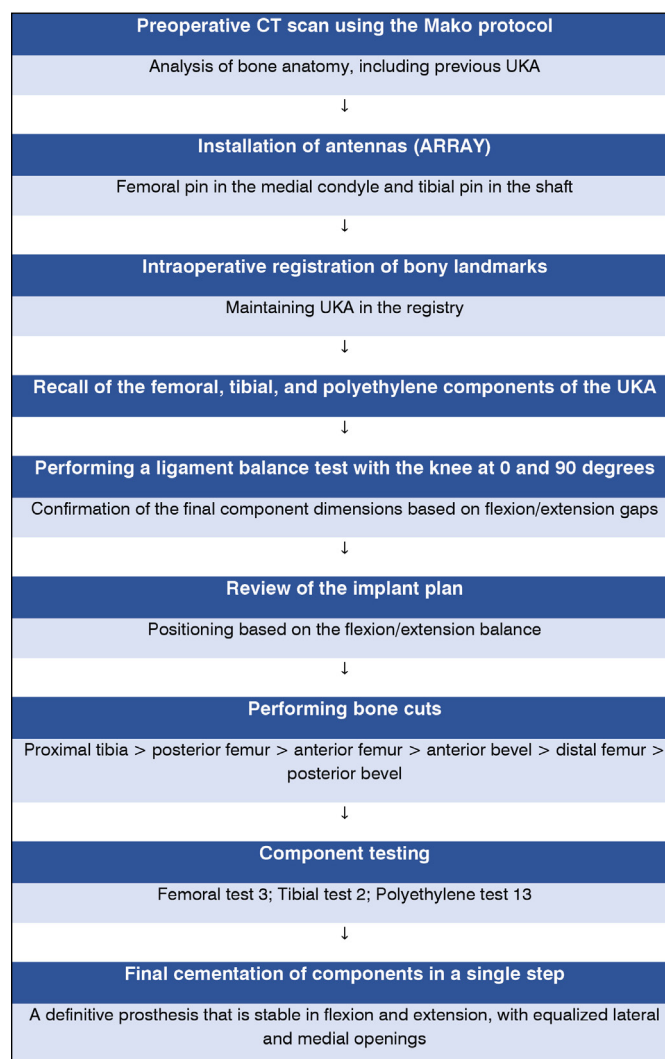


Figure 2. Step-by-step flowchart of robotic surgery.

landmarks were marked under robotic navigation, including the anterior unicondylar joint. After removal of the UKA components and resection of osteophytes (Figure 3), the ligament balance was adjusted to achieve equalized gaps in both extension and flexion, as shown in Figure 4.

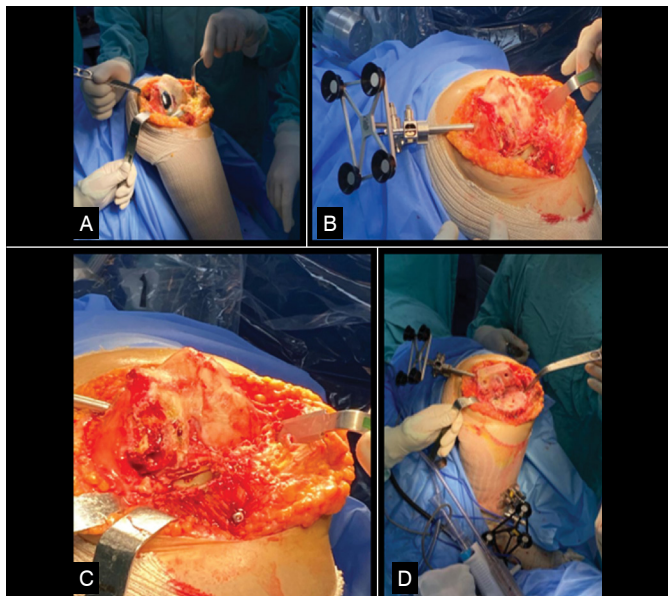


Figure 3. Intraoperative photos showing the bone stock following removal of the previous anterior cruciate ligament in the left knee.

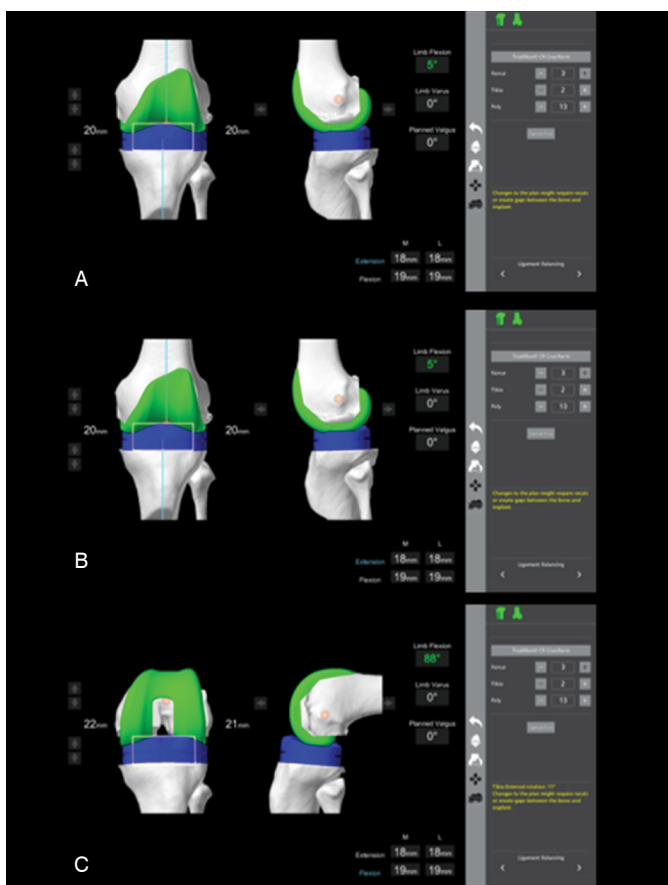


Figure 4. Screenshot from the Mako computer screen showing the alignment of the gaps in flexion and extension with the planned prosthetic components following the removal of the previous UKA.

The tibial and femoral cuts were performed using the Mako robotic arm, followed by cementing the Triathlon femoral 3 and tibial 2 components with 13-density polyethylene. The postoperative X-rays (anterior-posterior and lateral views) are shown in Figure 5. The patient received a postoperative adductor canal block, and her postoperative recovery proceeded without complications. He was discharged on the second postoperative day in excellent health. The patient was followed up at 2 weeks, 6 weeks, 3 months, and 6 months postoperatively. He participated in an outpatient physical therapy program for 3 months to improve his range of motion and strength. Currently, the patient is at the 2-year postoperative follow-up, with a range of motion of 0–120 degrees. During this time, she underwent surgery to perform a total knee arthroplasty on her opposite knee due to pre-existing osteoarthritis. The patient recovered satisfactorily following the procedure, reporting a pain score of 1 on a 10-point Visual Analog Scale (VAS) and regaining her previous level of function through functional exercises and Pilates.

DISCUSSION

Robot-assisted TKA has been and continues to be developed to improve accuracy, precision, and safety during the procedure. Numerous studies suggest that robot-assisted knee arthroplasty results in more precise bone cuts, less soft-tissue trauma, better component placement, and improved final alignment.^{8–11} In addition to precision and safety, studies have been published addressing patient satisfaction following robot-assisted knee arthroplasty.^{12,13} Revision knee arthroplasty poses a growing challenge for orthopedic surgeons, even specialists, due to the increasing number of cases resulting from infection, aseptic loosening, instability, periprosthetic fractures, and the progression of arthritis. While there are already several studies on robotic-assisted primary TKA and TKRA, there are currently few studies focusing on the use of robotics in knee revision arthroplasty.^{6,14,15}

In 2020, Kalavrytinis et al.¹⁴ reported the first described case of robotic conversion from UKA to TKA. This study presented an 87-year-old woman with a stiff and painful knee resulting from a malpositioned total knee replacement with varus deformity. Similar to the case presented in this study, Kalavrytinis et al. used Mako technology, accounting for both implants and native bone in surgical planning. The authors used robotic technology to perform bone measurements and assess ligament balance. Next, the primary implant was removed, and then the bone cuts were made, and the new implants were placed. The patient recovered without complications. One year after surgery, the patient had good knee range of motion, was able to walk without assistance or support, and was already able to climb stairs.

Also in 2020, Yun et al.¹⁵ presented the first case series of 34 failed UAK procedures, half of which were converted to TKA using the Mako robot and half of which were converted using conventional methods. All conversions were performed using primary implants. The authors observed a difference in the use of rods and shims, with 29% of manually converted knees requiring shims, and 0% of robotically converted knees requiring shims ($P = 0.04$). According to the authors, existing primary implants in both the femur and the tibia make it difficult to position manual cutting guides during revision surgeries. Furthermore, in traditional conversion surgery, the femoral cutting guides force the surgeon to choose between altering the extent of resection or changing the angle of the distal surface relative to the medullary canal. With the robot, this discrepancy does not occur, as the angle and cut adjustments are made independently, thereby producing more precise bone cuts and, consequently, reducing the need for bone grafts. Although this was not a study evaluating alignment metrics, the authors found that using the robot helped restore the mechanical axis. The authors do not believe that

robotic-assisted surgery is inferior to the conventional approach in conversion surgery from total ankle arthroplasty (TAA) to total knee arthroplasty (TKA); however, the study did not evaluate clinical prognosis or postoperative radiographic parameters.

In 2023, Ngim et al.⁶ conducted a retrospective study evaluating 19 patients who underwent rTKA using the Mako robotic system. Among these patients, 12 underwent revision total knee arthroplasty following primary total knee arthroplasty, 4 underwent revision surgery following unicompartmental knee arthroplasty, and 3 underwent revision following the use of a cement spacer. In cases of revision surgery following unicompartmental arthroplasty, Ngim et al. described the effectiveness of robotic assistance in assessing alignment options based on bone cuts and in maintaining joint space. Unlike the case presented in this article, the authors reported the possibility of using shims in the tibial component to balance the lateral and medial gaps. As was done in the case presented, the patients underwent surgical

scheduling with CT scans for surgical planning. Neither the primary femoral component nor the primary tibial component was used for bone landmarks. After removing the components, the flexion and extension forces were balanced, and the bone cuts were determined. The authors reported good postoperative results.

There is still no resolution from the Brazilian Health Regulatory Agency regarding the use of robotic assistance in rTKA. The success of this case report, along with previous studies describing robotic-assisted total knee arthroplasty, opens the possibility of future approval of this technique for this type of procedure.

CONCLUSION

The use of robotic-assisted surgery to convert an unsuccessful UKA to an ATJ is a new technique that yielded satisfactory postoperative outcomes in this case. Further studies are needed to better define the surgical technique and establish specific protocols.

CONTRIBUTIONS OF THE AUTHORS

EFT: study conception, case management, data analysis, manuscript writing and revision. FSA: manuscript writing, literature review and critical review of the text. LHC Jr: intellectual conception of the article, scientific supervision and final critical review. MBJG: data collection and organization, literature review and assistance in manuscript writing. RLC: data analysis and interpretation and critical review of the manuscript. VRM: manuscript organization, article correspondence, writing, final critical review and approval of the submitted version.

DATA AVAILABILITY DECLARATION







The contents underlying the research are available in the manuscript.

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EPIDEMIOLOGICAL ANALYSIS OF FEMUR FRACTURES IN THE PEDIATRIC POPULATION IN A REFERENCE SERVICE IN THE STATE OF SERGIPE

ANÁLISE EPIDEMIOLÓGICA DAS FRATURAS DE FÊMUR NA POPULAÇÃO PEDIÁTRICA EM UM SERVIÇO DE REFERÊNCIA DO ESTADO DE SERGIPE

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ABSTRACT

Objective: To evaluate the clinical-epidemiological profile of skeletally immature patients treated at a referral service in Sergipe, from January to December 2023. **Methods:** This is an observational, retrospective study, by analysis of electronic medical records. The data were analyzed descriptively and for inferential analysis, the ANOVA and Student's t tests were used. Multivariate analysis was performed through logistic linear regression adjustment. A significance level of 5% was adopted, using R software, version 4.0.3. **Results:** Of the 49 femur fractures evaluated, 35 (71.4%) occurred in boys, 29 (59.2%) on the left side, with a mean age of 5.4 years. Three fractures were proximal (6.1%), 37 diaphyseal (75.5%) and 9 distal (18.4%). The most frequent fracture pattern was spiral (46.9%). It was found that the fracture mechanism and treatment presented significant differences in relation to age. Younger children were mainly affected by falls from their own height, while older children suffered direct trauma. In terms of treatment, increasing age behaves as a risk factor for surgical therapy. **Conclusions:** The data analyzed are equivalent to other studies performed and described in the world literature. **Level of Evidence III; Comparative Retrospective Study.**

Keywords: Epidemiological Profile; Femoral Fractures; Intramedullary Fracture Fixation.

RESUMO

Objetivo: Avaliar o perfil clínico-epidemiológico dos pacientes esqueleticamente imaturos atendidos em um serviço de referência em Sergipe, de janeiro a dezembro de 2023. **Métodos:** Trata-se de um trabalho observacional, retrospectivo, por análise de prontuários eletrônicos. Os dados foram analisados de forma descritiva e para a análise inferencial foram utilizados os testes ANOVA e t student. Foi realizada análise multivariada através do ajuste de regressão linear logística. Foi adotado um nível de significância de 5%, utilizando o software R, versão 4.0.3. **Resultados:** Das 49 fraturas de fêmur avaliadas, 35 (71,4%) ocorreram em meninos, 29 (59,2%) no lado esquerdo, com média de idade de 5,4 anos. Três fraturas foram proximais (6,1%), 37 diafisárias (75,5%) e 9 distais (18,4%). O padrão de fratura mais frequente foi em espiral (46,9%). Verificou-se que o mecanismo da fratura e o tratamento apresentaram diferenças significativas em relação a idade. As crianças mais novas foram principalmente acometidas por quedas da própria altura, enquanto as crianças mais velhas sofreram traumas diretos. No quesito tratamento, o aumento da idade se comporta como um fator de risco para terapêutica cirúrgica. **Conclusões:** Os dados analisados são equivalentes a outros estudos realizados e descritos na literatura mundial. **Nível de Evidência III; Estudo Retrospectivo Comparativo.**

Descritores: Perfil Epidemiológico; Fraturas do Fêmur; Fixação Intramedular de Fraturas.

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INTRODUCTION

The distribution of femoral fractures in children shows a bimodal pattern, related to anatomical characteristics and the stage of bone

development, with fractures in early childhood generally resulting from low-impact trauma, while in adolescence, higher energy trauma is required.¹ These fractures are classified according to

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their location: proximal, mid-diaphyseal, and distal. It is observed that, unlike adults, children have a preference for fractures in the middle third of the bone, or diaphyseal, accounting for the majority of these fractures (64%).²⁻⁵

These fractures, located in the diaphysis of the femur, represent between 1.5% to 2% of all fractures during the growth period, a relatively low incidence compared to more common fractures, such as those of the clavicle and wrist.⁶ However, they remain the main traumatic injury requiring pediatric hospitalization.⁷⁻¹⁰ The frequency of these fractures varies according to the studied region and seasonality, with a tendency to increase during the summer and late winter.¹¹ Although there are few global epidemiological studies, a Swedish study indicated a rate of 11.3 cases per 100,000 individuals.²

The diagnosis of femoral fracture is straightforward, involving detailed physical examination and anteroposterior (AP) and lateral (P) radiographs. However, the possibility of associated injuries should be considered, especially in cases of high-energy trauma.¹¹ The therapeutic approach varies according to age and fracture characteristics, with flexible intramedullary rods being widely used in children between 5 and 11 years old.^{12,13} However, in some cases, such as when specific resources are unavailable in the Unified Health System (SUS), alternative treatment methods should be considered.^{14,15}

Given the limited number of comprehensive epidemiological studies, this study aims to evaluate the clinical and epidemiological profile of femoral fractures in skeletally immature patients in a reference service in the state of Sergipe.

METHODS

This is a retrospective observational study conducted in a single reference institution for pediatric care in the state of Sergipe, based on the analysis of data extracted from electronic medical records. Patients under 13 years old who were treated in the service and diagnosed with femoral fracture were included in the study. Patients with pathological fractures or missing data were excluded from the study.

Data collection was performed by researchers using the computers of the Dr. José Machado de Souza Children's Hospital. Initially, electronic medical records of all patients treated by orthopedics from January to December 2023 were selected. Subsequently, each record was analyzed individually to identify cases of femoral fracture, and the radiographs of these selected patients were evaluated by the institution's digital radiography system. Finally, all previously selected records that were not excluded were stored in Excel spreadsheets (Microsoft®).

The variables considered in this study were: patient age, sex, race, municipality of residence, fracture laterality, trauma mechanism, fracture classification, fracture displacement pattern, associated fractures, type of treatment (surgical or conservative), specific treatment method, and early complications.

Initially, a descriptive analysis was performed. Categorical variables were described by absolute and relative frequencies, while quantitative variables were described by mean, standard deviation, minimum and maximum values. In the inferential analysis, the adherence to the normal distribution of quantitative variables was evaluated using the Shapiro-Wilk test.¹⁶ As normality of distribution was observed, ANOVA and the Student's t-test were used. The multivariate analysis was performed using Logistic Regression,^{17,18} with a log link function. The area under the ROC curve (AUC)^{19,20} was used to measure the model calibration, and the Hosmer-Lemeshow test²¹ was used to assess the model calibration. The results were expressed in terms of Odds Ratio (OR), calculated by the exponential of the estimated parameters. All conclusions from the hypothesis tests were based on the interpretation of the p-value, adopting a significance level of 5%. Whenever the p-value was less than 0.05,

it was considered that there was a significant association between the analyzed variables. The software used for statistical analysis was R, version 4.0.3 (The R Core Team, 2024).

This study was approved by the Research Ethics Committee of the University of Tiradentes, under CAAE 76134323.8.0000.5371, according to opinion 7.041.777 and began after approval.

RESULTS

The study population consisted of 49 children, with a mean age of 5.4 years. There was a predominance of the male sex (71.4%), of mixed ethnicity (81.6%), and from rural areas (63.3%). Figure 1 shows the monthly distribution of fractures.

The characteristics of the fractures (laterality, mechanism of injury, location and pattern of the fracture, and association with other injuries) are in Table 1. In addition to these data, no fracture from the present study was exposed.

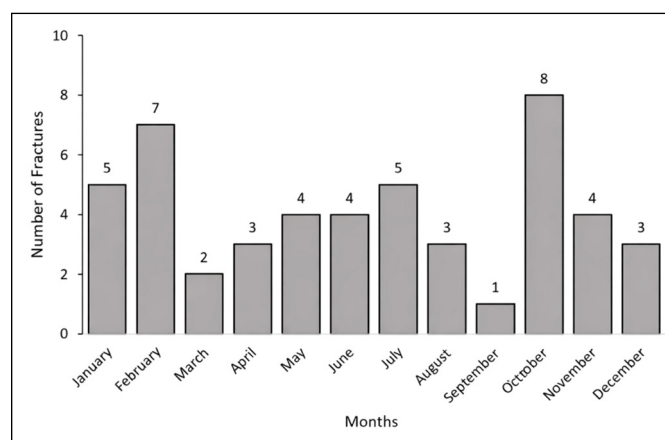


Figure 1. Monthly distribution of fractures.

Table 1. Characteristics and treatments of fractures.

Variable/Category	Frequency	Percentage (%)
Side		
Right	20	40.8
Left	29	59.2
Mechanism		
Motor vehicle collision	6	14.3
Fall from own height	18	42.9
Fall	14	33.3
Direct trauma	4	9.5
Fracture location		
Diaphysis	37	75.5
Distal	9	18.4
Proximal	3	6.1
Fracture pattern		
Articular	1	2.0
Wedge	3	6.1
Spiral	23	46.9
Oblique	6	12.2
Physal (Salter Harris 2)	1	2.0
Torus	2	4.1
Transverse	13	26.5
Other fractures		
No	47	95.9
Distal radius	1	2.0
Proximal humerus	1	2.0
Other injuries		
No	48	98.0
Yes	1	2.0

Most patients underwent conservative treatment using plaster, and among the surgical techniques, fracture fixation with an external fixator was the most commonly used (Table 2).

When comparing age with sex and fracture location, no statistically significant difference was observed. However, when comparing age with the mechanism of injury and treatment performed, a statistical difference was found (Figures 2 and 3). Regarding the mechanism, when performing pairwise comparisons, it was found that there is a significant difference between the ages of patients with falls from their own height (FOH) and those with direct trauma. Thus, the average age of patients with the FOH fracture mechanism is statistically lower compared to those with direct trauma (Figure 2). With respect to the type of treatment, the average age of patients who underwent surgical treatment is higher than those with conservative treatment (Figure 3).

The result of the multivariate analysis through logistic regression is presented in Table 3. Among the variables analyzed in the model, it was found that only age is a risk factor for surgical treatment ($p < 0.05$). In other words, as the child's age increases, the chances of choosing surgical treatment are greater.

Table 2. Characteristics of femur fracture treatment.

Variable/Category	Frequency	Percentage (%)
Treatment		
Surgical	23	46.9
Conservative	26	53.1
Treatment method		
External Fixator	9	18.4
Fio de Kirschner	1	2.0
Kirschner wire and external fixator	4	8.2
Plate	7	14.3
Screws	2	4.1
Plaster	25	51.0
Pavlik Harness	1	2.0

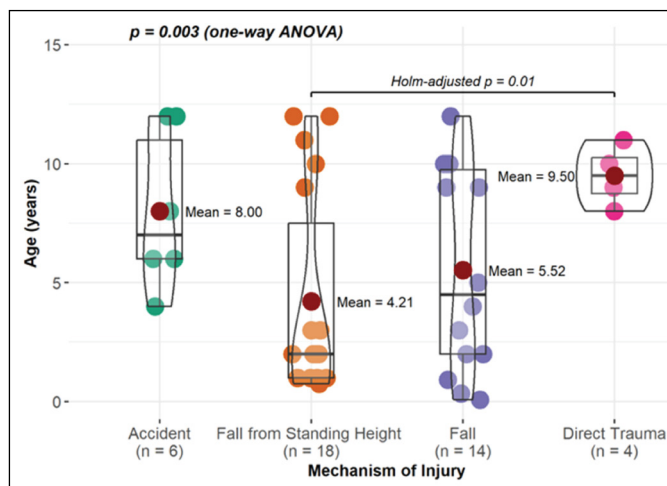


Figure 2. Comparison of age concerning the mechanism of injury.

DISCUSSION

Our study identified a trend of predominance of fractures in the male sex, corroborating the findings of previous studies.^{2,4} Although our numbers are similar to those reported by Engström et al.⁴ the percentage of fractures in the male sex was slightly higher in our analysis. This difference may be attributed to the fact that we included only fractures resulting from trauma, excluding pathological, stress, and spontaneous fractures.

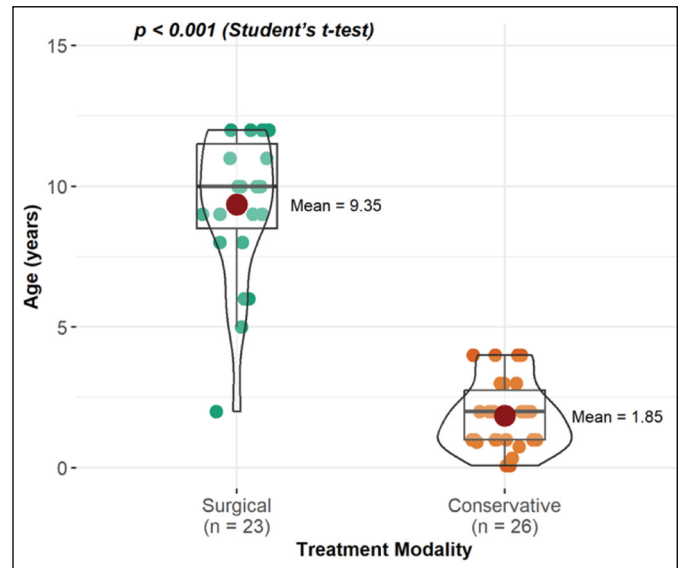


Figure 3. Comparison of age concerning fracture treatment.

Table 3. Factors associated with surgical treatment.

Variables	Estimate	OR	CI 95%	P-value
Intercept	-6.58	0.00	(0.00; 0.08)	0.027
Gender (Male)	0.60	1.83	(0.03; 284.72)	0.783
Age	1.42	4.14	(2.04; 18.60)	0.006
Fracture Location (Distal)	-3.55	0.03	(0.00; 32.21)	0.496
Fracture Location (Proximal)	-2.27	0.10	(0.00; 46.67)	0.671

95% CI - 95% Confidence Interval; OR - Odds Ratio. The ROC curve (AUC) was 0.99. The Hosmer-Lemeshow test was 0.96.

The bimodal age distribution observed in males is consistent with previous findings.^{2,4,22} The first peak occurs between 1 and 2 years of age, when children begin to walk, while the second peak is observed during higher energy activities, between 9 and 12 years. This second peak was not observed in females, which may be explained by social issues, such as lower exposure of girls to high-impact activities.

Regarding the location of fractures, there was a predominance of diaphyseal fractures, with results similar to those found in previous studies.²⁻⁵ Falls were identified as the main mechanism of trauma in our study, accounting for 76.2% of cases. This data is in line with previous studies,^{2,4,6} which also reported the predominance of this mechanism in younger ages. In older ages, however, traffic accidents are more common, especially in adolescents. This difference can be explained by the lower average age of the patients in our study compared to previous studies.

No specific seasonal pattern was observed regarding the incidence of fractures, although there was a predominance in the months of February and October. In contrast, Loder et al.³ reported a predominance in summer, while Von Heideken et al.² observed a bimodal peak in winter/spring and summer. The absence of seasonal variation in our study can be attributed to the geographical location, where climatic differences and patterns of human behavior between the seasons are not as significant as in previous studies.

Regarding the type of treatment, the average age of patients undergoing conservative treatment was lower than that of those undergoing surgical treatment, which is in agreement with other studies.⁴ Our results suggest that a cutoff point of 5 years may be established, since 95.65% of fractures in children aged 5 years or older were

treated surgically, while 100% of conservative treatments occurred in children below that age. This age is well established in the literature, especially for fractures located in the diaphyseal region, where, traditionally, until the age of five, the choice is for early reduction and cast immobilization, since what favors this type of treatment is the great potential for consolidation and remodeling, better tolerance to immobilization, and greater ease with general care, and after this age, fixation methods become more commonly used.^{23, 24}

CONCLUSION

The study covered demographic, epidemiological, and treatment aspects of femur fractures in children, contributing to guiding clinical practice and improving care for these patients. Moreover, the analyzed data are equivalent to other studies conducted and described in the global literature. Thus, we conclude that studies like this provide important information for health promotion policies and accident prevention for children.

CONTRIBUTIONS OF THE AUTHORS

Each author contributed individually and significantly to the development of this article. GHCPP: acquisition, analysis, and interpretation of data and writing of the manuscript; TOS: Initial study design, acquisition, analysis, and interpretation of data; GBP and mtm: acquisition, analysis, and interpretation of data; HSM: acquisition, analysis, and interpretation of data and writing of the manuscript; MAFC: Initial study design, acquisition, analysis, and interpretation of data, manuscript revision, and final approval of the version to be published.

DATA AVAILABILITY DECLARATION

The contents underlying the research are available in the manuscript.

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EVALUATION OF THE QUALITY AND RELIABILITY OF INFORMATION ON ADHESIVE CAPSULITIS (FROZEN SHOULDER) ON THE SOCIAL MEDIA PLATFORM INSTAGRAM

AVALIAÇÃO DA QUALIDADE E CONFIABILIDADE DAS INFORMAÇÕES SOBRE CAPSULITE ADESIVA (OMBRO CONGELADO) NA PLATAFORMA DE MÍDIA SOCIAL INSTAGRAM

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ABSTRACT

Objective: To assess the quality and reliability of information on adhesive capsulitis provided to the public on Instagram. **Method:** The 100 most relevant posts on #adhesivecapsulitis and the 100 posts on #frozenbrown hashtags were analyzed on a single day. The evaluation was carried out by three professionals at different levels - a general practitioner, an orthopedist, and a shoulder and elbow surgeon - using the Global Quality Score (GQS), the modified DISCERN, and the Frozen Shoulder Specific Score (FSSS). In addition, interobserver agreement was checked. **Results:** The majority (65.5%) of the 200 posts analyzed presented incomplete information, scoring 1 or 2, representing low scientific foundation and limited clinical applicability. The average scores on the three scores indicated unsatisfactory quality of the content. However, agreement between the evaluators was high, demonstrating the reliability of the methods used. **Conclusion:** Although Instagram is widely used as a source of health information, it has poor-quality content on adhesive capsulitis. These findings reinforce the importance of medical guidance and the production of more accurate, evidence-based information materials. **Level of evidence IV; observational, descriptive, cross-sectional.**

Keywords: Internet; Social Media; Frozen shoulder; Internet; Adhesive capsulitis.

RESUMO

Objetivo: Avaliar a qualidade e a confiabilidade das informações sobre capsulite adesiva fornecidas ao público no Instagram. **Método:** Foram analisados, em um único dia, os 100 posts mais relevantes da hashtag #capsuliteadesiva e os 100 posts da #ombrocongelado. A avaliação foi realizada por três profissionais de níveis distintos — médico generalista, ortopedista e cirurgião de ombro e cotovelo — utilizando os escores Global Quality Score (GQS), DISCERN modificado e Frozen Shoulder Specific Score (FSSS). Além disso, a concordância interobservador foi verificada. **Resultados:** Os 200 posts analisados apresentaram, em sua maioria (65,5%), informações incompletas, pontuando 1 ou 2, representando baixa fundamentação científica e limitada aplicabilidade clínica. As pontuações médias nos três escores indicaram qualidade insatisfatória dos conteúdos. No entanto, a concordância entre os avaliadores foi alta, demonstrando a confiabilidade dos métodos empregados. **Conclusão:** O Instagram, embora amplamente utilizado como fonte de informações em saúde, apresenta conteúdos de baixa qualidade sobre capsulite adesiva. Esses achados reforçam a importância da orientação médica e da produção de materiais informativos mais precisos e baseados em evidências. **Nível de evidência IV; observacional descritivo transversal.**

Descritores: Internet; Mídias Sociais; Ombro congelado; Internet; Capsulite adesiva.

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INTRODUCTION

Adhesive capsulitis, also known as “frozen shoulder,” is a clinically relevant condition affecting about 2-5% of the general population.¹ The disease causes loss of both passive and active range of motion in the shoulder, primarily affecting patients between 40 and 60 years

of age.² The disease significantly affects shoulder function due to pain and restriction of range of motion, particularly in external rotation. The condition is often idiopathic, but has a higher prevalence in individuals with *diabetes mellitus* and hypothyroidism. The natural course of adhesive capsulitis traditionally involves a painful phase

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The study was conducted at Departamento de Ortopedia e Traumatologia, Escola Paulista de Medicina, Universidade Federal de Sao Paulo, Sao Paulo, SP, Brazil. Correspondence: Fabio Teruo Matsunaga. Universidade Federal de Sao Paulo, 786, R. Borges Lagoa, Sao Paulo, SP, Brazil. 04038-002. fteruo@gmail.com

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followed by a recovery phase, usually lasting one to two years, with an expectation of complete resolution of symptoms. However, untreated adhesive capsulitis can lead to persistent functional limitations, challenging the notion of spontaneous complete recovery.³ Your risk factors include diabetes, hyperthyroidism, and previous cervical surgeries. Mostly, the cases are self-limiting⁴, but non-surgical treatments, such as physical therapy, corticosteroid injection, ultrasound-guided hydro-distension, hyaluronic acid injection, or even surgical treatment, such as manipulation under anesthesia or arthroscopic release, may be part of the treatment for some patients.⁵ In this context, obtaining correct and reliable information is necessary for a better understanding of the symptoms, prognoses, and treatment possibilities of the referred condition.

Among social networks, Instagram is a fast and widely used tool today, with Brazil ranked third in terms of users, totaling 134 million.⁶ However, the quality of the information provided by this platform appears to be questionable, as already evidenced by previous studies conducted on other topics, such as prostate cancer⁷, oral cavity cancer⁸, and hypothyroidism⁹.

The hypothesis of the present study is that the content on Instagram about adhesive capsulitis is low in quality and reliability. With the growing number of social media users², the number of *posts* providing information, whether for laypeople or professionals, has been gradually increasing. In this sense, it is necessary to evaluate the reliability of the information provided on Instagram, as this network reaches a large number of people. Therefore, a careful and objective evaluation of this information, often provided to people seeking a better understanding of the disease, is necessary. By knowing the quality and reliability of this information, it will be possible to inform patients and affirm the accuracy of the information provided, as well as anticipate misinformation and questions they may raise.

The quality of information on adhesive capsulitis on digital platforms has already been evaluated by various authors, particularly on YouTube. In general, the results of these studies affirmed that the information about adhesive capsulitis / frozen shoulder is of low quality and limited educational value, suggesting that patients rely on more trustworthy and reliable sources in search of knowledge.¹⁰⁻¹²

It is worth noting that the quality of information on Instagram regarding adhesive capsulitis has not yet been studied. Thus, this research proposed a systematic analysis of the *posts* on Instagram with the *hashtags* #capsuliteadesiva (#adhesivecapsulitis) and #ombrocongelado (#frozenshoulder), using the DISCERN¹³, Global Quality¹⁴, and Frozen Shoulder Specific Score (FSSS).¹⁰

OBJECTIVE

To evaluate the quality of the *posts* about adhesive capsulitis and frozen shoulder on the social media platform Instagram, using three different objective scores: modified DISCERN, GQS, and FSSS, in addition to inter-rater reliability.

METHOD

A scientific, exploratory, and cross-sectional study was conducted, analyzing, in a single day, 200 *posts* most relevant to the *hashtags* #adhesivecapsulitis (100 *posts*) and #frozenshoulder (100 *posts*), from a newly created Instagram account, configured as Brazilian and belonging to a fictitious female user aged 50 years. Contents that were not in Portuguese, not publicly accessible, or not related to adhesive capsulitis were excluded by two of the evaluators (DH and AM); if there was disagreement, a third evaluator (FM) would decide on inclusion.

The *posts* included were independently evaluated by three different evaluators: an orthopedic resident, a board-certified orthopedic

surgeon, and a shoulder and elbow surgeon. The scores used to evaluate the content were the modified DISCERN, GQS, and FSSS. The modified DISCERN (adapted from DISCERN, a tool created for evaluating written health content) assesses the reliability of the information source provided. The standards, which varied in scores from 0 to 5, followed these criteria: (A) Were the objectives clear and achieved? (A) Is a reliable source of information used? (C) Is the information provided balanced and impartial? (D) Are there other resources listed for patient reference? A score of 0 or 1 indicates a lack of information, a score between 2 and 3 indicates that some information is present, and a score of 5 indicates all available information.

The FSSS is a specific score for adhesive capsulitis or frozen shoulder that also assesses the quality of information and consists of 18 items, derived from guidelines published by the American Academy of Orthopaedic Surgeons, with a score from 0 to 18. This score evaluates information about common patient presentations and symptoms, anatomy, diagnosis and assessment, treatment, and postoperative evolution.

The Global Quality Score (GQS) assesses content quality based on a score from 0 to 5. Scores of 0 and 1 are for those with low-quality information, missing information, or little utility for patients; 5 points for content with excellent-quality information that is relevant and useful for the patient.

After checking the parametricity of the data using the Shapiro-Wilk test ($p > 0.05$), the scores were quantified and evaluated using descriptive statistics (mean and confidence interval calculated with the standard error (SE) and 1.96 standard deviations, corrected for stratification, based on the following formula: $\sqrt{p(1-p)/n}$ and with 95% confidence = $p' - 1.96 \times SE$; $p'' + 1.96 \times SE$). To analyze the differences between the scores, one-way analysis of variance (ANOVA) was applied with an alpha of 5%, and the Tukey test for means between groups was used to determine whether there were differences in the scores obtained with the FSSS, GQS, and DISCERN instruments. To assess the agreement and reliability between observers, Fleiss's *kappa* statistic was used $\{K = (P_o - P_e) / (1 - P_e)\}$. This measure has a maximum score of 1, indicating complete agreement between evaluators, while values closer to 0 would indicate a lack of inter-observer agreement. In general, values less than 0.5 are considered unsatisfactory, while values from 0.5 to 0.75 are considered satisfactory, and values greater than 0.75 are rated as excellent.

RESULTS

Initially, 217 *posts* were identified. Of these, 10 were excluded from the search for #frozenshoulder: 8 for not being in Portuguese and 2 for not being related to the subject. In the search for adhesive capsulitis, 7 *posts* were excluded: 5 because they were not in Portuguese and 2 because they were not related to the subject. Thus, 200 *posts* (100 from each topic) were evaluated using the instruments and evaluators previously mentioned.

Table 1 presents the average DISCERN, FSSS, and GQS scores, based on the scores provided by the three evaluators, with the mean and confidence interval calculated from the standard error and the tabulated standard deviation ($Z = 1.96$).

The confidence interval was adjusted to improve precision in comparisons, using the appropriate value from the standard normal distribution for the desired confidence level (95%) and accounting for the standard error, which was estimated from the parametric nature of the data. The *post hoc* tests assessed significance in specific areas, despite the absence of statistically significant differences in the scores provided by the three evaluators.

Table 2 presents the agreement between the results indicated by the three evaluators, based on Fleiss's *kappa* statistic. It was

Table 1. Evaluation of mean (M), confidence interval (CI) of the analysis of variance, along with the DISCERN, FSSS, and GQS scores among 3 evaluators for shoulder and adhesive capsulitis.

Frozen shoulder	DISCERN M(CI)	FSSS M(CI)	GQS M(CI)
Shoulder and elbow surgeon	2.43 (CI= 1.70 -4.13)	2.48 (IC= 1.79 – 3.92)	2.49 (CI=2.89- 4.05)
Orthopedist	2.52* (CI= 0.95 – 4.32)	2.54 (CI =2.27 – 2.51)	2.61* (CI= 0.91 – 4.32)
General practitioner	2.42 (CI= 1.65- 3.94)	2.42 (CI =1.06- 1.24)	2.88 (CI =0.90- 4.86)
ANOVA	p > 0.05	p > 0.05	p > 0.05
Adhesive capsulitis	DISCERN M(CI)	FSSS M(CI)	GQS M(CI)
Shoulder and elbow surgeon	3.28* (CI= 1.29 -5.00)	3.26* (CI= 1.27 – 5.00)	3.50 *(CI=2.30 – 4.32)
Orthopedist	2.75 (IC= 1.35 – 4.37)	2.86 (CI=2.16 – 3.56)	2.74 (IC= 1.14 – 4.34)
General practitioner	2.40 (CI=1.35- 4.15)	2.80 (CI=1.01- 4.71)	2.87 (CI=0.97 – 4.47)
ANOVA	p > 0.05	p > 0.05	p > 0.05

*Difference between the means as seen by the Tukey test (p < 0.05). ** Difference between the means as seen by the Tukey test (p < 0.05). *** Difference between the means as seen by the Tukey test (p < 0.05). Source: Authors.

Table 2. Reliability and agreement regarding the scores of DISCERN, FSSS, and GQS among the three evaluators for the topics frozen shoulder and adhesive capsulitis.

Frozen shoulder	DISCERN	FSSS	GQS
Evaluators	kappa of Fleiss and 95% CI 0.81 (0.70- 0.91)	kappa of Fleiss and 95% CI 0.72 (0.65- 0.87)	kappa of Fleiss and 95% CI 0.93 (0.90- 0.96)
Adhesive capsulitis	DISCERN	FSSS	GQS
Evaluators	kappa of Fleiss and 95% CI 0.70 (0.60- 0.80)	kappa of Fleiss and 95% CI 0.84 (0.80- 0.88)	kappa of Fleiss and 95% CI 0.66 (0.60- 0.72)

Source: Authors.

observed that agreement among the examiners was substantial (mean k=0.75 for DISCERN, mean K=0.78 for FSSS, and mean K=0.78 for GQS), demonstrating excellent agreement ($\geq 75\%$) among the three evaluation methodologies.

DISCUSSION

It is a fact that social networks and digital platforms provide numerous pieces of medical information. However, most of this information lacks technical and scientific validation, potentially leading to misleading guidance for patients.

Data on adhesive capsulitis/frozen shoulder available on YouTube have already been analyzed in previous studies conducted in the United States, and these studies have shown that they are of low quality and not very instructive.¹⁰⁻¹² As the posts published on Instagram related to these topics have not yet been evaluated, this work aimed to assess the quality of this information using three objective scoring systems: the modified DISCERN, the GQS, and the FSSS. Furthermore, the interobserver reliability was evaluated, considering the results indicated by an orthopedic surgeon, a shoulder and elbow surgeon, and a general practitioner.

It is worth noting that the social network Instagram was selected as one of the most widely used in Brazil. For the study, a profile of a 50-year-old woman was created on the network, which corresponds to the sex and age most commonly affected by adhesive capsulitis/frozen shoulder.¹⁵⁻¹⁷

The analysis of the results obtained in this study demonstrates that the information available on the social network Instagram about adhesive capsulitis/frozen shoulder is, in general, of low quality. When evaluating the modified DISCERN in isolation, most posts scored between 0 and 3, indicating either a lack of information in the posts or the presence of various *fake news* and misinformation. These data also reinforce studies previously conducted on other social media platforms, such as YouTube.¹⁰⁻¹²

The evaluation by three professionals with varying levels of experience — an orthopedic surgeon, a shoulder and elbow specialist, and

a general practitioner — with slight variation among the evaluators and high agreement, indicates that the evaluation methods used were consistent and applicable to the proposed context.¹⁸⁻¹⁹ These data align with existing literature, which demonstrates adequate interobserver reliability for validated assessment methods, such as DISCERN.¹³ The results reveal that most posts present incomplete information, with low technical depth and, in many cases, promotional bias. The absence of reliable references, clear explanations about symptoms, diagnosis, and therapeutic options was a constant among the analyzed content. This compromises not only the clinical utility of the publications but also the proper understanding of the disease by patients and the lay public. These findings corroborate the results of previous studies conducted on other digital platforms. Studies that evaluated YouTube videos, such as those by Tang et al.¹⁰, Yüce et al.¹¹, and Tuna and Ay¹², also concluded that the quality of information about adhesive capsulitis available online is limited, not very instructive, and sometimes inaccurate. Such studies reinforce the trend observed in the present work, suggesting that the problem is not exclusive to Instagram and our environment, but rather a recurring characteristic of informal medical content disseminated on social networks.

It is important to highlight that this study has significant strengths, such as the use of internationally validated scores applied by evaluators with different levels of experience, which provides methodological robustness to the analysis. Another positive aspect was the creation of a fictitious profile with demographic characteristics typical of patients with adhesive capsulitis — a 50-year-old woman — which makes the collection environment closer to reality. On the other hand, the research model adopted has inherent limitations. The dynamism of the Instagram platform, where content is frequently modified or deleted, compromises the reproducibility of the study. Furthermore, the analysis conducted in just one day represents a restricted snapshot of the universe of publications, which may not reflect variations over time.

Despite the popularity of Instagram as a source of health information, the data collected indicate that the content related to adhesive

capsulitis lacks reliability, clarity, and scientific grounding. In this sense, it is essential that patients seek professional help for accurate diagnosis and treatment, avoiding reliance solely on social media for clinical decisions. It is also necessary to promote the production of high-quality educational content by health professionals to combat misinformation and foster a proper understanding of the condition.

CONCLUSION

The quality of information available on the Instagram platform about adhesive capsulitis/frozen shoulder is unsatisfactory. The analyzed content demonstrated low reliability, a scant scientific foundation, and limited clinical utility for the lay audience, as reflected in the low scores assigned in the ratings.

CONTRIBUTIONS OF THE AUTHORS

MJST and FTM conceived the research and developed the methodology. DHH, FTM and AYM conducted the research and collected the data. DHH and GS wrote the manuscript. FTM and MJST reviewed the text.

DATA AVAILABILITY DECLARATION










The contents underlying the research are available in the manuscript.

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COMPARATIVE STUDY OF DISTAL RADIUS FRACTURE FIXATION WITH A VOLAR PLATE VERSUS KIRSCHNER WIRES

ESTUDO COMPARATIVO DA FIXAÇÃO DE FRATURAS DO RÁDIO DISTAL COM PLACA VOLAR VERSUS FIOS DE KIRSCHNER

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ABSTRACT

Introduction: Distal radius fractures are the most common fractures of the human skeleton and can be surgically treated using Kirschner wires (K-wires) or a volar plate. **Objective:** To analyze and compare the post-surgical results of patients treated with K-wire and volar plate for distal radius fracture. **Methods:** Retrospective, quantitative study with medical records and postoperative evaluation questionnaires in ten patients divided into two groups: K-wire and volar plate. The study was conducted at the Hospital de Clínicas Dr. Radamés Nardini, Mauá - SP. **Results:** Distal radius fractures were more common in the dominant upper limb, with the volar plate group tending to be older. Volar plate patients had later procedures (median of 13 days), compared to 4 days for K-wire patients. Functional assessment showed better outcomes for the volar plate group, including grip strength. Dorsal flexion loss was 5.2% for K-wire and 21.8% for volar plate when compared to the contralateral limb ($P < 0.05$). **Conclusion:** Volar plate fixation showed reduced functional limitations, while K-wire fixation demonstrated a shorter time from trauma to surgery and better range of motion. The small sample size and lack of systematic allocation limit the validity of these results. **Level of Evidence III; Retrospective comparative study.**

Keywords: Distal radius fracture; Kirschner Wires; Bone plates; Wrist injuries.

RESUMO

Introdução: As fraturas do rádio distal são as fraturas mais comuns do esqueleto humano e podem ser tratadas cirurgicamente utilizando fios de Kirschner (K-wires) ou uma placa volar. **Objetivo:** Analisar e comparar os resultados pós-cirúrgicos de pacientes tratados com K-wire e placa volar para fratura do rádio distal. **Métodos:** Estudo retrospectivo e quantitativo com prontuários médicos e questionários de avaliação pós-operatória em dez pacientes divididos em dois grupos: K-wire e placa volar. O estudo foi realizado no Hospital de Clínicas Dr. Radamés Nardini, Mauá - SP. **Resultados:** As fraturas do rádio distal ocorreram principalmente no membro superior dominante, com o grupo da placa volar sendo tendente a ser mais envelhecido. Pacientes com placa volar realizaram o procedimento mais tardiamente (mediana de 13 dias), enquanto no grupo K-wire a mediana foi de 4 dias. A avaliação funcional mostrou melhores resultados para o grupo da placa volar, incluindo força de preensão. A perda de flexão dorsal foi de 5,2% para K-wire e 21,8% para a placa volar quando comparado ao membro contralateral ($P < 0,05$). **Conclusão:** A fixação com placa volar apresentou menores limitações funcionais, enquanto a fixação com K-wire demonstrou menor tempo entre trauma e cirurgia e melhor amplitude de movimento. O pequeno tamanho da amostra limita a validade dos resultados. **Nível de evidência III; Estudo retrospectivo comparativo.**

Descritores: Fraturas Distais do Rádio; Fios de Kirschner; Placas Ósseas; Traumatismos do Punho.

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INTRODUCTION

Extra-articular distal radius fractures represent a significant challenge in contemporary orthopedic practice, particularly due to their high incidence in elderly populations.¹ These injuries, often resulting from falls or low-energy trauma, have a considerable impact on patients' quality of life, with repercussions that extend

beyond physical recovery, affecting the functionality of the upper limb and the ability to perform daily activities.² The complexity of treating these fractures arises from factors such as variability in clinical presentation, the presence of comorbidities, and the necessity to restore both the anatomy and function of the wrist.³

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The study was conducted at Faculdade de Medicina do ABC, Sao Paulo, SP, Brazil.

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Page 1 of 4



<< SUMÁRIO

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Surgical treatment has become a common approach for distal radius fractures, especially when closed reduction is not achieved.⁴ In this context, volar plate fixation and the use of Kirschner wires (K-wires) emerge as two of the most discussed options in the orthopedic literature.⁵ According to recent studies, volar plate fixation offers superior stabilization, allowing for faster functional recovery and a lower rate of complications, such as infections and non-union.⁶ This is attributed to the design of the plates, which promotes effective compression of the bone fragments and enables early mobilization of the wrist.⁷

On the other hand, fixation with Kirschner wires, while less invasive and technically simpler, may result in a higher incidence of complications, such as wire migration and the need for additional interventions for removal⁸.

Furthermore, early mobilization is often more limited, which can negatively impact the patient's rehabilitation⁹.

METHODS

Retrospective, comparative, descriptive and quantitative study based on patients with unilateral distal radius fracture classified like AO 2R3A2 from February 2023 to July 2023 submitted for volar plate or k-wire fixation at Hospital das Clínicas Dr. Rafamés Nardini in Mauá-SP, according to exclusion criteria: non-traumatic fractures; open fractures of the distal radius; injuries with previous sequelae of the upper limb; joint and bilateral fractures; immature skeleton; loss of outpatient follow-up. All the patients signed an Informed Consent Form, and the research was approved by the Local Research Ethics Committee (CAAE: 74031023.8.0000.0082). The epidemiological data, which were descriptively analyzed, included the variables: age, gender, occupation, and the characteristics of both the fracture and the main limb, trauma mechanism, and Δt (trauma - surgery). The immobilization period with a splint is 2 weeks for the volar plate and 6 weeks for the K-wire after surgery. The K-wire and splint were removed simultaneously in the outpatient clinic. Functional, clinical, and radiographic assessments were conducted six months after surgery. Postsurgical assessments were performed to measurements of range of motion, grip strength, volar tilt, radial inclination through the goniometer, upper-limb global grip strength was measured using a dynamometer and functional parameters at least 11 items were evaluated through the quickDASH, a self-reported questionnaire in which the response options are presented as 5-point Likert scales. The quickDASH score calculator ranges from 0% (no disability) to 100% (most severe disability). Statistical significance was established at $P < 0.05$ using the Mann-Whitney test in the GraphPad Prism 9 software.

RESULTS

Ten patients were included in the analysis, with 5 patients for the volar plate group and 5 for the K wire group. Predominance of distal radius fracture in the dominant upper limb trended towards older age at a median of 61.7 years old for the volar plate group against 55. Both groups consisted exclusively of women. Most of the patients in the K wire group were manual workers (Table 1).

Volar plate patients tended to have their procedures later at a median of 13 days, this value was 4 on the K wire group (Table 1). Postsurgical immobilization period with a splint of 2 weeks for the volar plate and 6 weeks for the k-wire. No complications were reported.

Six months after the surgery, all the patients who participated in the research had already completed the rehabilitation protocol under the supervision of a physiotherapist, and manual workers had returned to work. The other patients were retired but had returned to basic daily activities.

The assessment of the upper limb's functionality was through the quickDASH questionnaire, showing better functional outcome for the volar plate group ($P=0.135$), as well as better grip strength ($P=0.151$) (Table 2).

In patients of the k-wire group, the median for forearm supination was 88°, whereas in the volar plate group it was 80°. Radiographic outcome showed the median of the volar tilt 11° for the k-wire group against 10° for the volar plate group (Table 2).

On comparison of the targeted variables, there was a significant difference ($P < 0.05$) in the dorsal flexion variability from both techniques, with K wire showing an average loss of 5.2% and volar plate 21.8% when compared to the contralateral member (Table 2).

Table 1. Comparison between volar plate group vs k-wire group.

	Volar Plate	K wire
Age (interval)	61,7 (21-69) years	55 (34-73) years
Gender (men: women)	02:03	02:03
Occupation	Active labor workers (40%)	Active labor workers (60%)
Energy of trauma	Low (40%)	Low (80%)
Upper limb fracture	Right (80%)	Right (80%)
Dominant side	Right (80%)	Right (100%)
Exposed fracture	No	No
Associated injuries	No	No
Δt trauma-surgery (interval)	13 (3-18) days	4 (2-17) days

Table 2. Clinical, radiographic, and functional outcomes.

Clinical Outcomes	Volar plate		K Wire		P value
	Value Median (min-max)	%	Value Median (min-max)	%	
Dorsal flexion	56° (24-70°)	16.7% (5.4-52%)	76° (52-90°)	2.5% (0-12.5%)	0.040
Palmar extension	58° (42-70°)	14.3% (0-31.6%)	52° (50-80°)	23% (11-28%)	0.421
Forearm supination	80° (30-90°)	11.1% (0-67%)	88° (82-90°)	2.2% (0-11%)	0.238
Forearm pronation	80° (70-90°)	9.1% (0-22%)	88° (70-90°)	0 (0-22%)	0.270
Grip strength	24.1 kg (9.8-38.7kg)	21% (1.2-38%)	15.5 kg (5.2-22 kg)	40.1% (14.6-65%)	0.151
Radiographic Outcomes					
Volar tilt	10° (2-11°)		11° (10-12°)		0.524
Radial inclination	20mm (2-22mm)		20mm (15-22mm)		1.000
Functional Outcome					
quickDASH		2.3% (0-43%)		36.4% (11.4-63.6%)	0.135

DISCUSSION

Distal radius fracture is a pathology that can occur in different age groups, following a bimodal trend, present in both young adults and elderly patients¹¹⁻¹⁴. Our sample was slightly older than most literature bases that average around 40-50 years old but reflects the bimodal distribution. This bimodal distribution, usually presented with a slight prevalence of males on the younger quartiles, usually related to car accidents and similar mechanisms while older patients often show a prevalence of low-energy traumas, notably fall from one's own height^{13,14-17}. Other noteworthy caveats of our group were the expected prevalence of dominant member fractures¹⁵ and the absence of related fracture with, in some texts, are present on close to 20% of the cases¹⁶. Differences in trauma mechanisms and small sample size are likely to explain these observations. Regarding postoperative results, a recent study from a University Hospital in Pakistan performed a functional evaluation with a better result in the group with the volar plate approach at 6 months compared to the K-wire. Varshney et al.¹⁸ obtained a similar conclusion to the present study, with a mean DASH score of 33.47±5.26 in the percutaneous procedure group and 28.03±5¹⁴. in the volar plate group ($p < 0.05$). However, no significant difference was observed between the two types of treatment at the end of the 12-month follow-up. A meta-analysis also did not record a statistically significant difference in the OR between the comparison of techniques, as observed in the multicenter controlled study in the United Kingdom with a 5-year follow-up¹⁴. There were no differences in wrist extension, pronation, radial deviation, or ulnar deviation during follow-up, which corroborates the present study, in which a statistically significant difference was considered only in wrist dorsiflexion, favoring K-wire ($p = 0.040$). The 2023 study that analyzed the results of range of motion after 12 months of osteosynthesis with volar plate in 28 patients with AO type B and C fractures observed a result similar to that recorded in the present study degrees in patients treated by this technique with flexion of 60±9 degrees and extension 50±10 degrees, average supination of 77±11 degrees and pronation 84±5 degrees.

The grip strength observed in this study in patients in the postoperative period of osteosynthesis with volar plate corroborates the data found by Albeny et al.¹⁹ in a retrospective study with 18 patients, recording 24.83 kg with an average loss of 27.9% in relation to the contralateral side. Evaluating functional results, some studies suggest superior grip strength records in the group treated with volar plate compared to treatment with external fixator associated with K wire in the first year after surgery, but at 2 years, there was no difference between the groups²⁰.

A published meta-analysis did not observe differences in volar tilt (four trials, 0.1° greater in the K-wire group; 95% CI, -4.6° to 4.9°; $p = 0.96$). This data is similar to that evaluated in the present study. The data from the study by Choubey et al.¹⁰ in patients with osteosynthesis with volar plate also converge since at the end of 12 months of observation, there was an average of 17±4 degrees of radial tilt and 7± 5.1 degrees of volar tilt.

CONCLUSION

The patients evaluated obtained excellent postoperative results in both techniques observed. Despite the small sample size and inherent limitations, we observed that volar locking plates showed better DASH scores and grip strength records at the 6-month follow-up compared with K-wires for distal radius fractures in adults, however, these differences were not statistically significant, while the K-wire technique was superior in recording dorsiflexion range of motion.

Our study reinforces current evidence suggesting that the choice between these two surgical approaches is not trivial and should be based on a careful assessment of the fracture characteristics, the patient's clinical conditions, and treatment objectives. A review of the literature reveals a variety of outcomes and clinical experiences, emphasizing the importance of a personalized approach that considers the specificities of each case. Adequate knowledge of each technique's limitations and strengths, as well as surgeon experience and patient clinical data, are fundamental to sustain a case-by-case decision in the lack of conclusive evidence.

CONTRIBUTIONS OF THE AUTHORS

Each author contributed individually and significantly to the development of the manuscript. KSO: Substantial contribution to the conception or design of the work; drafting of the work; final approval of the version of the manuscript to be published. KCBC: Drafting of the work; final approval of the version of the manuscript to be published. PAG: Interpretation of data for the work; drafting of the work. GKSS: Substantial contribution to the conception; final approval of the version of the manuscript to be published. VAQM: Drafting of the work; final approval of the version of the manuscript to be published. FNZP: Substantial contribution to the conception; interpretation of data for the work. RSA: Substantial contribution to the conception; final approval of the version of the manuscript to be published. EPL Jr: Interpretation of data for the work; drafting of the work; final approval of the version of the manuscript to be published. PCVS: Contribution to the design of the work; drafting of the work; final approval of the version of the manuscript to be published.

DATA AVAILABILITY DECLARATION

The data underlying this study are available in the manuscript.

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THERMOGRAPHY ACCURACY IN THE DIAGNOSIS OF CARPAL TUNNEL SYNDROME

ACURÁCIA DA TERMOGRAFIA NO DIAGNÓSTICO DA SÍNDROME DO TÚNEL DO CARPO

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ABSTRACT

Objective: To evaluate the accuracy of thermography for diagnosing carpal tunnel syndrome (CTS) compared to electroneuromyography (ENMG), considered the gold standard, in patients with an indication for surgical treatment recruited from the neurosurgery outpatient clinic of the Irmandade da Santa Casa de Londrina. **Methods:** This is a cross-sectional, descriptive diagnostic accuracy study, oriented by the Guideline for Reporting Reliability and Agreement Studies (GRAAS), with a sample from the database of the project "Clinical-functional characterization and evaluation of the treatment efficacy of patients with carpal tunnel syndrome" of 44 patients, both genders, divided into a study group with 17 participants and a control group with 27 participants. A FLIR® T540 camera was used to capture the thermographic images. The data was acquired and analyzed using FLIR Tools+ software, which measured the average temperature of the region of interest. Artificial Neural Networks were used to classify the thermographic images. **Results:** In terms of the area under the curve was 0.908, the precision obtained was 90.81%, the accuracy 91.66%, the sensitivity 87.25% and the specificity 94.44%. The F1-score was 88.99%. **Conclusion:** The main findings, such as the sensitivity and specificity values, showed significant results indicating that thermography is effective in detecting CTS. **Level of Evidence I; Diagnostic studies – Investigating a Diagnostic Test.**

Keywords: Carpal Tunnel Syndrome; Thermography; Electromyography.

RESUMO

Objetivo: Avaliar a acurácia da termografia no diagnóstico da síndrome do túnel do carpo (STC) em comparação com a eletroneuromiografia (ENMG), considerada o padrão-ouro, em pacientes com indicação de tratamento cirúrgico recrutados no ambulatório de neurocirurgia da Irmandade da Santa Casa de Londrina. **Métodos:** Trata-se de um estudo transversal, descritivo, de acurácia diagnóstica, orientado pela Guideline for Reporting Reliability and Agreement Studies (GRAAS), com amostra proveniente do banco de dados do projeto "Caracterização clínico-funcional e avaliação da eficácia do tratamento de pacientes com síndrome do túnel do carpo", composta por 44 pacientes de ambos os sexos, divididos em grupo de estudo com 17 participantes e grupo controle com 27 participantes. Foi utilizada uma câmera FLIR® T540 para captura das imagens termográficas. Os dados foram adquiridos e analisados por meio do software FLIR Tools+, que mediu a temperatura média da região de interesse. Redes neurais artificiais foram utilizadas para classificar as imagens termográficas. **Resultados:** A área sob a curva foi de 0,908; a precisão obtida foi de 90,81%, a acurácia de 91,66%, a sensibilidade de 87,25% e a especificidade de 94,44%. O escore F1 foi de 88,99%. **Conclusão:** Os principais achados, como os valores de sensibilidade e especificidade, apresentaram resultados significativos, indicando que a termografia é eficaz na detecção da STC. **Nível de Evidência I; Estudos diagnósticos – Investigação de um exame para diagnóstico.**

Descritores: Síndrome do Túnel Carpal; Termografia; Eletromiografia.

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INTRODUCTION

Carpal tunnel syndrome (CTS) can involve the dominant hand, the non-dominant hand or both¹. The CTS is a restricted, elliptical space, ventrally confined by the flexor retinaculum; it is inelastic and resistant; its floor is formed medially by the pisiform and the

hook of the hamate and laterally by the tubercle of the scaphoid and the tubercle of the trapezium².

CTS is primarily diagnosed through clinical history, physical examination, and supplementary tests, specifically neuroconduction studies CTS is diagnosed eminently clinically, through clinical

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The study was conducted at the Irmandade da Santa Casa of Londrina.

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Page 1 of 5



<< SUMÁRIO

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history, physical examination and supplementary tests, specifically neuroconduction studies³. Loss of discrimination between two points in the distribution of the median nerve and tenar atrophy occur in the later stages and show low sensitivity and high specificity. Loss of discrimination between two points in the distribution of the median nerve and tenar atrophy occur in the later stages of CTS.

While diagnostic imaging is not routinely required for initial diagnosis in most cases⁴, it can be valuable in specific situations, such as dubious cases, recurrent or unrelieved symptoms after surgical release of the carpal tunnel, and importantly, for evaluating surrounding soft tissue structures in the carpal tunnel. Ultrasound and MRI, for example, allow direct visualization of median nerve compression and these other tissues⁵.

Although electroneuromyography (ENMG) is accepted as the gold standard for diagnosis, it does not provide information on the surrounding tissues, which could be important for the etiological diagnosis⁶. ENMG alone is unable to confirm or rule out the diagnosis of CTS, but it is useful for characterizing the severity of median nerve neuropathy and aiding in differential diagnosis⁷. In recent years, the use of thermography to help diagnose inflammatory conditions has been questioned. Thermographic images show temperature changes in certain body regions, helping with diseases diagnosis and treatment⁸. Therefore, the internationally standardized cutaneous thermometric evaluation is carried out by always comparing the corresponding halves (dimidia) of the human body⁹. Infrared thermography is the preferred method for studying the physiology and thermoregulation of thermal dysfunction associated with pain^{10,11}.

Current image acquisition systems consist of sophisticated thermal cameras coupled to computers with specific programs where images can be processed to obtain reliable information, making thermography a safe and accurate diagnostic method¹².

The problem with CTS is that it can be misdiagnosed and other syndromes may be diagnosed as CTS. A study of nerve conduction and temperature distribution may prove beneficial in clarifying the diagnosis¹³.

The aim of the study is to evaluate the accuracy of surface thermography and compare it with ENMG, considered the gold standard in the CTS diagnosis, in patients with an indication of surgical treatment recruited from the neurosurgery outpatient clinic of the Irmandade da Santa Casa de Londrina.

The evaluation of this technological tool as a safe and reliable diagnostic resource could contribute to new knowledge in the process of investigating CTS and lead to better treatment results, as well as being a technique with low operating costs, avoiding the immediate use of more expensive tests and lower costs for public authorities, generating a significant scientific and social contribution.

MATERIALS AND METHODS

Type of Study

This is a cross-sectional, descriptive diagnostic accuracy study, oriented by the Guideline for Reporting Reliability and Agreement Studies (GRAAS)¹⁴, carried out at *Universidade Pitágoras Unopar*. The data analyzed in this study was collected in Londrina-PR.

Ethical Procedures

The study was approved by the ethics committee of the Irmandade da Santa Casa de Londrina under number 3.276.439, and the Informed Consent Form was signed by all participants, after an induction session where a member of the team provided a verbal description of all the measures and procedures to be carried out.

Eligibility criteria

Inclusion criteria - age 18 or over, having idiopathic bilateral CTS, presenting one or more of the clinical criteria defined by the American

Academy of Orthopaedic Surgeons, normal laboratory tests to exclude associated pathology (blood count, renal function, glycemic curve, rheumatic profile and thyroid profile), having ENMG criteria indicating mild or moderate impairment in the different combinations between the hands, and no upper limb limitations or skin lesions preventing them from undergoing the proposed therapies.

Exclusion criteria - participants with a background of psychiatric disorders or intellectual disability, pregnant, who had received previous treatment for CTS or who had been symptomatic for a period of no more than six months.

Study Sample

This study sample was made up of 44 participants of both genders, 17 of whom were recruited from the neurosurgery outpatient clinic of the *Irmandade da Santa Casa de Londrina* with idiopathic carpal tunnel syndrome with indication of surgical treatment, while the other 27 individuals formed the control group. All the participants in the sample underwent ENMG and thermography tests.

Participants selected for the present study were included based on having idiopathic carpal tunnel syndrome with a clear indication for surgical treatment. Specifically, eligibility for surgical intervention was determined by criteria including the presence of idiopathic bilateral CTS and electroneuromyography (ENMG) indicating mild or moderate impairment in one of the hands, according to Stevens' (1997) criteria.

The statistical program SPSS (Statistical Package for Social Sciences version 22) was used to analyze the data in which frequencies, means and standard deviations were calculated for each variable. Anthropometric data was assessed for normality using the Shapiro-Wilk test. For normal data, the difference between the study and control groups was checked using the student's t-test for independent samples and, for data with no normal distribution, the Mann-Whitney test. The chi-square test (Fisher's exact test) was used for categorical data. A 95% confidence interval and 5% significance level ($p < 0.05$) were used for all tests.

Study Development

ENMG was used to capture neuromuscular activity and a FLIR® T540 camera was used to record thermographic images (Figure 1). The patients remained in an orthostatic position for 20 minutes to become acclimatized before commencing the measurements. This position was chosen to achieve balance in skin temperature and the patients positioned in an elongated state.

All measurements were carried out in a room with controlled environment, temperature set at $22 \pm 2^\circ\text{C}$. The data was acquired and analyzed using FLIR Tools+ software, which assessed the average temperature of the region of interest (ROI). This average



Figure 1. Thermographic imaging equipment (Camera FLIR® T540).

ROI temperature was obtained from both upper limbs separately and the maximum and minimum temperatures were analyzed using the software to obtain the average temperature.

Artificial Neural Networks (ANN) were used to classify the thermographic images. The MobileNetV2 architecture is a convolutional neural network (CNN)24. The first processing layer consists of 32 convolutional filters. Generating a 32-channel activation map. The next 19 layers are residual bottlenecks. A bottleneck layer consists of 3 convolution operations.

The first is a 1x1 convolution, which means that the operation only takes into account the different channels of a single point. The second layer is a two-dimensional convolution in a 3x3 neighborhood, applied to each channel separately. This step has a non-linear activation, i.e., the result of the convolution is transformed using an activation function. The last operation is another 1x1 convolution.

In the case of a binary classification, this layer has only 1 node. For the classification, images of affected patients were labeled 1 and images of normal patients were labeled 0. Figure 2 shows thermographic images of both the control group and the study group.

Convolutional neural network (CNN) performance

The initial data set consisted of 27 images of regular cases and 17 images of carpal tunnel syndrome cases, all captured by the same operator using a FLIR T530 camera with 320x240 resolution. In order to carry out a more thorough validation of A.I. efficiency, we artificially increased the image bank by performing two operations.

1. For each image in the image bank, a new mirror image was created, doubling the number of elements in the analysis bank.

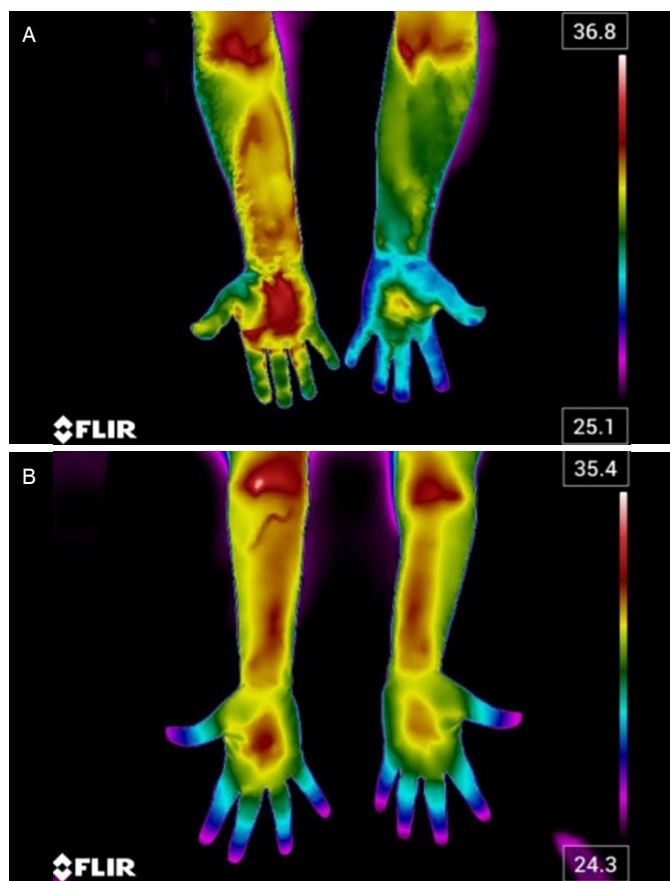


Figure 2. Thermographic images of the wrists of individuals in the study group (A) showing bilateral asymmetric temperature distribution and the control group (B) showing bilateral symmetric temperature distribution.

2. Next, two new versions for each image were created, changing the temperature of all the pixels in the image. To one image 0.5°C was added and to the Other one 0.5°C was subtracted.

In this way, we will have 5 new images for each image in the original database. By performing the two operations, we obtained a total of 162 regular cases and 102 cases of patients diagnosed with carpal tunnel syndrome. Although the operation of varying the temperature in each pixel changes the nature of the image, it does help A.I. not to solely base its analysis on the temperature of the pixel, but rather on the temperature variations throughout the human body. This process helps AI to focus on the temperature distribution pattern of the healthy body and mitigates the influence of factors that can globally alter the temperature value, such as lack of calibration in the sensors, room temperature variation during collection, altered metabolism due to coffee intake. The ML.NET library was used to train and test the network.

The architecture used for the classifier was MobileNetV225. Cross-validation with 5 different groups was used to obtain the following statistics. Each group was used as a test set for a model trained with the other 4 groups. In order to carry out the cross-validation, the images were split before the operations to increase the database. Therefore, if an image is in the training set, none of its 5 variants will be in the test set.

Performance measures were calculated by considering the cases involving people diagnosed with carpal tunnel syndrome as positive, those where the neural network output was > 0.5. An ROC curve was generated, as well as the standard metrics, sensitivity and specificity.

RESULTS

The study included 44 individuals of both genders with an average age of (49±11) years. Descriptions of the anthropometric data are shown in Table 1. According to the data found in the comparisons between the individuals in the study group and the control group, the variables gender, height and weight did not show any statistically significant difference, only the variable age showed a difference. The following confusion matrix shows the number of occurrences of each combination between the class to which the image belongs and the class assigned by the classifier. (Table 2)

Precision was 90.81%, accuracy 91.66% and F1-score 88.99%. Table 3 shows the results of the specificity, sensitivity, positive predictive value and negative predictive value of thermography in relation to ENMG.

In terms of the Operating Characteristics Curve(OCC) of the trained CNN, the area under the curve (AUC) was 0.908.

Table 1. Comparisons of anthropometric characteristics between individuals in the study group and the control group.

Variable	Study Group (n=17)	Control Group (n=27)	p
Sex, M/F (%)	2(12)/15(88)	1(4)/26(96)	0.549
Age (years)	55.3 (± 11.8)	45.9 (± 10.0)	0.007
Height (mt)	158.5 (± 4.7)	160.4 (± 5.8)	0.267
Weight (Kg)	75[68-87]	73[66-85]	0.595

Categorical data described in absolute (relative) frequencies. M: Male, F: Female. Numerical data described as mean (± standard deviation) or median [interquartile range 25% -75%].

Table 2. Confusion matrix of two classes (Positive/Negative).

Confusion matrix		ENMG	
		Positive	Negative
Thermography	Positive	89	9
	Negative	13	153

Data obtained from the ENMG and Thermography diagnostic tests of both the study and control groups.

Table 3. Sensitivity, Specificity, PPV and NPV of Thermography compared to ENMG.

	Thermography X ENMG
Sensitivity	87.2%
Specificity	94.4%
PPV	90.0%
NPV	92.0%

PPV: positive predictive value; NPV: negative predictive value.

DISCUSSION

In the present study, thermography was used in patients with carpal tunnel syndrome and ENMG was used as the gold standard. Satisfactory results were obtained from the thermographic images classified by the convolutional neural network for disease detection. The sensitivity and specificity achieved were 87.25% and 94.44%, respectively, indicating that thermography is a suitable method to supplement clinical diagnosis.

CTS is the most common compressive peripheral neuropathy and is accurately diagnosed in most cases when there is an association between pain, nocturnal numbness and positive Tinel, Phalen and Durkan tests, the latter being the most sensitive for detecting CTS on physical examination¹⁵.

In their studies, De Jesus Filho et al¹⁶ confirmed that the ENMG sensitivity for diagnosing CTS was significantly higher than the USG sensitivity and the sensitivity of the three physical examination tests (Tinel, Phalen and Durkan) evaluated in isolation. In combination, the three clinical tests showed higher sensitivity than USG.

Ultrasound is a useful method for evaluating superficial musculoskeletal structures, but it does not identify minor injuries such as muscle contusions and cramps¹⁷. According to Carvalho et al¹⁸, electroneurographic evaluation would be recommended in cases of symptomatic patients with a negative ultrasound diagnosis.

According to Fowler et al¹⁹ US and ENMG have similar diagnostic accuracy to clinical tests, but ENMG can diagnose other etiologies of hand paresthesia besides CTS, such as cervical radiculopathy, cubital tunnel syndrome and pronator syndrome. Electroneuromyography confirms the clinical diagnosis of CTS with a high degree of sensitivity (over 85%) and specificity (over 95%)²⁰.

Electroneuromyography should be requested whenever neuropathy is suspected. However, it is an invasive method, sometimes uncomfortable, and the result may not show the presence of nerve compression. The test results may also show no injuries as it is not possible to detect them²¹. Many studies have focused on thermographic wrist evaluation, especially in carpal tunnel syndrome, tendonitis and myofascial syndromes, all of which have shown statistically significant positive results correlating images with local disorders²².

In a study by Zycák, Hudák and Madaras²³, they also obtained satisfactory results when using thermography in patients with carpal tunnel syndrome. According to the authors, sensitivity and specificity were 71% and 82% respectively, indicating that thermography is a suitable method to complement clinical diagnosis.

Côrte and Hernandez²⁴ reported that the main advantage of thermography is its safety, however, its disadvantage results from its physical limitations. The two-dimensional, non-radiating technique provides information on superficial structures.

Consequently, while thermography shows promise as a diagnostic tool and a valuable supplement to clinical examination, it cannot be considered a standalone method for the comprehensive diagnosis of CTS. This is because, unlike electroneuromyography (ENMG), which is useful for characterizing nerve severity and critically, aiding in the differential diagnosis of other conditions mimicking CTS symptoms, thermography's current application primarily focuses on thermal patterns associated with the condition itself rather than identifying alternative etiologies or providing detailed information on surrounding tissues important for etiological diagnosis.

Thermography, like many other diagnostic test, thus requires confirmation from other modalities to ensure diagnostic accuracy^{9,11} and can be used to monitor the patient's progress and treatment²⁵. Romano²⁶ stated that thermography is useful for identifying signs of pathology and that there is much evidence that diseases or dysfunctions are often associated to changes in skin temperature. Ramos et al²⁷ checked the skin behavior of the wrist and finger extensors during a brief typing task in individuals with and without injuries. Lower minimum, average and maximum temperatures were observed in the elbow region in individuals with injuries. Lower temperatures were found on the right side when compared to the left side in the elbow skin region. The presence of chronic injuries leads to discontinue the use of the musculoskeletal structures, resulting in reduced blood supply and therefore lower temperatures.

Thermography is a suitable tool for assessing and preventing muscle injuries in athletes, but care must be taken with the control variables during its use. The most efficient variables for capturing the thermographic image seem to be in an environment with a temperature between 18 and 25°C, for 15 minutes for acclimatization and with the individual placed in a predetermined position, depending on the body segment that is being assessed, without contact with another object^{28,29}.

Thermal imaging offers an objective criterion in supplementary diagnosis of fibromyalgia, which generally has vague symptoms associated with a psychosomatic component. These patients have a non-specific hyper-radiant pattern corresponding to the classic painful muscle areas, due to local muscle hypertonia; unlike myofascial trigger points which have a very regular, ellipsoid thermal image with well-defined contours. Infrared can be an additional diagnostic method for documenting and monitoring fibromyalgia³⁰.

For Magas et al³⁰ the main findings in their study refer to changes in variation rates and mean temperature difference, as well as sensitivity and specificity values, which showed meaningful results indicating that thermography can detect wrist tendonitis. The study found that thermography has high sensitivity, ranging from 71% to 100% according to the listed studies, and is increasingly gaining ground in diagnostic support, monitoring and assessment of musculoskeletal symptoms, especially in wrist, elbow and shoulder pathologies.

CONCLUSION

Based on the findings, thermography was proven to have significant sensitivity and specificity values, it can then be concluded that thermography is a non-invasive, painless and promising method in the diagnostic process of CTS, unlike ENMG, which is an invasive and sometimes uncomfortable method.

CONTRIBUTIONS OF THE AUTHORS

Each author contributed individually and significantly to the development of the manuscript. DAMFFO; MMAG: Significant contribution to the conception or design of the work, or the collection, analysis, or interpretation of data for the work. DAMFFO; GSM: Write the work or critically examine its intellectual content. ARAC: Final approval of the text version to be published.

DATA AVAILABILITY DECLARATION

The data set for this article is available in the digital repository: <https://data.mendeley.com/datasets/m7wfbxhfg3/1>

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TREATMENT OF INFERIOR POLE FRACTURE OF THE PATELLA IN ADULTS: SYNTHESIS OF CLINICAL EVIDENCE

TRATAMENTO DA FRATURA DO POLO INFERIOR DA PATELA EM ADULTOS: SÍNTESE DE EVIDÊNCIAS CLÍNICAS

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ABSTRACT

Fractures of the Inferior pole patellar fracture (IPPF) affect the distal end of the bone, where the patellar tendon inserts, and are more common in young, active adults due to direct trauma or intense muscle contractions. This region, which is structurally more fragile and subjected to high tensile loads, becomes vulnerable to fractures that compromise the knee extensor mechanism, resulting in pain, functional limitation, and loss of mobility. Treatment can be conservative or surgical, depending on the degree of displacement and the integrity of the extensor apparatus, and involves various techniques, including minimally invasive procedures. Given the clinical relevance and controversy regarding optimal management, it is necessary to synthesize the available evidence to support therapeutic decisions and optimize functional outcomes. To review the literature on the treatment of IPPF in adults. The search was performed in the PUBMED database using the following search strategy: *inferior[title] AND pole[title] AND patella[title] AND fracture[title]*, with a time cut-off of five years. Results: Initially, 22 studies were identified that met the previously established search strategy. After reading the titles and abstracts, six studies were excluded, leaving 16 articles that constituted the sample for this review. The studies demonstrated stable fixation techniques for IPPF that favored bone consolidation and early functional recovery, but the choice of the ideal method still depends on the type of IPPF, the surgeon's experience, and the reduction of complications such as reoperations, in addition to the presence of a low patella. **Level of Evidence IV, Case Series.**

Keywords: Orthopedics; Traumatology; Knee; Surgery; Fractures; Bone; Patella.

RESUMO

As fraturas do polo inferior da patela (FPIP) acometem a extremidade distal do osso, onde se insere o tendão patelar, sendo mais comuns em adultos jovens e ativos devido a traumas diretos ou contrações musculares intensas. Essa região, estruturalmente mais frágil e submetida a altas cargas de tração, torna-se vulnerável a fraturas que comprometem o mecanismo extensor do joelho, resultando em dor, limitação funcional e perda de mobilidade. O tratamento pode ser conservador ou cirúrgico, conforme o grau de deslocamento e a integridade do aparelho extensor, e envolve técnicas variadas, incluindo procedimentos minimamente invasivos. Diante da relevância clínica e da controvérsia quanto ao manejo ideal, torna-se necessário sintetizar as evidências disponíveis para embasar decisões terapêuticas e otimizar os desfechos funcionais. Revisar a literatura acerca do tratamento da FPIP em adultos. A pesquisa foi realizada na base de dados PUBMED, utilizando a seguinte estratégia de busca: *inferior[title] AND pole[title] AND patella[title] AND fracture[title]*, com um corte temporal de cinco anos. Resultados: Inicialmente foram identificados 22 estudos que atenderam a estratégia de busca previamente estabelecida. Após a leitura dos títulos e resumos, 6 trabalhos foram excluídos, restando 16 artigos que efetivaram constituíram a amostra da presente revisão. Os estudos demonstraram técnicas de fixação estável para FPIP que favorecessem a consolidação óssea e a recuperação funcional precoce, mas a escolha do método ideal ainda depende do tipo de FPIP, da experiência do cirurgião e da redução de complicações como reoperações, além da presença de patela baixa. **Nível de Evidência IV, Série de Casos.**

Descritores: Ortopedia; Traumatologia; Joelho; Cirurgia; Fraturas; Patela.

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INTRODUCTION

The inferior pole of the patella corresponds to the distal portion of the patellar bone, where the patellar tendon inserts, forming part of the knee extensor complex.¹ Structurally, this region has less bone thickness and is subjected to high tensile loads during activities

that involve flexion-extension under resistance.² This configuration makes the inferior pole susceptible to fractures, especially in situations of direct trauma or violent contraction of the quadriceps.³ The inferior pole patellar fracture (IPPF) consist of bone injuries that affect the distal end of the patella, often resulting in separation of

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Page 1 of 7



<< SUMÁRIO

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the tendon insertion fragment.⁴ Etiologically, they are associated with direct traumatic mechanisms to the knee or traction caused by muscle contractions, such as falls with the knee flexed.⁵ These fractures compromise the extensor mechanism, leading to the inability to actively extend the leg, pain, functional limitation, and loss of mobility, impacting the patient's quality of life.⁶

Patellar fractures account for about 1% of all fractures, with IPPF responsible for a significant fraction of these cases, especially among young adults and active individuals.⁶ They are more prevalent in adult males aged between 20 and 50 years due to greater exposure to physical activities and direct trauma. In the elderly, they also occur associated with osteoporosis and bone fragility.² The nature of the trauma determines the fracture pattern, with IPPF classified as transverse fractures with detachment of the patellar tendon.^{2,6}

The treatment of IPPF can be conservative or surgical, depending on the degree of displacement of the fragment and the integrity of the extensor apparatus.² In cases without detachment or instability, immobilization and physical therapy may be indicated.⁵ However, in unstable fractures or with loss of the extensor mechanism, surgical intervention is generally necessary.⁴ Techniques include resection of the fractured fragment with reinsertion of the patellar tendon, fixation with wires or anchors, and the use of biocompatible materials and minimally invasive techniques for anatomical and functional restoration.^{2,4}

Given the importance of the patella and the impact of fractures on gait, knee extension capacity, and patient independence, it becomes essential to understand the most effective approaches. Although relatively common, inferior pole patellar fracture still generate controversies regarding treatment, varying according to the technique used, outcomes, and rehabilitation time. Thus, this

work is justified by the need to synthesize the available evidence, promoting technical-scientific support for decision-making and improvement of outcomes in affected patients.

OBJECTIVE

Review the literature on the treatment of IPPF in adults.

METHOD

This study was conducted based on the integrative literature review method, focusing on the synthesis of evidence. The research was conducted in the PUBMED database, using the following search strategy: *inferior[title] AND pole[title] AND patella[title] AND fracture[title]*, with a five-year cutoff. All types of articles were included for evaluation, with no restrictions regarding the methodological model. This review followed the methodological steps described by Souza et al.⁷ which include: (a) formulation of the guiding question; (b) survey of published studies; (c) preliminary selection of articles for analysis; (d) critical evaluation of studies by experts; (e) discussion of the results of the evaluated articles; and (f) synthesis of the convergences and divergences among the analyzed works. The guiding question of this review was: "what clinical evidence is available on the most effective treatment methods for inferior pole patellar fracture in adults?"

RESULTS

Initially, 22 studies were identified that met the previously established search criteria. After reading the titles and abstracts, six articles were excluded for not addressing the treatment of IPPF in adults. The remaining 16 articles were read in full, summarized, and presented in the next section in chronological order of publication year. Table 1 presents a summary of the information related to the reviewed works.

Table 1. Summary of the information related to the works.

Authors	Title	Type of Study	No. of patients	Conclusion
He et al. ⁸	<i>Novel Rim Plating Technique for Treatment of the Inferior Pole Fracture of the Patella</i>	Prospective observational study	4	The technique proved effective, with bone consolidation in 6–9 weeks and excellent functional results without complications.
Chang et al. ⁵	<i>Fracture of the inferior pole of the patella: tension band wiring versus transosseous reattachment</i>	Retrospective cohort study	55	The tension band wiring (TBW) and transosseous reattachment (TOR) were effective, but displacement >30 mm increased the risk of radiological loss of reduction; 60% of cases with TBW required implant removal.
Wang et al. ⁹	<i>A case-control study of two internal fixation methods in the treatment of comminuted fracture of inferior pole of patella</i>	Retrospective comparative study	60	The group that used the Patellar Concentrator in Memory Alloy (NiTi PC) had a better Böstman score, fewer complications, and better functional recovery, being an effective alternative for comminuted IPPF.
Lu et al. ¹⁰	<i>"Fishing net" suture augmenting tension-band wiring fixation in the treatment of inferior pole fracture of the patella</i>	Clinical study	37	Fixation with "fishing net" demonstrated better stability and fewer failures, being a viable alternative to TBW.
Kim et al. ¹¹	<i>Suture anchor fixation of comminuted inferior pole patella fracture-novel technique: suture bridge anchor fixation technique</i>	Retrospective clinical study	22	All patients achieved bone consolidation and good range of motion (ROM); functional scores were satisfactory, indicating good results from the technique.
Lin et al. ¹²	<i>Treatment of comminuted fracture of inferior pole of patella with locking suspension and vertical fixation with three steel wires</i>	Prospective clinical study	23	The technique showed reliable fixation, high consolidation rate, rapid rehabilitation, and satisfactory clinical effect.
Gao et al. ¹³	<i>Treatment of avulsion fracture of inferior pole of patella with improved angle of anchor and double pulley technique</i>	Retrospective study	22	Technique of easy execution with satisfactory curative effect and good functional recovery of the knee joint.
Pu et al. ¹⁴	<i>Treatment of inferior pole fracture of the patella with tension-free external immobilization</i>	Retrospective cohort study	11	Viable treatment, allowing early functional exercise with satisfactory clinical results.
Ma et al. ¹⁵	<i>Treating Inferior Pole Fracture of Patella with Hand Plating System: First Clinical Results</i>	Retrospective cohort study	30	Secure fixation with excellent bone consolidation rate, adequate functional recovery, and absence of relevant complications.

Authors	Title	Type of Study	No. of patients	Conclusion
Liu et al. ¹⁶	<i>Tension-band wiring through a single cannulated screw combined with suture anchors to treat inferior pole fracture of the patella</i>	Retrospective cohort study	22	Technique provides good stability with low surgical complexity and satisfactory clinical results.
Zhou et al. ¹⁷	<i>Treatment of inferior pole patella fracture using Krackow suturing combined with the suture bridge technique</i>	Retrospective cohort study	18	The combined technique showed stable fixation and good clinical results, with good/excellent functional recovery in 100% of patients.
Kim et al. ¹⁸	<i>Comparison of Fixation Methods Between Transosseous Pull-Out Suture and Separate Vertical Wiring for Inferior Pole Fracture of Patella: A Systematic Review and Meta-Analysis</i>	Systematic review and meta-analysis	16 studies (274 patellas)	Both techniques showed satisfactory and similar results; supplemental fixation reduced bone complications.
Nair et al. ¹⁹	<i>Inferior Pole of the Patella Fracture Fixed by Percutaneous Approach: A Case Report</i>	Case report	1	Percutaneous fixation was effective and minimally invasive, with good functional results in six weeks.
Solunkhe et al. ²⁰	<i>Comparative Study of Inferior Pole of Patella Fracture Treated with Transosseous Technique using Modified Krackow's Technique Versus Traditional Anterior Tension Band Wiring</i>	Comparative Study	20	KT proved to be a viable alternative to TBW, with comparable results in ADM, radiology, and WOMAC score.
Murase et al. ²¹	<i>Fracture of the patella involving the inferior pole is associated with postoperative patella baja - A retrospective multicenter study</i>	Retrospective cohort study	251	Inferior pole patellar increased from 14.3% to 19.5% in six months; IPPF on computed tomography was identified as a risk factor, but there was no difference in clinical outcomes between the groups.
Yan et al. ²²	<i>Krackow suturing combined with the suture-bridge technique versus Kirschner-wire tension band combined with patellar cerclage for the treatment of inferior pole patella fracture: a retrospective comparative study</i>	Retrospective comparative study	47	Both techniques were effective, but the suture bridge technique had fewer complications, lower cost, and a lower reoperation rate.

Source: Data collected by the authors.

DISCUSSION

He et al.⁸ presented a fixation technique for the treatment of IPPF. To this end, they conducted a prospective observational study of consecutive cases of IPPF that were treated at a single clinical center between January 2018 and June 2019. The patients included three men and one woman, with an average age of 47 years (42-59 years). All patients were treated with a fixation technique using a plate that preserved the inferior pole of the patella. During surgery, a 2.4 mm locking compression plate was contoured to fit the inferior arch of the patella. After reduction, the plate was fixed to the proximal fragment using locking screws, against the traction of the patellar tendon. The plate surrounded and compressed the inferior pole fragments, functioning as a compression and locking construct. When necessary, an additional anterior tension band or a mini-plate could be used to prevent anterior displacement of the inferior pole fragments. Under this fixation, knee movement and weight-bearing were encouraged postoperatively. Patients were followed up monthly for 12 months after surgery. The time to achieve a 90° movement without pain, full range of motion (ROM), and consolidation was recorded. Complications were monitored, including infection, loss of reduction, fixation failure, anterior knee pain, and soft tissue irritation. The modified Cincinnati knee classification system was used for functional assessment, and the average operative time was 58.8 minutes (52-63 minutes). The average blood loss was 59.8 mL (45-71 mL), and for all patients, the ROM of 90° without pain was restored in two to four weeks, with full ROM in 8 to 11 weeks. All patients achieved bone consolidation in six to nine weeks, with no displacement of fragments or breakage of the implant. No patient complained of pain in the anterior region of the knee or soft tissue irritation. The modified Cincinnati score at the 12-month follow-up

showed excellent results in all patients. For the authors, the edge plate technique could be a viable option for the treatment of IPPF. Chang and colleagues,⁵ compared clinical and radiological outcomes after IPPF fixation with tension band wiring (TBW) and transosseous refixation (TOR) without excision of the bone fragment and determined the risk factors for postoperative loss of reduction. For this retrospective cohort study, patients with IPPF were recruited between January 2010 and December 2017. Patients were grouped according to the fixation method (TBW or TOR), and demographic data, clinical outcomes, and postoperative Insall-Salvati (IS) index were analyzed. Then, patients were grouped according to loss of reduction, potential risk factors for loss of reduction were identified, and odds ratios were calculated. The study included 55 patients; 30 patients treated with TBW and 25 with TOR. Clinical failures occurred in two patients in the TBW group (7%) and three in the TOR group (12%). The rate of loss of reduction was significantly higher in the TOR group, while implant removal was more common in the TBW group. Low patella was observed after surgery in the TOR group, but the IS ratios of the two groups were similar after three months. Fracture displacement of more than 30 mm was the only independent risk factor for postoperative loss of reduction. According to the authors, in the treatment of IPPF, both TBW and TOR were effective and had a low failure rate. In 60% of patients undergoing TBW, however, additional surgery was required to remove the implants. Low patella occurred after TOR, but patellar height was similar to that of the TBW group after three months. The authors commented that surgeons should be aware of the risk of postoperative loss of reduction, especially when the fracture displacement is greater than 30 mm. Wang et al.⁹ compared the effects of tension band combined with cerclage and patellar concentrator fixation in memory alloy in the

treatment of comminuted IPPF. To this end, from July 2015 to July 2019, 60 patients with patellar fractures were treated and divided into two groups according to different surgical methods. In group A, 30 patients were fixed with a patellar concentrator in memory alloy (NiTi PC), 17 men and 13 women, aged between 20 and 71 years (39.4 ± 9.9), including 19 cases of falls, nine traffic accidents, and two sports injuries. The time between injury and surgery was 10 to 75 hours (33.1 ± 7.8); thirty cases in group B were fixed with tension band and cerclage, patients aged between 21 and 76 years (38.6 ± 10.2), including 17 falls, 12 traffic accidents, and one crush injury. The time between injury and surgery was 10 to 91 hours (34.5 ± 9.1). The effects of the two groups were compared. All patients were followed up for 9 to 30 months, and there was no significant difference in intraoperative bleeding, operative time, follow-up time, and consolidation time between the groups. Six months later, according to the Böstman function score of the knee joint: In 30 cases in group A, the total score was 28.6 ± 4.7 , of which 26 were excellent and 4 were good. The score of 30 cases in group B was 25.5 ± 4.4 , of which 20 were excellent, eight were good, and two were poor. There were differences in the Böstman score and the assessment of the healing effect. The score of group A was better than that of group B, with one case in this group having the Kirschner wire removed, two presenting joint stiffness, and three presenting irritation of the internal fixation. For the authors, the memory patellar concentrator was robust and reliable in the treatment of comminuted IPPF. However, rehabilitation exercises may be necessary after surgery, with good recovery of function and ROM, as well as fewer complications.

Lu and colleagues,¹⁰ evaluated the biomechanical resistance and outcomes of a new fixation procedure for IPPF with “fishing net” suture. To this end, four finite element models, fixation with modified TBW wire, with anchor suture, with basket plate, and with “fishing net” suture were constructed to compare the effectiveness of the latter with the other three methods during IPPF fixation. From January 2018 to February 2019, 17 patients treated with “fishing net” suture fixation (FNS) were compared with 20 patients treated with TBW in a database, and both groups were evaluated using the Cincinnati knee classification system. The biomechanical assessment showed that the values of proximal patellar relative displacement, measured by three pairs of points on both sides of the fracture line, were lowest using FNS fixation, while TBW and basket plate fixation showed similar, less desirable stability levels than the “fishing net” method. Regarding the outcomes, 17 (100%) patients had excellent or good results, compared to three failures in internal fixation in the TBW group. According to the authors, the biomechanical results suggested that the “fishing net” fixation was a candidate for IPPF fixation.

Kim et al.¹¹ evaluated the results of bridge suture anchor fixation for comminuted IPPF. To this end, from March 2012 to December 2018, 22 patients were evaluated. 21 patients with comminuted IPPF and 1 with avulsion fracture of the lower periosteal cuff. The results were evaluated, including the SF-36 score, the *Knee Injury and Osteoarthritis Outcome Score* (KOOS), and the postoperative ROM. In all patients, fixation was performed with a bridge suture anchor, and in two patients, a tension band with K-wire was added for fixation of large fragments. Additionally, consolidation and patellar height were evaluated using the Insall-Salvati ratio and its complications. The mean age was 46 ± 20 (15-82) years, and the mean follow-up period was 25 ± 18 (11-74) months. In all patients, consolidation was achieved at four months. At the final follow-up, the average score on the SF-36 was 72 ± 15 (30-91) points, and the KOOS score was 66.7 ± 16 (43-97). The ROM was 134 ± 5 (125-140) degrees, and as a complication, one patient developed a wound infection and subsequent osteomyelitis of the IPPF.

Compared to the normal knee, the Insall-Salvati index of the injured knee is, on average, 0.73, and this index less than 0.8 indicates a low patella. According to the authors, in IPPF, fixation with a bridge anchor demonstrated good consolidation and satisfactory results in short-term follow-up, which may be a satisfactory treatment option. Furthermore, they also commented that although fixation with a bridge suture anchor in these fractures caused a decrease in the Insall-Salvati ratio (patellar height), there was no development of patellofemoral pain or limitation of ROM.

Lin and colleagues,¹² explored the application of Lockge suspension combined with vertical fixation with steel wires in IPPF. To this end, from August 2016 to May 2019, 23 patients with comminuted IPPF, including 14 men and nine women, were treated with Lockge suspension combined with fixation with steel wires. The age of the patients ranged from 34 to 68 years (55.0 ± 1.2), and one year after the operation, pain and function were evaluated using a visual analog scale (VAS) for pain and knee ROM, with efficacy assessed by the Lysholm score. All 23 patients were followed for 12 to 14 months, with an average of (13.0 ± 0.5) months. One patient had skin irritation caused by the tail of the steel wire, and the rest had no complications, such as incision infection, loosening of internal fixation, or fracture displacement. The fractures of 23 patients healed, and the healing time averaged (12.0 ± 1.1) weeks. The VAS score decreased from 7.96 ± 0.93 before the operation to 0.83 ± 0.65 one year after the operation. The range of motion of the knee increased from (20.30 ± 8.69) ° to (127.39 ± 6.55) ° in 1 year. The Lysholm score of the knee increased from 18.48 ± 4.00 to 96.09 ± 4.91 one year after the operation. According to the authors, the treatment of comminuted IPPF with blocked suspension combined with vertical fixation using steel wires showed reliable fixation and a high rate of fracture consolidation. Moreover, the technique met the requirements for rapid rehabilitation and functional exercise, and the clinical effect was satisfactory.

Gao et al.¹³ evaluated the positioning angle of the anchoring pin and the healing effect of the double pulley technology in the treatment of IPPF due to extreme avulsion. To this end, from December 2015 to December 2018, a total of 22 patients (10 men and 12 women) with IPPF due to avulsion were analyzed retrospectively. The average age was 44.00 ± 15.24 years (ranging from 19 to 70 years), and all patients were treated with a modified anchoring angle and double pulley technique. The range of motion and the Böstman score were used to assess the functional recovery of the knee joint. All 22 cases were followed up for an average of 30.86 ± 8.00 weeks (18 to 46 weeks). At the last follow-up, the range of motion of the affected knee was 130.82 ± 4.69 ° and of the contralateral knee was 133.23 ± 3.15 °, with no significant difference between the two groups. The average Böstman score was 28.45 ± 1.41 , with 18 cases showing excellent results and four cases showing good results. According to the authors, the improvement of the positioning angle of the anchor and the double pulley technique for the treatment of FPIP due to avulsion were easy to perform, with satisfactory healing effect and good recovery of knee function. Pu and colleagues,¹⁴ proposed a new treatment method for IPPF with non-tension external immobilization.

To this end, the clinical data of 11 patients with IPPF treated with non-tension external immobilization between May 2016 and June 2019 were analyzed. The study subjects were six male patients and five female patients, with ages ranging from 39.0 ± 12.8 years (age range of 18 to 53 years). The average age was 44.00 ± 15.24 years (ranging from 19 to 70 years), and all patients were treated with a modified anchoring angle and double pulley technique. The preoperative range of motion of the knee was 22.0 ± 7.5 ° (10-30°) and the time until the operation was 4.5 ± 1.3 days (3 to 7 days). The preoperative range of motion of the knee was 22.0 ± 7.5 °

(10-30°) and the time until the operation was 4.5 ± 1.3 days (3 to 7 days). The indices related to the operation were recorded, and the knee function was evaluated using the Böstman score. All surgeries were successful, with an operative time of 56.4 ± 8.4 minutes (45 to 70 minutes). The average follow-up time was 20.4 ± 7.6 months (12-36 months), the duration of fracture consolidation was 8.9 ± 1.5 weeks (7-12 weeks), and the time for removal of the immobilization device was 10.4 ± 0.9 weeks (9-12 weeks). At the last follow-up, the range of motion showed no significant difference between the affected knee ($129.7 \pm 3.3^\circ$, range of 125 - 135°) and the unaffected knee ($130.8 \pm 3.8^\circ$, range of 126 - 137°). Additionally, the Böstman score for the knee was 29.2 ± 1.0 points (27-30 points), including 10 excellent cases (90.9%) and one good case (9.1%). For the authors, external non-tension immobilization was a viable treatment for IPPF, potentially aiding in early functional exercise and achieving a satisfactory clinical effect.

Ma et al.¹⁵ presented the Hand Plate System (HPS), a new surgical technique for IPPF, and reported the results after the application of the procedure. To this end, they outlined a retrospective cohort study that took place between July 2017 and December 2018. Thirty patients diagnosed with IPPF without additional injuries were observed, and after X-ray and 3D computed tomography examinations, all patients underwent open reduction and internal fixation using HPS, with or without supplemental stabilization with a cannulated screw and fixation screw. Bone consolidation time, range of motion, Böstman score, VAS, and complications were measured as clinical outcomes at a minimum of 12 months of follow-up. All surgeries occurred without issues, with an average operative time of 76.2 ± 15.3 minutes. Bone consolidation was achieved in all cases, averaging 9.5 ± 1.4 weeks after surgery. There was no loss of reduction, failure of the fixator, or surgical removal of the implant during follow-up. The average range of motion after one year post-operation was 0° to 123.3° , and the average Böstman score at the last follow-up was 26.8 ± 2.1 , with a satisfaction rate of 100%. The sensation of pain while walking, measured by the VAS, averaged 0.9 ± 1.3 , and there were no complications except for one case of poor incision healing, which eventually healed after surgical debridement. For the authors, the EHP proved to be a safe fixation method.

Liu and collaborators,¹⁶ evaluated the feasibility and results of tension band fixation using a single cannulated screw with two suture anchors in the treatment of IPPF. To this end, between September 2018 and September 2021, 22 patients with an average age of 55 years who suffered IPPF were included and treated with tension band fixation using a single cannulated screw combined with two suture anchors. Radiographs were performed to observe the bone consolidation time, and the duration of each surgery was recorded to reflect the complexity of the treatment. Functional measurements were taken, including range of motion, Böstman scale, and KOOS. Complications, including fixation failure, incision infection, loss of reduction, and malunion, were evaluated. All patients were followed for an average of 17 months (12-25 months), with an average consolidation time of 11 weeks (8-12 weeks). At the final follow-up, the average range of motion was 136° (range: 115° - 140°), the KOOS was 85 (range: 68-100), and the Böstman score was 28 (range: 20-30); these results were classified as excellent in 17 cases and good in five cases, with no cases of poor outcomes. Loss of reduction occurred in one case, while no cases of incision infection, fixation failure, or malunion were observed. According to the authors, for IPPF, fixation with a tension band through a single cannulated screw with suture anchors could provide sufficient fixation stability to achieve a satisfactory clinical outcome with reduced surgical complexity.

Zhou et al.¹⁷ evaluated the feasibility and clinical effect of Krackow suture combined with the bridge suture technique for the treatment of acute IPPF. To this end, 18 patients with acute IPPF who received treatment with Krackow suture combined with the bridge suture technique between January 2019 and March 2020 were reviewed. The average age was 44.00 ± 15.24 years (ranging from 19 to 70 years), and all patients were treated with a modified anchoring angle and double pulley technique. There were 10 men and eight women, with an average age of 50.1 years (range from 24 to 69 years). Radiographic examinations were performed to assess fracture consolidation and the IS index. The clinical effect was measured by the ROM of the knee joint and the Böstman scale. Patients were followed for 13 to 26 months, with an average follow-up period of 19.6 months. The X-ray indicated that fracture consolidation occurred in all patients on average 10.1 weeks after surgery (range from eight to 14 weeks). The average IS index immediately after surgery and at the final follow-up was 0.98 ± 0.07 and 0.90 ± 0.22 , respectively. At the last follow-up, the average flexion and extension range of the knee joint were $135.8^\circ \pm 8.8^\circ$ and $-2.8^\circ \pm 3.9^\circ$, respectively, and the average Böstman scale was 28.9 ± 1.1 points. Functional recovery was excellent in 17 patients and good in one patient, resulting in an overall good/excellent recovery rate of 100%. According to the authors, the results indicated that Krackow suture combined with the bridge suture technique could achieve stable fixation of acute IPPF, providing good clinical outcomes, making it worthy of clinical application.

Kim and colleagues,¹⁸ compared through a systematic review the fixation methods with Krackow transosseous suture (KT) and with separate vertical wire fixation (VW) in IPPF and assessed whether supplemental fixation affected bone consolidation. To this end, the MEDLINE, Embase, and Cochrane databases were searched from their inception until January 15, 2023. The keywords were "*patella inferior pole fracture*", "*patella distal pole fracture*", "*transosseous*", "*pull-out suture*", "*reattachment*", and "*vertical wiring*". All clinical studies that described KT or VW techniques for IPPF and reported complications related to bone consolidation were included. The meta-analysis included 16 studies with 274 patellas with demographic data, surgical techniques, clinical outcomes, and recorded complication rates. The Methodological Index for Non-Randomized Studies criteria were used to assess the quality of the publications. The techniques used for the analysis were random effects models and meta-regression. The meta-analytic estimate of complications related to bone consolidation was 3.8% for KT or VW techniques in fractures of the lower pole of the patella. The rates of complications related to bone consolidation did not differ significantly between the two techniques (KT, 5.7%; VW, 3.0%). Meanwhile, fixation with supplementation was significantly associated with a reduction in rates of complications related to bone consolidation. For the authors, the fixation of IPPF using KT or VW techniques provided satisfactory and similar clinical results, with minimal complications related to bone consolidation. For them, supplemental fixation would have a positive impact on reducing complications related to bone consolidation in IPPF after KT and VW techniques.

Nair et al.¹⁹ reported the case of a treatment for IPPF using a percutaneous approach. The case involved a 70-year-old female patient who presented significant pain and swelling in the knee after a fall. The radiographic examination revealed a displaced fracture of the lower pole of the patella, along with a fracture of the ipsilateral tibial plateau. Surgical intervention was deemed necessary due to the extent of the displacement and the potential compromise of knee function. A percutaneous technique was employed for the reduction and fixation of the fracture using cannulated screws under fluoroscopic guidance. Post-operative rehabilitation focused on early mobilization and strengthening exercises, and at a six-week

follow-up, the patient demonstrated satisfactory clinical results with restoration of knee function and minimal residual symptoms. For the authors, this case highlighted the effectiveness of percutaneous fixation in the treatment of IPPF, offering a minimally invasive approach with favorable functional outcomes.

Solunkhe and colleagues,²⁰ evaluated 20 patients divided into two groups of 10 each: Group A, composed of patients operated on with TBW and Group B, with patients operated on with Krackow KT. Both groups underwent the same physiotherapy in the post-operative period and the results were compared. The radiological results and the WOMAC score (*Western Ontario and McMaster Universities Osteoarthritis Index*) of the patients were comparable in both groups. The return to total ADM was also similar in both groups, with similar physiotherapy administered in both. For the authors, this demonstrated that, with careful patient selection, KT of IPPF can be used as an alternative to TBW.

Murase et al.²¹ aimed to clarify the incidence of low patella after IPPF surgery, as well as the clinical outcomes associated with and without the presence of low patella. Additionally, the researchers also clarified the potential correlation between the detection of IPPF on computed tomography and the occurrence of low patella. To this end, they conducted a multicenter retrospective study involving 251 patients who underwent surgical treatment for IPPF. The patients were divided into the low patella group (PB; n = 49) and the normal patella group (PN; n = 202). The collected data included demographic data, radiographic findings, surgical details, and postoperative complications. Logistic regression analyses were used to identify risk factors for low patella. Immediately after surgery, 36 (14.3%) patients presented with low patella, a number that increased to 49 cases (19.5%) at six months postoperatively. There was no statistically significant difference in demographic data, surgical details, clinical outcomes, and complications between the PB and PN groups. Meanwhile, in the radiographic evaluation, the prevalence of IPPF on computed tomography in the low patella group was significantly higher than in the normal patella group. By logistic regression analysis, IPPF on computed tomography was identified as an independent risk factor for low patella. For the authors, in patients with patellar fractures, the incidence of low patella increased from 14.3% immediately after surgery to 19.5% at the six-month assessment. No significant differences were observed in clinical outcomes between the low patella group and the normal group. Additionally, the identification of IPPF on computed tomography emerged as a predictive factor for low patella.

Finally, Yan and collaborators,²² conducted a retrospective study of 47 patients with IPPF who underwent fixation procedures at a single clinical center between January 2019 and May 2022, of which 25 received Krackow suture combined with the bridge suture technique (Group 1) and 22 received a tension band with Kirschner wire combined with patellar cerclage (Group 2). The operative time, reoperation rate, Böstman score, knee ROM, fracture consolidation time, IS index, complications, and hospital costs were compared between the two groups. The mean follow-up period was 23.1 ± 5.8 months, and the rates of complications and reoperations in Group 2 were significantly higher than in Group 1. While Group 1 had lower hospital expenses than Group 2, no significant differences were found regarding the

Böstman score, knee ROM, IS index, fracture consolidation time, and operative time between the two groups. For the authors, both the Krackow suture combined with the bridge suture technique and the tension band technique with Kirschner wire could achieve comparable clinical efficacy in the stable fixation of IPPF, subsequently allowing for the early initiation of rehabilitation exercises, while the bridge suture technique could also reduce the incidence of complications, hospital costs, and the need for surgical reoperation.

The analysis of the articles demonstrated that there was a general agreement among the authors on the need for stable fixation that would allow for early rehabilitation and knee movement to optimize clinical outcomes. Many studies, such as that of He et al.⁸ with the edge plate, Ma et al.¹⁵ with the Hand Plate System (HPS), and Pu et al.¹⁴ with external immobilization without tension, highlighted satisfactory results in terms of bone consolidation and recovery of ROM with their respective techniques. The low rate of clinical failure and good functional recovery are points of convergence, with some studies, such as those by Liu et al.¹⁶ and Zhou et al.¹⁷ reinforcing the idea that the stability of fixation is crucial for these positive outcomes, using methods such as tension band combined with suture anchors and Krackow suture with bridge suture.

However, there are notable disagreements and variations in technique preferences and associated complications. For example, while Chang and colleagues,⁵ compared TBW and TOR, highlighting that implant removal was significantly more common in the TBW group and that low patella occurred immediately after TOR, Yan and colleagues (22) suggested that Krackow suture combined with the bridge suture technique could reduce the incidence of complications and the need for reoperation compared to the tension band technique with Kirschner wire. This latter technique, while effective, has been associated with a higher rate of reoperation and complications in some contexts. Wang et al.⁹ on the other hand, pointed out that NiTi PC outperformed the tension band with cerclage in terms of knee function scores, suggesting that some approaches could offer superior functional outcomes. Additionally, the occurrence of low patella, as observed by Murase et al.²¹, was a complication present in different techniques, although the authors did not find significant differences in clinical outcomes between patients with and without low patella. The choice of technique, therefore, seemed to depend on the surgeon's experience, the characteristics of the fracture, and the minimization of specific complications, such as the need for implant removal or the occurrence of low patella, with some authors, such as Lu et al.¹⁰ proposing new approaches, such as fixation with "fishing net" suture, which demonstrated greater stability in biomechanical studies and promising clinical outcomes.

CONCLUSION

In summary, the studies converge in the search for stable fixation techniques for IPPF that promote bone consolidation and early functional recovery, although the approaches vary in their efficacy and complication profile. In this context, the choice of the ideal technique still depends on factors such as the type of IPPF, the surgeon's experience, and the minimization of adverse outcomes, such as the need for reoperation or the occurrence of low patella.

CONTRIBUTIONS OF THE AUTHORS

Each author contributed personally and significantly to the development of this article: JPM, SB, DDVM, AM, and CG: conception and design of the work, acquisition, analysis, and interpretation of data for the work, drafting the text and critical revision of its intellectual content, as well as final approval of the version of the manuscript to be published.

DATA AVAILABILITY DECLARATION

Data will be made available upon request.

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USE OF PERONEUS LONGUS AS A GRAFT FOR ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION: A META-ANALYSIS

USO DO FIBULAR LONGO COMO ENXERTO PARA RECONSTRUÇÃO DO LIGAMENTO CRUZADO ANTERIOR: UMA METANÁLISE

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ABSTRACT

To evaluate the advantages and disadvantages of anterior cruciate ligament reconstruction using the long fibular graft, compared to the hamstrings. This is a systematic review with meta-analysis, analyzing articles published in English and Portuguese between 1980 and 2025, in the databases MEDLINE, PUBMED, COCHRANE, and SCIELO. The variables of interest were: IKDC, Lysholm, AOFAS, sample size, and participants' age. Cochrane's Q test and I² statistics were used to assess heterogeneity. Significant heterogeneity was identified when p-values were below 0.10, and I² values were above 25%. Twelve articles were included in the scope of this review. The studies involved 1,212 patients, of whom 72.23% were male, and 18.49% were female. The follow-up time of the patients ranged from six months to five years. No statistically significant differences were found in IKDC and Lysholm of the two samples. There was a small statistical difference in the AOFAS scale. We did not find studies in the literature with sufficient relevance to demonstrate the superiority of long fibular reconstruction as a graft. There are also not enough studies to determine morbidity at the donor site. The use of the long fibular as a graft is promising, but requires caution. **Level of Evidence I; Systematic Review.**

Keywords: Anterior Cruciate Ligament; Anterior Cruciate Ligament Reconstruction; Tendons.

RESUMO

Avaliar as vantagens e desvantagens da reconstrução ligamentar do ligamento cruzado anterior utilizando o fibular longo como enxerto, em comparação com os isquiotibiais. Trata-se de uma revisão sistemática com metanálise, com análise de artigos publicados nas línguas inglesa e portuguesa entre 1980 e 2025, nas bases de dados: MEDLINE, PUBMED, COCHRANE E SCIELO. As variáveis de interesse foram: IKDC, Lysholm, AOFAS, tamanho da amostra e idade dos participantes. O teste Q de Cochrane e as estatísticas I² foram utilizadas para avaliar a heterogeneidade. Determinou-se heterogeneidade significativa para valores de p abaixo de 0,10 e valores de I² acima de 25%. Fizeram parte do escopo dessa revisão 12 artigos. Os estudos envolveram 1212 pacientes, 72,23% do sexo masculino e 18,49%, do sexo feminino. O tempo de seguimento dos pacientes variou de seis meses a cinco anos. Não foram encontradas diferenças estatísticas significativas em IKDC e Lysholm das duas amostras. Houve uma pequena diferença estatística na escala AOFAS. Não encontramos na literatura estudos com relevância o suficiente que consigam comprovar a superioridade da reconstrução do fibular longo como enxerto. Também não há estudos o suficiente para determinarmos morbidade no sítio doador. O uso de fibular longo como enxerto é promissor, mas requer cautela. **Nível de Evidência I; Revisão Sistemática.**

Descritores: Ligamento Cruzado Anterior; Reconstrução do Ligamento Cruzado Anterior; Tendões.

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INTRODUCTION

The anterior cruciate ligament (ACL) is the primary static stabilizer of anterior knee stability; it is the second most commonly injured structure in the knee, after the menisci, with an annual incidence of approximately 100,000 to 200,000 cases in the United States alone.¹ The leading cause of injuries remains sports activities. An ACL tear can result in permanent and severe complications such as knee

instability, cartilage damage, and meniscal damage, which can lead to osteoarthritis and negatively impact the individual's quality of life.² The gold standard treatment is arthroscopic reconstruction of the anterior cruciate ligament using an autograft. Common choices for grafting include the patellar tendon, quadriceps tendon, and hamstring tendons. However, some postoperative drawbacks include anterior knee pain and weakness of the extensor mechanism.

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

The study was conducted at Centro Estadual de Reabilitação e Readaptação Dr. Henrique Santillo located on Av. Ver. Jose Monteiro, 1655, Setor Negro de Lima, Goiânia, GO, Brazil. 74653-230.

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The hamstring tendon (HT) is currently the most commonly used autograft for ACL reconstruction.³

Currently, the use of the long fibular tendon has gained prominence due to its ability to reduce residual morbidity at the donor site³ and because it shows no difference in tensile strength and yields better functional scores compared to the hamstring tendon.² The choice of graft is patient-centered, considering anatomical variations, patient preference, reduction of morbidity, and appropriate rehabilitation. Therefore, expanding the range of options makes ACL reconstruction more effective.

The main objective of this study is to present satisfactory clinical and functional outcomes following the use of the long fibular tendon in arthroscopic ACL reconstruction, compared with the most commonly used graft, the hamstring, through a systematic review and meta-analysis of randomized clinical trials.

METHODOLOGY

The formulation of the research question and search strategy for this article was based on the PICO model (*Population, Intervention, Comparison, Outcome*), which is widely used in evidence-based practice methodology and recommended for conducting systematic reviews. The PRISMA model was used as a reference for the article selection flowchart.

Search strategy

The study included articles published between 1980 and 2025 in English and Portuguese that described the use of the long fibular in anterior cruciate ligament reconstruction, using the following databases as references: MEDLINE, PUBMED, COCHRANE E SCIELO. For the initial search, the following search terms were used: “anterior cruciate ligament” combined with “reconstruction” and “peroneus longus.”

The articles were selected by two independent reviewers based on the title and abstract. The potentially eligible articles were read in their entirety. Afterward, the reviewers also reviewed the reference lists of all eligible articles to identify additional references for this study.

Eligibility criteria

The inclusion criteria were: (1) population (adults, aged 16 years and older); (2) intervention (ACL reconstruction using the peroneus longus tendon compared with the flexor tendons); (3) outcomes of interest (functionality, quality of life); (4) articles published in the last 45 years—in English or Portuguese; (5) randomized clinical trials, prospective observational studies, retrospective observational studies, cross-sectional studies, case-control studies; (6) studies with full-text versions available in the searched databases; (7) primary and isolated ACL reconstruction.

Exclusion criteria

The exclusion criteria were: (1) studies involving participants under the age of 16; (2) studies involving patients with multi-ligament injuries; (3) studies that did not compare the use of flexor tendons and the long fibular tendon; (4) other types of articles, such as case reports, biomechanical studies, surgical techniques, and others not selected based on the inclusion criteria.

Data extraction

After completing the previous steps, a reviewer extracted the following data from each article: year of publication, sample characteristics (sample size, population, age, gender), surgical technique, follow-up period, and outcomes (functionality and quality of life).

The variables of interest were entered into a spreadsheet by one of the authors using Excel (Microsoft Corp., United States). The relevant data were analyzed using descriptive statistics.

The risk of bias assessment for randomized trials was conducted independently by two authors using the Risk of Bias for Randomized Trials (ROB-2) tool, in accordance with Cochrane guidelines.

The results were compared using the standardized mean difference (SMD), and binary outcomes were assessed using risk ratios (RR), with their respective 95% confidence intervals (CI). The DerSimonian and Laird method was used to conduct the random-effects meta-analysis. Statistical analyses were performed using Review Manager 5.4 (The Cochrane Collaboration, London, United Kingdom).

The Cochrane Q-test and I^2 statistics were used to assess heterogeneity. Significant heterogeneity was identified when p-values were below 0.10, and I^2 values were above 25%. The interpretation of heterogeneity measures followed the guidelines provided in the Cochrane Handbook for Systematic Reviews of Interventions.

RESULTS

Based on the search terms used and the publication date specified by the authors, a total of 120 articles, including 96 from PubMed, 8 from MEDLINE, 3 from SCIELO, and 13 from Cochrane.

After reviewing the titles and abstracts, 86 articles were excluded based on the eligibility criteria. Among the most common reasons for exclusion are: studies that did not compare grafts, biomechanical studies, and studies that did not include the desired outcomes. Articles for which the full text was not available were also excluded. The selected studies (34) were screened for duplication, resulting in 8 articles. Subsequently, the articles were read in full, and 10 were excluded because they lacked data relevant to this review. Following the selection process and the application of the eligibility criteria, 12 articles were included in this systematic review. The PRISMA flowchart was used to aid understanding (Figure 1).

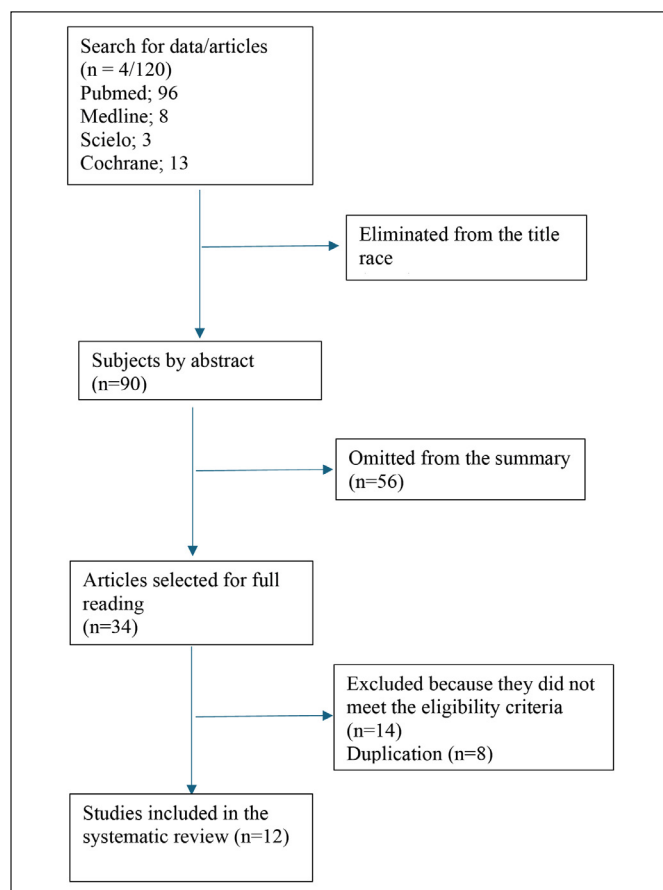


Figure 1. Flowchart.

The data extracted for the analysis were then summarized in a table for easier visualization, including the following variables: year of publication, type of study, sample size and characteristics, surgical technique, patient follow-up period, and outcomes measured using specific scales (IKDC, Lysholm, AOFAS, FADI) (Table 1).

The studies involved a total of 1,212 patients, of whom 72.23% were male (876) and 18.49% were female (224). Shi et al.⁸ did not report this. Among the grafts used, 560 were taken from the peroneus longus and 553 from the flexor muscles. The follow-up period for patients ranged from six months⁵ to five years.³

The graphs show that patients who underwent ACL reconstruction using an autologous long fibular graft had higher preoperative IKDC scores compared to those who underwent reconstruction using

a flexor tendon graft (MD -0.50; 95% CI -1.13 to 0.13; p=0.48; I²=0%), however, there was no statistically significant difference (p > 0.05). (Figure 2)

When examining postoperative IKDC scores, we observed scores that slightly favored the use of flexors (MD 0.05; 95% CI -2.21 to 2.31; p < 0.00001; I² = 93%). Nevertheless, the difference was not significant, as the confidence interval has a value of 0. (Figure 3)

The long fibular group had lower preoperative Lysholm scores (MD 0.50; 95% CI -0.95 to 1.94; p = 0.04; I² = 95%); however, these differences were also not statistically significant (Figure 4).

On the other hand, the long fibular group had higher postoperative Lysholm scores (MD -0.21; 95% CI -2.67 to 2.25; p < 0.00001; I² = 96%) compared to the group that used flexors (Figure 5).

Table 1. Data analysis.

Author / Year	Type of Study	Sample size	Genre	Age	Surgical technique	Follow-up period
Agarwal et al. (2023) ⁴	Prospective cohort study	194 patients Long fibular group: 98 Flexor muscle group: 96	Men's: Women's 125: 69	Long fibular: 28± 4.91 Flexors: 27.50 ± 4.06	Femoral fixation with an endobutton Tibial fixation using a bio-absorbable interference screw	12 months
Dwidmuthé et al. (2024) ⁵	Prospective randomized study	36 patients Long fibular group: 18 Flexor muscle group: 18	Men's: 29 Women's: 7	29.27±7.87	Femoral fixation with a closed-loop endobutton Tibial fixation using a bio-absorbable interference screw	6 months
Saeed, et. al (2023) ¹	Prospective cohort study	158 patients Long fibular group: 85 Flexor muscle group: 73	Men's: 138 Women's: 20	29.55 ± 6.40	Femoral fixation with an endobutton Tibial fixation using a bio-absorbable interference screw	24 months
Asif et al. (2024) ⁶	Randomized controlled clinical trial	120 patients Long fibular group: 60 Flexor muscle group: 60	Men's: Women's 112: 8	Long fibular: 24.4 ± 9.54 Flexors: 24.73 ± 8.18	Femoral fixation using an endobutton with a fixed loop or an adjustable loop Tibial fixation using an interference screw, tibial post screw, or tibial suture disk	24 months
Gok et al. (2024) ⁷	Comparative cohort study	106 patients Long fibular group: 52 Flexor muscle group: 54	Men's: 93 Women's: 13	Long fibular: 28 ± 6.2 Flexors: 28.9 ± 6.1	Femoral fixation with an endobutton Tibial fixation using a bio-absorbable interference screw	18 months
Shi et al. (2018) ⁸	Observational study	38 patients Long fibular group: 18 Flexor muscle group: 20	Not specified	Long fibular: 42 Flexors: 40	Femoral fixation with an endobutton Tibial fixation prior to 2008 using the transtibial drilling technique and, thereafter, drilling of separate anteromedial femoral tunnels	24 months
Rhatomy et al. (2019) ⁹	Prospective observational study	52 patients Long fibular group: 24 Flexor muscle group: 28	Men's: 44 Women's: 8	Long fibula: 23.4 ± 8.1 Flexors: 26.4 ± 8.6	Femoral fixation with an endobutton Tibial fixation using a bio-absorbable interference screw	12 months
Butt et al. (2024) ³	Prospective randomized study	60 patients Long fibular group: 30 Flexor muscle group: 30	Men's: 59 Women's: 1	Long fibular: 29.2 ± 5 Flexors: 27.7 ± 4.1	Femoral fixation with ACL Tight rope Tibial fixation using a bio-absorbable interference screw	5 years
Keyhani et al. (2022) ²	Cross-sectional study	130 patients Long fibular group: 65 Flexor muscle group: 65	Men's: 119 Women's: 11	Long fibular: 29.8 ± 7.5 Flexors: 27.60 ± 8.1	Femoral fixation with ACL Tight rope Tibial fixation using a bio-absorbable interference screw	2 years
Mingguang et al. (2018) ¹⁰	Prospective randomized study	124 patients Long fibular group: 62 Flexor muscle group: 62	Men's: 65 Women's: 59	Long fibular: 29.1 ± 6.5 Flexors: 27.9 ± 6.7	Femoral fixation with ACL Tight rope Tibial fixation with ACL Tight rope	2 years
Ahmed et al. (2022) ¹¹	Prospective comparative study	75 patients Long fibular group: 25 Flexor muscle group: 25 Group quadriceps: 25	Men's: 57 Women's: 18	Long fibular: 33.3 ± 6.4 Flexors: 31.5 ± 3.9	Femoral fixation with ACL Tight Rope and interference screws Tibial fixation using a bio-absorbable interference screw	12 months
Vijay et al. (2022) ¹²	Prospective randomized study	45 patients Long fibular group: 23 Flexor muscle group: 22	Men's: 35 Women's: 10	Long fibular: 33.57 ± 9.54 Flexors: 31.82 ± 9.62	Not specified	12 months

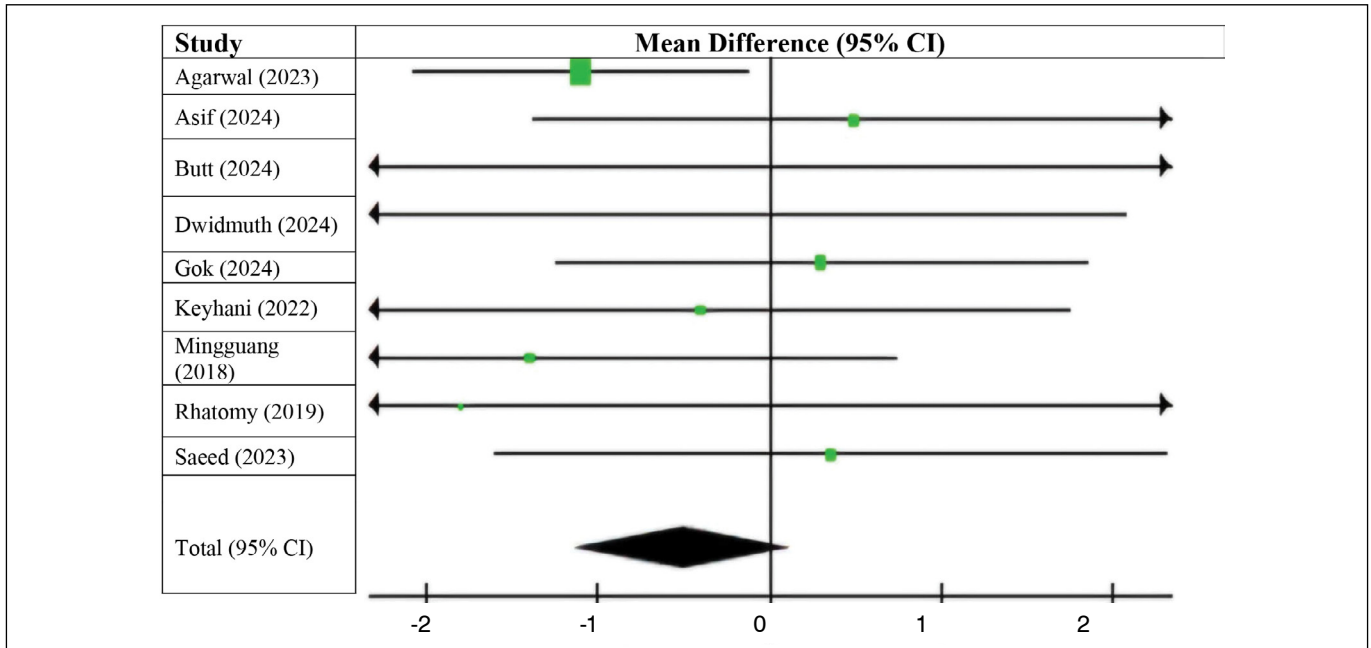


Figure 2. Preoperative IKDC.

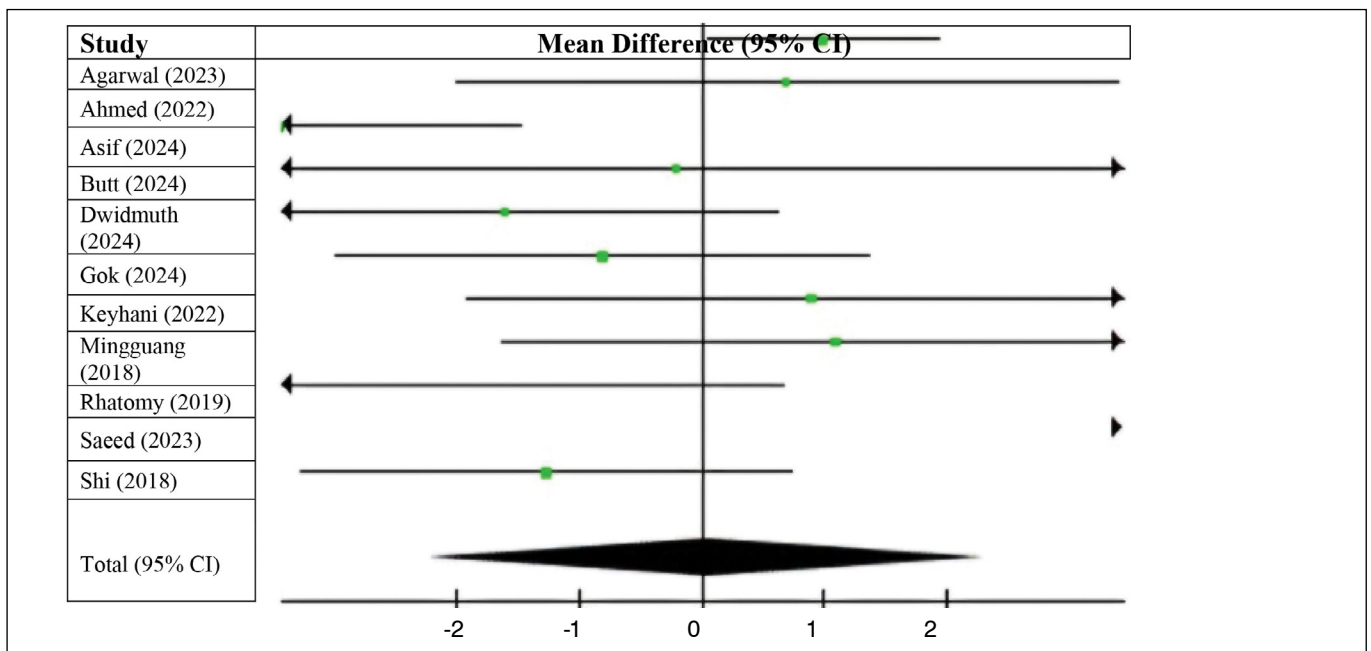


Figure 3. Postoperative IKDC.

Nevertheless, our confidence interval includes 0, so there is no statistically significant difference either.

Patients who underwent ACL reconstruction surgery using autologous long fibular grafts had lower postoperative AOFAS scores (MD 0.52; 95% CI -0.14 to 0.90; $p < 0.07$; $I^2 = 0\%$) (Figure 6) compared with those who received autologous flexor grafts. This difference was considered statistically significant.

We also analyzed the pre- and postoperative AOFAS scores in patients in the group who underwent ACL reconstruction surgery using the long fibular. The results favored the preoperative group (MD 1.39, 95% CI -0.35 to 3.12, $p < 0.00001$; $I^2 = 93\%$). As with previous results, we did not observe a statistically significant difference (Figure 7).

DISCUSSION

The strength and stiffness of the graft are important factors to consider when choosing the type of graft and the reconstruction technique. It is widely accepted that an autologous hamstring tendon graft is a reliable option for ACL reconstruction; however, the use of alternative grafts has been increasing significantly.

The aim of this meta-analysis was to compare the clinical outcomes of anterior cruciate ligament (ACL) reconstruction using autografts from the long fibular tendon versus flexor tendons. Overall, both types of graft yielded similar results on the main functional scores (IKDC, Lysholm, AOFAS, FADI), with differences that were, for the

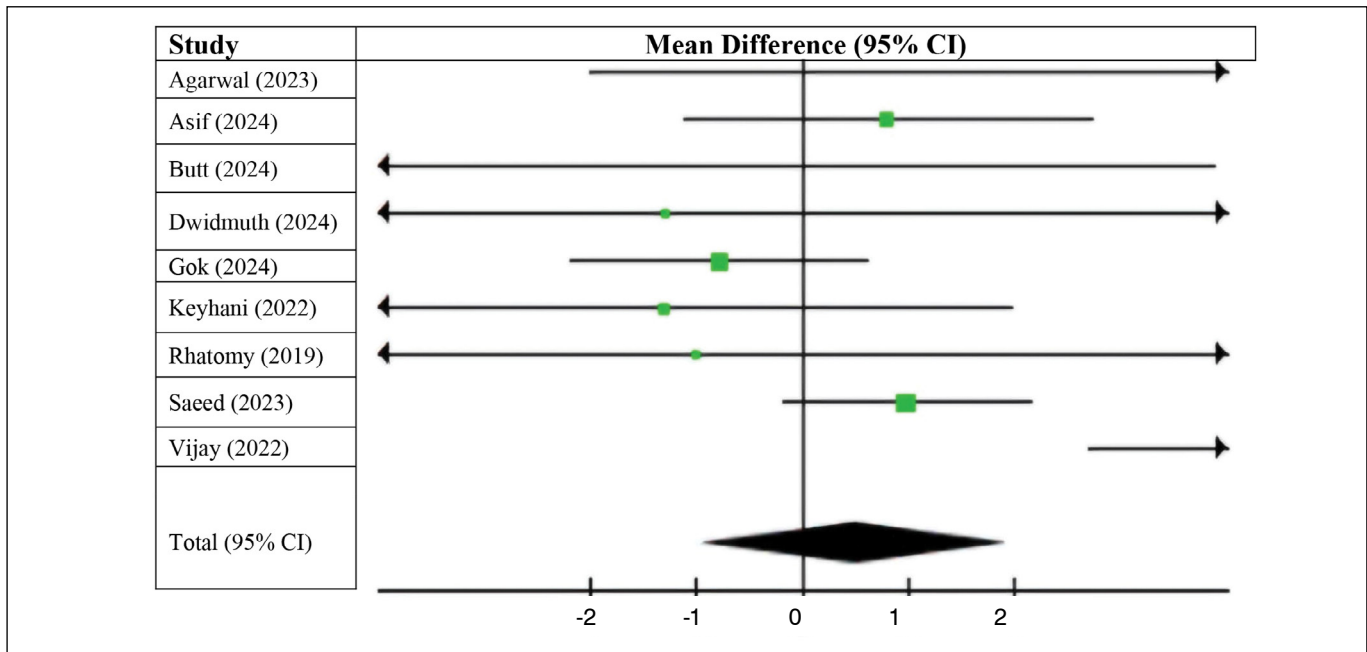


Figure 4. Preoperative Lysholm score.

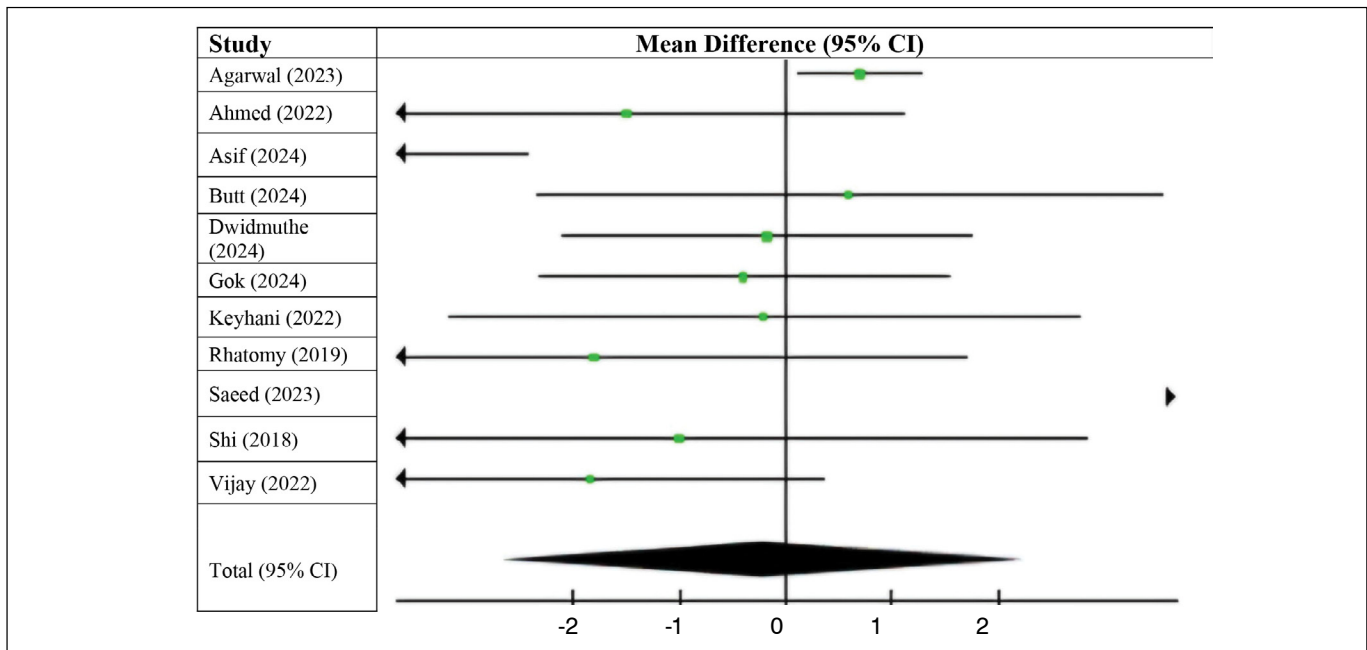


Figure 5. Postoperative Lysholm score.

most part, not statistically significant. This similarity underscores the potential of the long fibular tendon as a viable alternative to the grafts traditionally used most often, as suggested by Shi et al.⁸ and corroborated by Ahmed et al.¹¹

Regarding the preoperative IKDC score, patients in the group using the long fibular tendon had slightly higher scores, although this difference was not statistically significant. This finding may reflect a selection bias in some studies, since patients with different functional characteristics may have been allocated differently across groups, as noted by Keyhani et al.² In the postoperative period, there was a slight advantage for the flexor group, but again without statistical significance, which is consistent with the results of Rhatomy et al.⁹ and Gok et al.⁷ who

found no significant differences in functional recovery among patients operated on with different types of grafts.

Regarding the Lysholm score, the long fibular group had lower preoperative scores and slightly higher postoperative scores, although the difference was not statistically significant. These results support the notion that the long fibular muscle provides functional stability comparable to that of the flexor muscles, as also noted by Dwidmuthe et al.⁵ and Keyhani et al.², especially when used in conjunction with appropriate fixation and rehabilitation techniques.

On the other hand, the postoperative AOFAS score was the only outcome measure that showed a statistically significant difference, favoring the flexor group. This finding, also noted by Saeed et al.¹, suggests that,

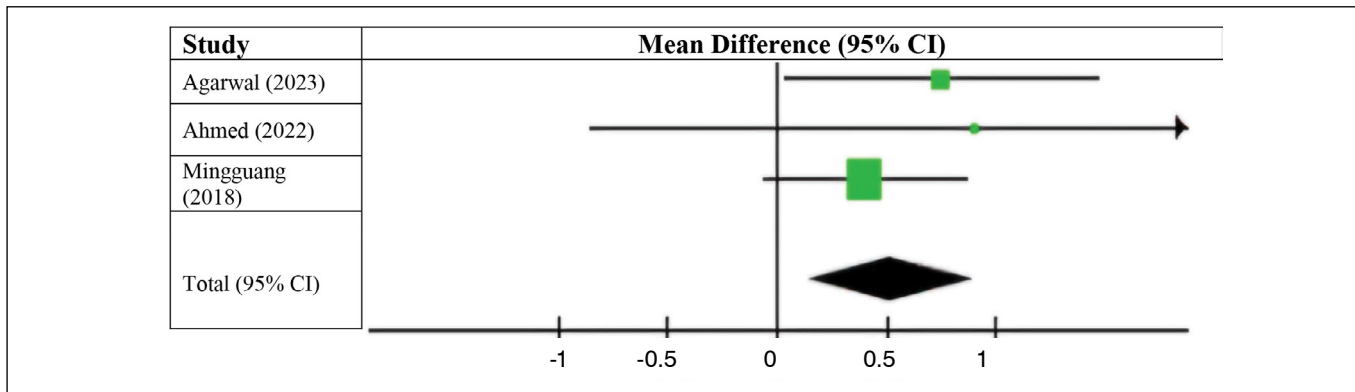


Figure 6. Postoperative AOFAS score.

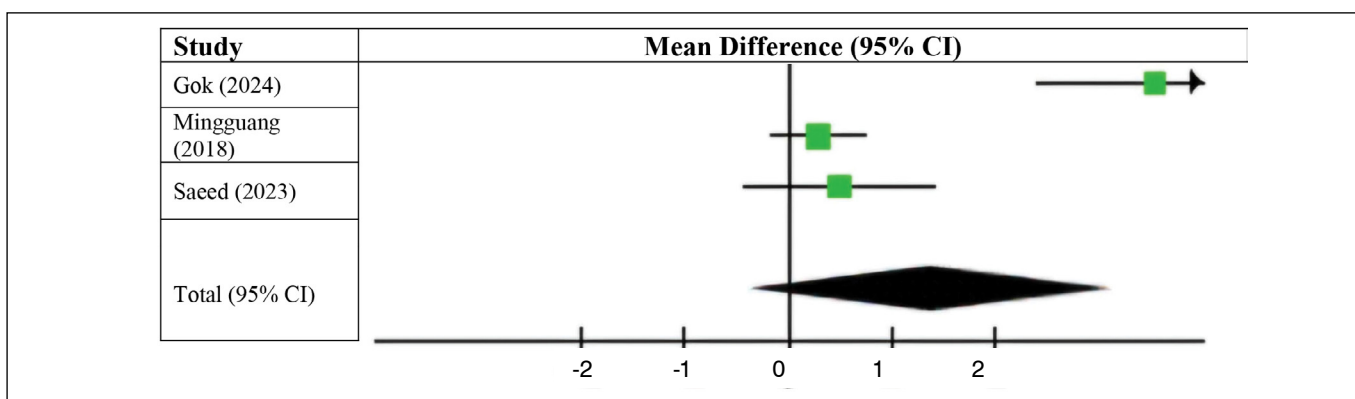


Figure 7. AOFAS score with the use of the peroneus longus tendon.

although functionally similar in most respects, the flexor tendon graft may still offer a slight advantage in terms of pain and distal functional capacity of the operated limb, especially in the medium term.

It is important to note, however, that the high heterogeneity observed in several analyses (I^2 above 90%) limits the generalizability of the findings. This variability can be attributed to methodological differences among the studies, including follow-up duration (ranging from 6 months to 5 years), surgical techniques, rehabilitation protocols, and clinical assessment criteria.

In addition, several methodological limitations are worth noting. The lack of blinding of evaluators in some studies, inconsistencies in patient inclusion criteria, and the absence of complete data in certain articles may have affected the robustness of the statistical synthesis. The still-limited number of high-quality studies—particularly randomized clinical trials with large sample sizes—underscores the need for more standardized future research.

Despite these limitations, the findings of this meta-analysis provide valuable insights for clinical practice. The long fibular tendon has proven to be a valid alternative to flexor tendons in ACL reconstruction, particularly in cases where the use of flexor tendons is

contraindicated, when graft diameters are inadequate, or when the flexor tendons have been previously used as autografts. It is up to surgeons to consider each patient's individual characteristics, as well as the team's experience and available resources, when selecting the most appropriate graft.

CONCLUSION

After analyzing 12 studies comparing the use of the peroneus longus tendon with the hamstring tendons, it is evident that autologous peroneus longus tendons are promising, yielding functional outcomes similar to those of traditional tendons.

However, a higher incidence of morbidity is observed at the donor site compared to the contralateral ankle. It should be noted that the number of studies with Level 1 evidence regarding ankle morbidity is limited; therefore, the use of the long fibular should be approached with caution. It can be concluded that autologous long fibular grafts do indeed yield satisfactory results in the knee; however, their implications for the ankle and foot, as well as additional studies with larger sample sizes and long-term follow-up, may provide further insight into their use.

CONTRIBUTIONS OF THE AUTHORS

Each author made a personal and significant contribution to the development of this article: Each author made an individual and significant contribution to the development of the manuscript. YNS and JVS were the main contributors to the drafting of the manuscript. JDN evaluated the statistical analysis data; HRSA, MRT, and HPJ conducted the literature review, reviewed the manuscript, and contributed to the intellectual framework of the study. Finally, all authors contributed to the final revision of the original article presented here.

DATA AVAILABILITY DECLARATION

The contents underlying the research are available in the manuscript.

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SPINAL DISORDERS IN PROFESSIONAL ESPORTS ATHLETES: PROTOCOL FOR A SYSTEMATIC REVIEW

DISTÚRBIOS DA COLUNA VERTEBRAL EM ATLETAS PROFISSIONAIS DE ESPORTS: PROTOCOLO DE REVISÃO SISTEMÁTICA

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ABSTRACT

Electronic sports, or esports, have become increasingly popular worldwide. Official tournaments are organized for participants to compete in a specific gaming titles. However, professional-level competitive participation can lead to health problems that affect the player's quality of life and performance. Previous studies have shown that participation in esports is associated with health risks and challenges, such as a higher incidence of musculoskeletal injuries, sleep problems, sedentary lifestyles, anxiety, and depression. This article presents a systematic review protocol that aims to investigate the effects of professional esports practice on the musculoskeletal system, with a specific focus on the spine. A systematic literature review will be conducted, including observational and intervention studies that evaluate musculoskeletal changes in the spine. This systematic review is expected to provide an overview of the characteristics of professional esports players with spinal complaints and the symptoms observed. The findings of this review may help develop prevention and rehabilitation strategies to promote the physical health of esports players. **Level of Evidence II; Systematic Review.**

Keywords: Spine; Computer Game; Musculoskeletal Pain; Musculoskeletal Diseases; Professional Practice.

RESUMO

Os esportes eletrônicos (e-sports) têm se tornado cada vez mais populares em todo o mundo. Atualmente, torneios oficiais são organizados para os participantes competirem em determinada modalidade de jogos virtuais. No entanto, a prática profissional pode levar a problemas de saúde que afetam a qualidade de vida e o desempenho do jogador. Estudos prévios demonstraram que a participação em e-sports está associada a riscos e desafios para a saúde, como maior incidência de lesões musculoesqueléticas. Este artigo apresenta um protocolo de revisão sistemática que tem como objetivo investigar os efeitos da prática profissional de esportes eletrônicos no sistema musculoesquelético, com foco específico na coluna vertebral. Será realizada uma revisão sistemática da literatura, na qual serão incluídos estudos observacionais e de intervenção que avaliam queixas musculoesqueléticas da coluna, como dor, incapacidade funcional e alterações de sensibilidade. Espera-se que esta revisão sistemática forneça uma visão geral das características dos jogadores profissionais de e-sports que apresentam queixas na coluna vertebral e dos sintomas observados. Os achados desta revisão podem ser úteis no desenvolvimento de estratégias de prevenção e reabilitação para promover a saúde física destes profissionais. **Nível de Evidência II; Revisão Sistemática.**

Descritores: Coluna Vertebral; Jogos de Computador; Dor Musculoesquelética; Doenças Musculoesqueléticas; Prática Profissional.

Citation: Miachiro NY, Menezes MD, Pontes MDS, Herrero CFPS. Spinal disorders in professional esports athletes: protocol for a systematic review. *Acta Ortop Bras.* [online]. 2026;34(2) Esp.: Page 1 of 3. Available from URL: <http://www.scielo.br/aob>.

INTRODUCTION

Electronic sports, or e-sports, have grown exponentially in popularity and have established themselves as a form of competition and entertainment widely practiced worldwide.¹ The intensive practice of electronic games can lead to a series of health problems, which affect players' quality of life and performance.¹ In a recently published review, researchers investigated the relationship between participation in e-sports and different aspects of health, including physical health, mental health, cognitive abilities,

health behaviors and quality of life.² Although they found positive results related to the improvement of cognitive ability, motor coordination and decision-making in virtual gamers, the authors noted that this participation may be associated with some health risks and challenges, such as a higher risk of developing musculoskeletal injuries, sleep problems, sedentary lifestyle and mental health problems such as anxiety and depression.² Once this relationship between health and the practice of sports has been established, some authors argue that sports medicine

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

The study was conducted at Faculdade de Medicina de Ribeirao Preto, Universidade de Sao Paulo (FMRP-USP), Av. Bandeirantes, 3900, Vila Monte Alegre, Ribeirao Preto, Sao Paulo, Brazil, 14048-900.

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should expand its focus to include virtual sports, providing guidance and support to practitioners.³ They highlight the importance of a multidisciplinary approach involving physicians, physical therapists, nutritionists, and psychologists to assess and address the specific health needs of esports players.³

Data indicate that 76% of college e-sports players reported at least one musculoskeletal injury during their competitive career.⁴ Among the problems identified, pain in the lower back, neck, shoulders, and hands, as well as symptoms of muscle fatigue and stiffness, stand out.⁵ These researchers suggest that e-sports players are susceptible to developing musculoskeletal disorders, possibly due to factors such as poor posture during play, repetitive movements, and lack of adequate intervals.⁵

In an update on e-sports medicine focusing on pre-participation screening and injury management, the authors discuss the most common dysfunctions and highlight carpal tunnel syndrome, tendinopathies, and spinal injuries as the primary musculoskeletal injuries.⁶ This study also highlights the importance of adequate rehabilitation and a gradual return to training and competition after an injury.⁶

Recent reports in the literature have shown that electronic sports can negatively influence the musculoskeletal system, affecting different body regions, including the spine.⁴⁻⁶ How professional practice influences this condition has yet to be discussed. This systematic review aims to provide an overview and review the evidence available in the literature regarding how the professional practice of electronic sports (e-sports) interferes with musculoskeletal conditions of the spine. So, the following question will be investigated: What are the characteristics of musculoskeletal injuries of the spine presented by professional electronic sports players?

The findings of this review may provide relevant information for developing prevention and rehabilitation strategies that favor the physical health of professional electronic sports players.

METHODS

Research Question

This article will aim to answer the question, "How are musculoskeletal injuries of the spine presented by professional e-sports players characterized?" which was developed using the acronym PICO.⁷ In this context, "P" represents the population involved in the research, "I" refers to the intervention or exposure studied, "C" refers to the control used, and "O" encompasses the outcomes analyzed.⁷

The population included in this study consists of professional e-sports players over the age of 15. The intervention will be based on the professional practice of e-sports using computers. The control will be represented by people who do not practice electronic games using computers. The outcome will be assessed through musculoskeletal injuries of the spine, such as pain, functional disability and changes in sensitivity originating in the spine.

Eligibility criteria

Observational studies (case reports, case series, cross-sectional, case-control, cohort) and intervention studies (quasi-experimental studies, randomized controlled trials, community trials, field trials) that assess outcomes related to musculoskeletal injuries of the spine, such as pain, functional disability, and changes in strength or sensitivity in the limbs will be included. The study sample must be composed of professional e-sports players of both sexes who use computers aged 15 or older. Studies in which players use other tools, such as racing simulators (steering wheel or bicycle), cell phones, and console controllers, will be excluded, as well as studies that assess only psychological, social, or cardiovascular outcomes.

Sources of information

The following databases will be consulted: MEDLINE (via PubMed), Embase, PEDro, LILACS, SciELO, Scopus, and Web of Science Cochrane Library. There will be no language or year of publication limit. In addition to the terms belonging to the Medical Subject Headings (MeSH),⁸ words related to the professional practice of electronic sports and musculoskeletal injury or pain will be used to identify appropriate keywords.

Search strategy

The terms used in the search will be: e-sport, e-sports, esport and esports. These terms will be worked with the Boolean operators [OR] and [AND] in advanced searches. Two researchers will search independently, following the Peer Review of Electronic Search Strategies (PRESS) protocol rules.⁹

Data recording

Two researchers will carry out the selection of studies that will be part of the systematic review in two stages. In the first phase, the evaluators will select potentially relevant studies based on the titles and abstracts. The full text of the studies selected in the previous phase will be read in the second phase. The articles chosen for full reading will be evaluated according to the eligibility criteria.

If opinions are divergent, the impasse will be resolved through consensus with a third evaluator specialized in the subject. In addition, Mendeley (Mendeley, London, United Kingdom), a reference manager available as an online application, will be used to avoid duplication and facilitate file sharing between researchers.

The two evaluators will also extract the data from the studies in a paired and independent manner. The systematic review manager Rayyan (Rayyan Systems Inc., Cambridge, MA, USA), available in the form of a web application, will be used to allow better exploration of the results of the included studies. The third researcher will analyze possible disagreements.

The data extraction form will contain the following:

- general information: title, authors, year of publication, study design, country of origin.
- characteristics of participants: age, sex, length of professional experience, physical activity practice and body mass index (BMI).
- study design.
- results: number of participants, measurement tools and respective results (numerical pain scale, self-report questionnaires, dynamometry, endurance tests), location of symptoms, statistical tests, descriptive information (type of console, daily practice time).

Analysis of the Risk of Bias of the Included Studies

An adapted version of the Newcastle-Ottawa Scale (NOS)¹⁰ will be used to analyze the risk of bias of the studies included in the review for cross-sectional studies and the ROB 2.0 tool for intervention studies. The NOS scale includes four items for selection, one for comparability and two for outcome. Each study can be rated on a scale of 0 to 10 stars, with a total of 7 or more stars indicating high quality, 4 to 6 stars indicating medium quality, and 3 or fewer stars indicating low quality. The ROB 2.0 tool assesses the risk of bias in intervention studies in five domains: bias resulting from the randomization process, bias related to deviations in the application of interventions, bias due to missing outcome data, bias in the measurement of outcomes, and bias in the selection of reported outcomes.

Data synthesis

The studies found are expected to be heterogeneous in terms of study design and description of results. Therefore, the results will be summarized in a narrative format, without additional statistical analysis.

Assessment of the Quality of Evidence

After completing the critical evaluation of the study methodology, the quality of the evidence related to each outcome assessed in the systematic review will be carefully considered. The Grading of Recommendations Assessment, Development, and Evaluation (GRADE) system will be used to classify the level of evidence for each outcome as high, moderate, low, or very low.¹¹

Registration

This protocol was registered on the PROSPERO platform¹² (CRD42024527224) according to the guidelines for systematic

reviews of the Centre for Reviews and Dissemination (CRD) at the University of York.¹³ The results of the review will be reported following the PRISMA guidelines.¹⁴ As this work will be based on published studies, there is no need for approval by the ethics committee.

Amendments

This protocol does not imply a modification of a previously completed or published protocol. If necessary, any amendments to the protocol will also be registered on the PROSPERO platform.¹²

CONTRIBUTIONS OF THE AUTHORS

Each author contributed personally and significantly to the development of this manuscript: NYM: data acquisition, analysis, and interpretation; drafting of the manuscript; MDM: data acquisition, analysis, and interpretation; drafting of the manuscript; MDSP: data analysis and interpretation; drafting and critical revision of the manuscript; CFPSH: study conception, design, and critical revision of the manuscript.

DATA AVAILABILITY DECLARATION

The data will be made available when requested.

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