

# Journal of the Asociación Argentina de Ortopedia y Traumatología

AN ORGAN OF THE ASOCIACIÓN ARGENTINA DE ORTOPEDIA Y TRAUMATOLOGÍA



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# AATO Special Issue

**Dr. Germán Garabano**  
AATO President 2025



The Argentine Association of Orthopedic Trauma (AATO) continues to strengthen its role as a national reference in the care of polytrauma patients and in the ongoing development of medical education in our country and the region. It is with great satisfaction that we present this special supplement of the *Argentine Journal of Orthopedics and Traumatology*, a scientific platform that reflects the collaborative work of our members, healthcare teams, and training centers.

Trauma remains one of the leading causes of morbidity and mortality in Argentina and worldwide. In this context, continuous knowledge updating, clinical research, and the standardization of evidence-based practices constitute essential pillars for achieving better outcomes. Since its foundation 31 years ago, AATO has embraced this commitment: promoting specialist training, fostering collaborative networks, and encouraging open discussion on technological and therapeutic advances.

In recent years, AATO has significantly strengthened its regional and international ties, particularly with AO Trauma and the International Orthopaedic Trauma Association (IOTA), expanding educational, training, and professional exchange activities. These strategic alliances reinforce our presence in the region and create valuable opportunities for our professionals to access first-rate training experiences and actively participate in global trauma research initiatives.

This supplement brings together contributions that reflect the diversity and complexity of contemporary orthopedic trauma: from high-energy fractures and challenging periarticular injuries to the management of elderly patients with bone fragility. All manuscripts share a common thread: the pursuit of answers to real clinical problems, grounded in rigorous methodology, critical thinking, and the conviction that research is an indispensable tool for transforming daily practice.

I would like to express my deep appreciation to the authors, reviewers, and editorial coordinators who made this publication possible. My gratitude also extends to the institutions that support and accompany the growth of our association. I am convinced that collaboration among scientific societies, hospitals, universities, and responsible industry partners is the path toward a modern, efficient, and patient-oriented orthopedic practice.

I invite our readers to explore these pages with a reflective and constructive spirit. May this special issue serve as an incentive to continue researching, innovating, and contributing original knowledge from Argentina to the world. The challenge is significant, but the passion and excellence of our professionals provide a clear course forward.

Let us continue working together to strengthen education, research, and the quality of care in orthopedic trauma, honoring the commitment that unites us: restoring function and life to our patients.

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# Case Presentation

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*Case Resolution on page 604.*

## Non-Accidental Trauma

### ABSTRACT

We present the case of an 18-month-old boy with multiple fractures resulting from non-accidental trauma, after being dragged down a flight of stairs by his caregiver. The radiological protocol used in our institution for suspected non-accidental trauma is described, along with the diagnostic process and the orthopedic and social management implemented.

**Keywords:** Non-accidental trauma; pelvic fracture; hip epiphysiolysis; children.

**Level of Evidence:** IV

### Trauma no accidental

### RESUMEN

Se presenta el caso de un niño de 18 meses con múltiples fracturas secundarias a un trauma no accidental, al ser arrastrado por las escaleras, por su cuidadora. Se define el protocolo radiológico utilizado en nuestra institución para los casos de trauma no accidental, su diagnóstico y el tratamiento ortopédico y social.

**Palabras clave:** Trauma no accidental; fractura de pelvis; epifisiólisis de cadera; niños.

**Nivel de Evidencia:** IV

## INTRODUCTION

An 18-month-old boy was brought unconscious to the clinic by his grandmother, who reported that he had been dragged down the stairs by his caregiver approximately 45 minutes earlier. Bruises were observed on all four limbs and on the lower abdomen, in different stages of evolution. He was treated in the emergency department with suspected non-accidental trauma. After stabilizing the child and given the clinical suspicion, anteroposterior pelvic radiographs were requested. The Radiological Protocol for Children (Table) was applied.

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**Table.** Areas to be examined and recommended projections.

Skull*	Anteroposterior and lateral; additional Towne projection if clinically indicated
Thorax	Anteroposterior including clavicles; oblique projections of both rib cages
Abdomen	Includes pelvis and hips
Spine	Lateral projection of the cervical, thoracic, and lumbar regions
Extremities	Anteroposterior view of both humeri, both forearms, femurs, tibiae, and fibulae Hands: anterior Feet: dorsoplantar

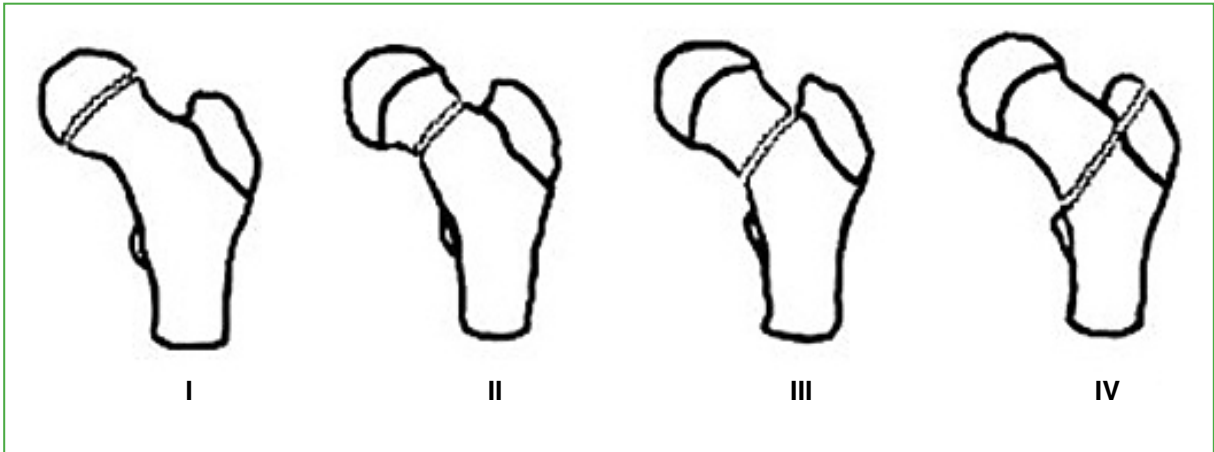
\*Skull radiographs should be taken even if a CT scan has been performed.

## FINDINGS AND INTERPRETATION OF IMAGING STUDIES

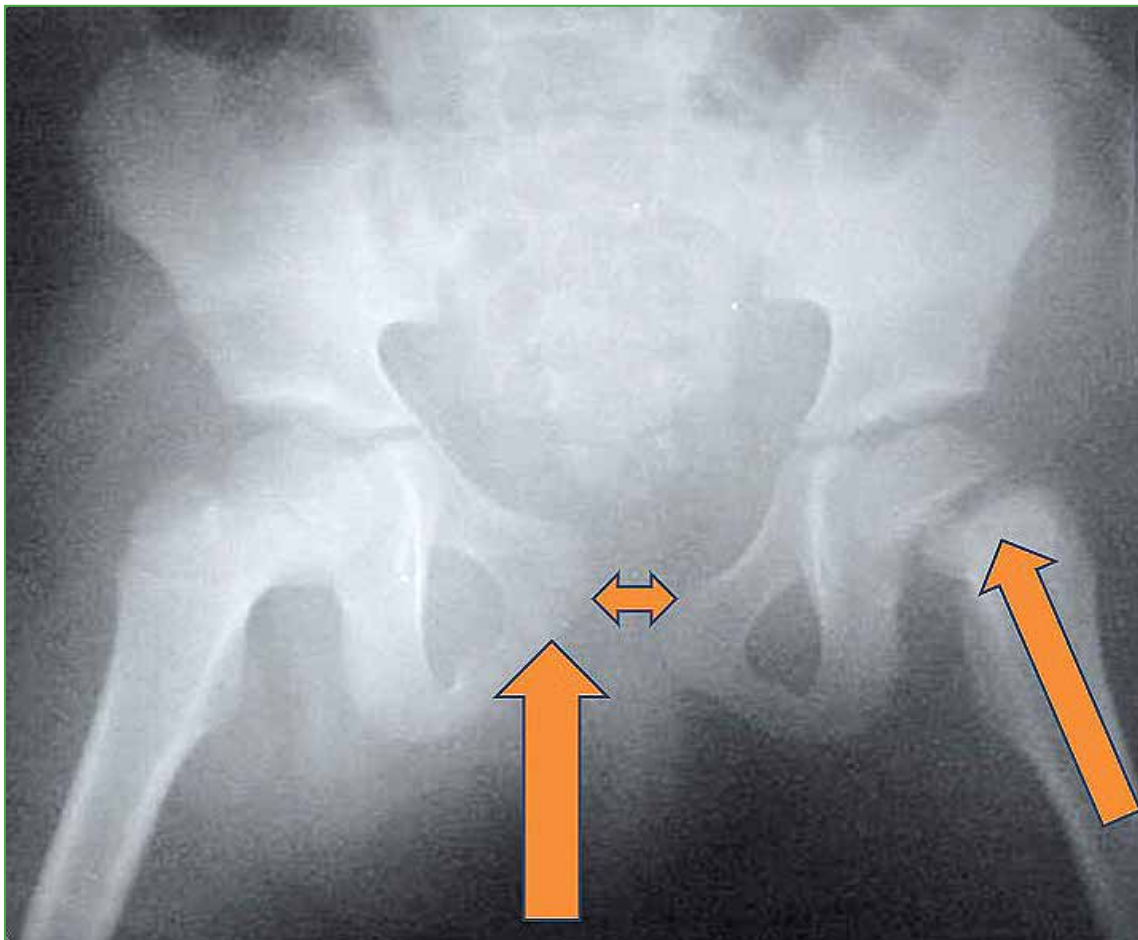
Of all the radiographs obtained, the AP pelvic radiograph revealed fractures consistent with polytrauma (Figure 1). A type C pelvic fracture according to the AO classification was observed, along with an avulsion of the iliac wing and a type A fracture within the same classification.<sup>1</sup> In the left proximal femoral epiphysis, a type I (trans-epiphyseal) epiphysiolyis was identified according to the Delbet classification (Figures 2 and 3).<sup>2</sup>



**Figure 1.** Anteroposterior pelvic radiograph showing vertical and rotational “open-book” displacement of the pelvic ring, avulsion of the right iliac wing, and Delbet type I hip epiphysiolyis of the ipsilateral femoral head, as described by Colonna.



**Figure 2.** Delbet fracture classification.



**Figure 3.** Anteroposterior pelvic radiograph. Each arrow indicates one of the multiple fracture displacements identified.

Conflicts of interest: The authors declare no conflicts of interest.

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# Current Status of Scientific Research on Musculoskeletal Trauma in Argentina: A Survey-Based Study

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## ABSTRACT

**Introduction:** The aim of this study was to assess the level of training, interest, and barriers related to research among orthopedic trauma surgeons in Argentina. **Materials and Methods:** A descriptive cross-sectional study was conducted using an anonymous, voluntary electronic survey between August and November 2024. The survey consisted of six closed-ended questions: the first four (single-choice) collected demographic information and data regarding previous publications, while the last two (multiple-choice) addressed training and interest in receiving specific research education. The survey was designed by the *Grupo de Apoyo a la Investigación Argentina* [Argentine Research Support Group]. **Results:** A total of 467 responses were obtained. 35% of respondents reported having at least one publication, while only 3% indicated having received training in all assessed items. Among those who had never published (the remaining 65%), the most frequently cited reasons were the lack of a research support group and the absence of protected research time. Regarding interest in receiving specific training, the most common responses were related to study design, scientific writing, and receiving external support from a research group. **Conclusions:** This study revealed a low publication rate but a strong interest in participating in research among Argentine orthopedic trauma surgeons. The lack of training and knowledge in basic research principles, along with the absence of support groups, emerged as potentially modifiable barriers. National and regional educational and collaborative action plans are needed to change this situation.

**Keywords:** Research; scientific work; writing; research study design; barriers.

**Level of Evidence:** IV

## Estado actual de la investigación científica sobre el trauma musculoesquelético en la Argentina. Estudio a partir de una encuesta

### Resumen

**Introducción:** El objetivo de este estudio fue investigar el nivel de formación, el interés y las barreras respecto a la investigación en los traumatólogos de la Argentina. **Materiales y Métodos:** Se realizó un estudio descriptivo transversal utilizando una encuesta electrónica anónima y voluntaria, entre agosto y noviembre de 2024. Constaba de 6 preguntas cerradas de respuesta simple (preguntas 1-4) y múltiple (preguntas 5 y 6). Las primeras 4 reunían datos sobre las características demográficas y la cantidad de publicaciones, y las segundas 2, la formación y el interés en recibir formación específica en investigación. La encuesta fue diseñada por el Grupo de Apoyo a la Investigación Argentina. **Resultados:** Se obtuvieron 467 respuestas. El 35% respondió contar con alguna publicación, y el 3%, haber recibido formación en todos los ítems. Respecto a las razones de no haber publicado (65% restante), las respuestas más frecuentes fueron: falta de un grupo de apoyo en investigación y de tiempo protegido. En cuanto al interés en recibir formación específica, las respuestas más frecuentes correspondieron al diseño y la redacción de trabajos, y

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al apoyo externo de un grupo de investigación. **Conclusiones:** Este estudio reveló la baja frecuencia de publicaciones y el gran interés en participar en estudios de investigación entre los traumatólogos de la Argentina. La falta de formación y conocimientos en aspectos básicos de la investigación y la falta de grupos de apoyo se identificaron como barreras potencialmente modificables. Se necesitan planes de acción educativos, colaborativos nacionales y regionales para cambiar esta realidad.

**Palabras clave:** Investigación; trabajo científico; redacción; diseño de trabajos de investigación; barreras.

**Nivel de Evidencia:** IV

## INTRODUCTION

Scientific research is a fundamental component of the development of a country's health system. It is essential for generating authentic knowledge that enables the resolution of specific clinical problems and the design of health strategies.<sup>1-3</sup> In the field of musculoskeletal trauma, given its disproportionately increasing incidence, especially in low- and middle-income countries, research acquires a decisive role.<sup>1</sup> However, the vast majority of research studies are produced in high-income countries, and their findings are subsequently extrapolated to middle- and low-income regions despite clear economic, cultural, and demographic differences.<sup>4-6</sup> Currently, and focusing exclusively on our region, Latin America contributes only 1% to 2% of scientific publications in high-impact journals.<sup>6</sup>

In order to complete the publication process, the final step of any research initiative, it is necessary to overcome numerous barriers, including the lack of formal research training, insufficient resources, and the absence of protected time dedicated to research, among others.<sup>2,7</sup> As a result, the pathway toward publication can be overwhelming and isolating when viewed from the outset. One of the most effective tools for overcoming these difficulties is collaborative research.<sup>8-10</sup> This approach involves pooling efforts and capabilities among individuals, groups, institutions, and organizations whose strengths complement one another in the shared goal of producing high-quality scientific work.

For these reasons, in Argentina we formed a group of orthopedic trauma surgeons (*Grupo de Apoyo a la Investigación Argentina* [Argentine Research Support Group]) with the purpose of promoting and strengthening the development of local research studies in musculoskeletal trauma. The initiative was inspired by the regional research group (*Grupo de Apoyo a la Investigación*, GAI) created several years ago by the Board of AO Trauma Latin America (AOTLA).<sup>11,12</sup>

As our group's initial objective, we set out to: 1) conduct a survey to assess the level of research training and general interest in research among orthopedic trauma surgeons in Argentina; 2) identify the most common shortcomings and difficulties in research training; and 3) design future strategies to foster and support the training of physicians interested in research.

## MATERIALS AND METHODS

A descriptive cross-sectional study was designed using an anonymous, voluntary online survey created with Microsoft Forms®. The survey was distributed by email between August and November 2024, using the database of the Argentine Association of Traumatology and Orthopedics (AAOT). It was also promoted at this year's congress of the Argentine Association of Orthopedic Trauma (*Asociación Argentina de Trauma Ortopédico*, AATO) and through the social media accounts of both associations (AAOT, AATO). It was announced across all channels as an anonymous and voluntary survey, with the aim of gaining an overview of the local situation of research in orthopedics and traumatology.

The survey was designed to be completed by both trainees (residents) and more experienced specialists who had already finished their residency. No identifying information was requested, and the data collected were encrypted in an Excel® file generated by the survey platform.

The questionnaire consisted of six closed-ended questions: the first four required a single-choice response, question five used multiple-choice format, and question six used a Likert scale.

The first four questions collected information regarding respondents' gender, level of experience, prior research activity, and interest in undertaking research:

**Questions:**

1. Which gender do you identify with?

- Male
- Female
- Other

2. You are an orthopedist with:

- more than 5 years since completing your residency
- less than 5 years since completing your residency

3. Do you currently conduct—or would you be interested in conducting—research?

Yes

No

4. Have you published scientific articles in specialty journals in the last 3 years?

- Yes, more than 4 papers
- Yes, between 1 and 3 papers
- No, none

If the participant selected either of the first two affirmative options in question 4, the survey branched to question 5, which explored the basic research training received during their education:

5. During your training, did you receive instruction in:

- Research methodology
- Scientific writing
- Statistics
- Development of patient databases

If the participant selected the negative option (“No, none”) in question 4, question 5 instead explored potential reasons for this, offering seven possible explanations. Each was rated using a Likert scale from 1 to 5, where 1 = minimally relevant and 5 = highly relevant:

- Why? (Rate each reason according to its importance)

- I lack basic knowledge of research methodology.
- I did not receive training in scientific writing.
- I did not receive basic training in statistics.
- I do not have a team to conduct research with.
- I do not have access to a patient database.
- I do not have time.
- I do not perceive any benefit in conducting research.

All participants concluded the survey with question 6, which assessed the areas in which they would be interested in receiving additional training, again using a Likert scale from 1 (least interested) to 5 (most interested):

6. Would you be interested in receiving training in:

- Research study designs
- Scientific writing
- Statistics
- Development of patient databases
- External (non-financial) support in the development of scientific projects

## Statistical Analysis

The data obtained were transferred to an Excel® spreadsheet by the platform used and were subsequently coded for analysis. Descriptive statistics were performed for all questions, applying a total and cumulative proportion test to obtain the values corresponding to each question and, in turn, to allow subdivision by group. The analysis was carried out using the Jamovi software (the jamovi project, 2024; version 2.5).

## RESULTS

A total of 467 responses were received. The proportions of gender, experience, interest, and number of publications reported by respondents are shown in [Table 1](#).

**Table 1.** Gender, research interest, experience, and number of publications among respondents.

		Frequency	Proportion	
Gender	Female	74	15.80	
	Male	392	83.90%	
	Other	1	0.20	
Interest in research	Yes	72	15.40	
	No	395	84.60%	
Experience	Orthopedist with <5 years since completion of residency	211	45.20	
	Orthopedist with >5 years since completion of residency	256	54.80	
Number of publications	>4	50	10.70	
	Between 1 and 3	305	65.30	
	None	112	24	
Gender	Publications	Frequency	% of total	Cumulative %
Female	Yes, more than 4	6	1.30	1.30
	None	48	10.30	11.60
	Yes, between 1 and 3	20	4.30	15.80
Male	Yes, more than 4	44	9.4	25.30
	No, none	256	54.80	80.10
	Yes, between 1 and 3	92	19.70	99.80
Other	Yes, more than 4	0	0	99.80
	No, none	1	0.20	100
	Yes, between 1 and 3	0	0	100

In the subgroup that reported having published ( $n = 162$ ), 25% indicated having received training in research methodology; 15% in scientific writing; 8% in patient database development; and 1.9% in statistics. Regarding multiple selections within this question, 3% reported having received training in all four selectable items; 7% in all items except statistics; and 2.5% reported combined training in research methodology and statistics. All other combinations had a frequency below 1%.

Within the subgroup that reported not having published (n = 305), the reasons for this were evaluated using a Likert scale (1 = least relevant, 5 = most relevant). Details are presented in Figures 1-7.

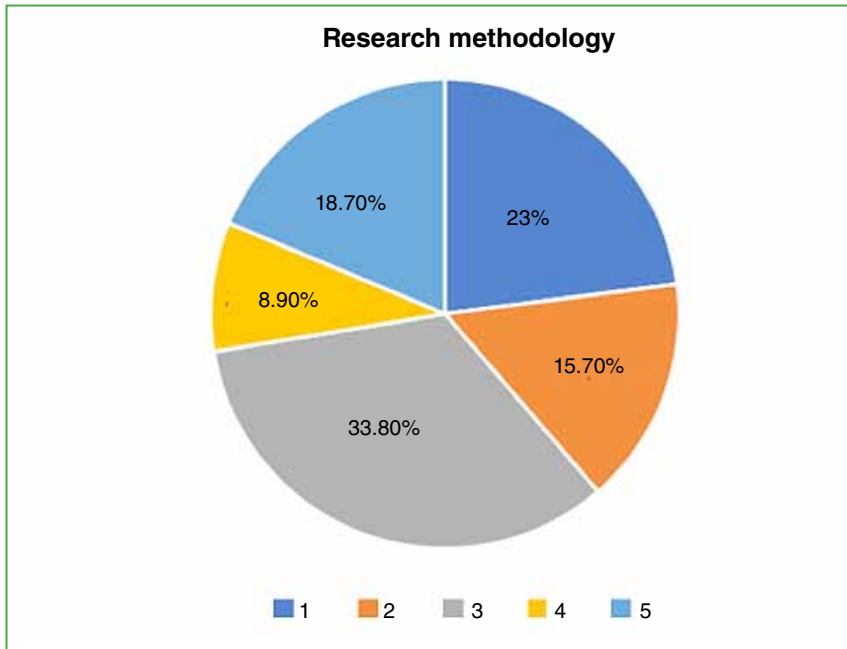


Figure 1. I do not have basic knowledge of research methodology.

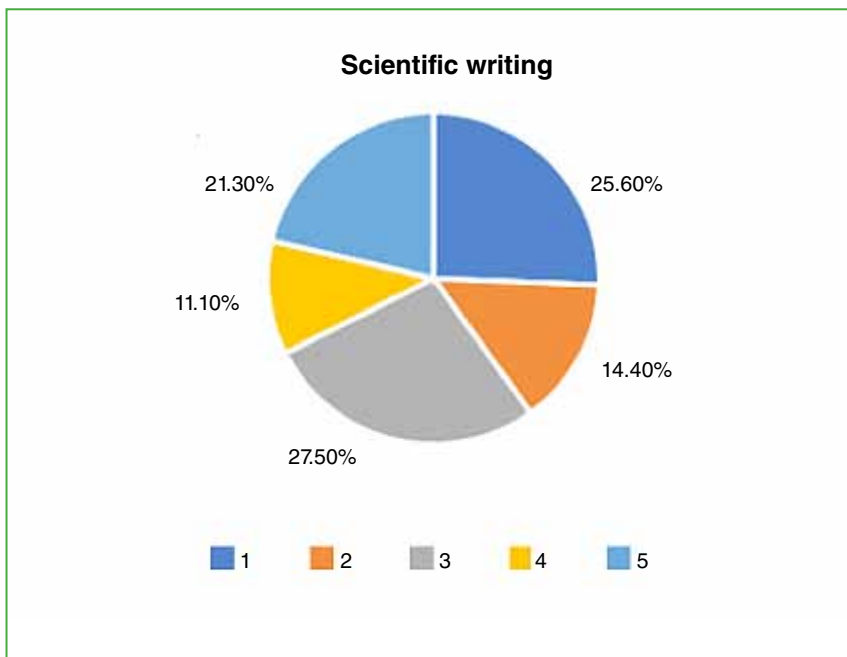


Figure 2. I did not receive training in scientific writing.

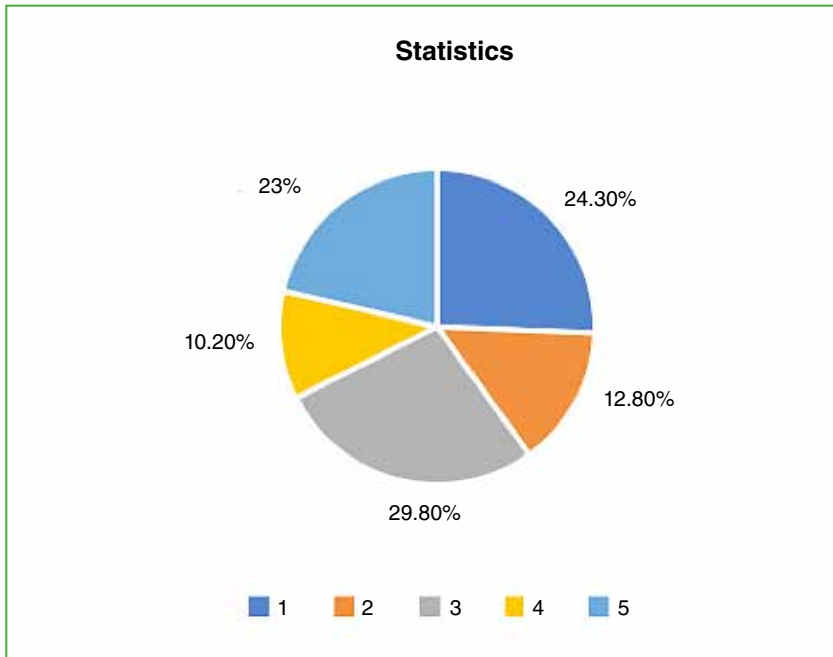


Figure 3. I did not receive basic training in statistics.

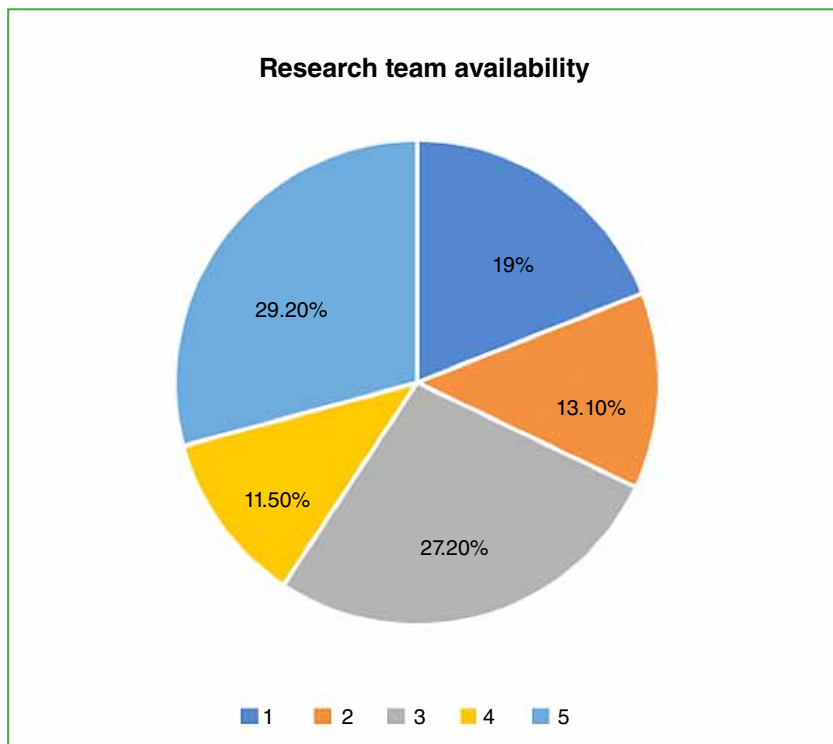


Figure 4. I do not have a team of people to conduct research with.

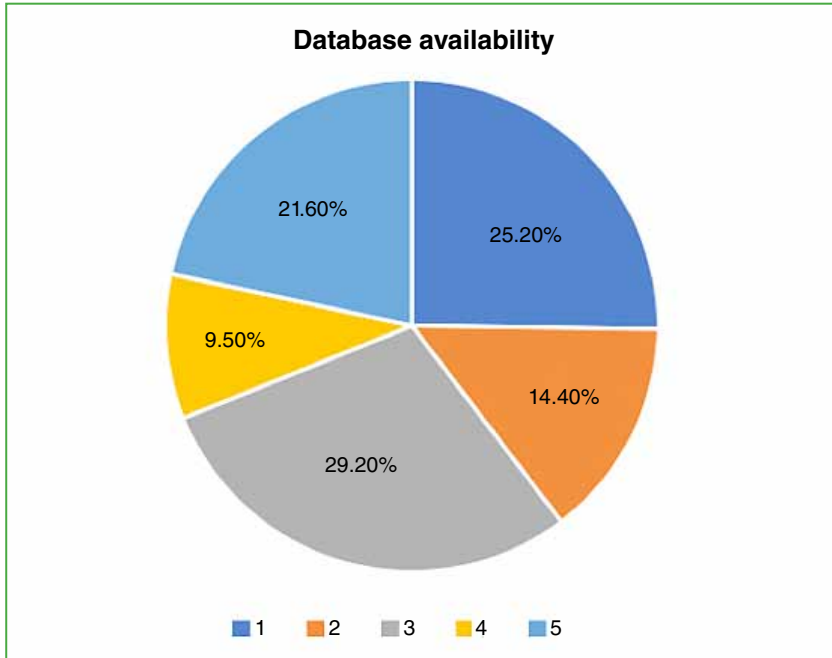


Figure 5. I do not have access to a patient database.

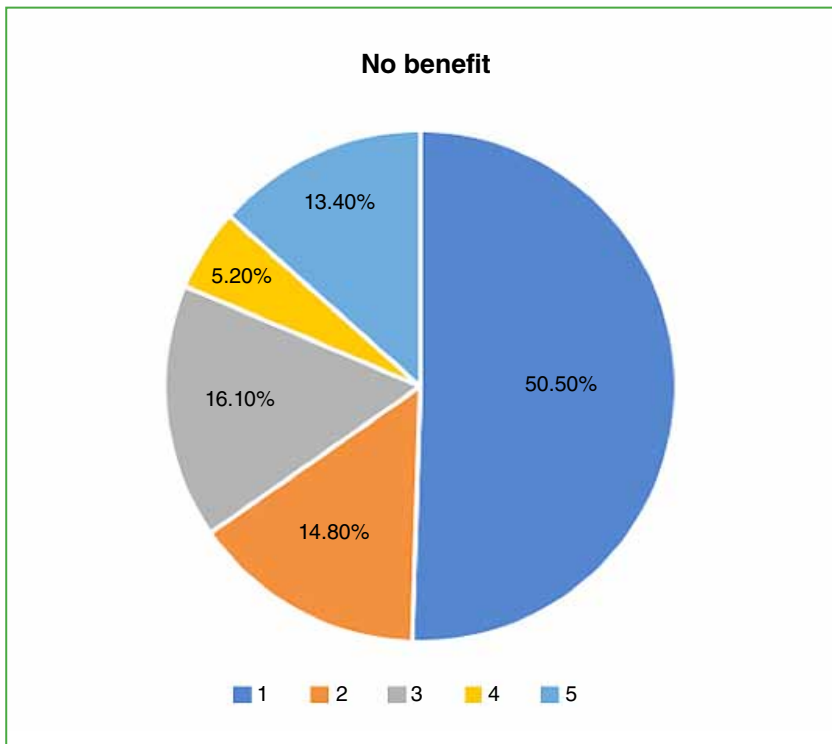


Figure 6. I do not perceive a benefit in conducting research.

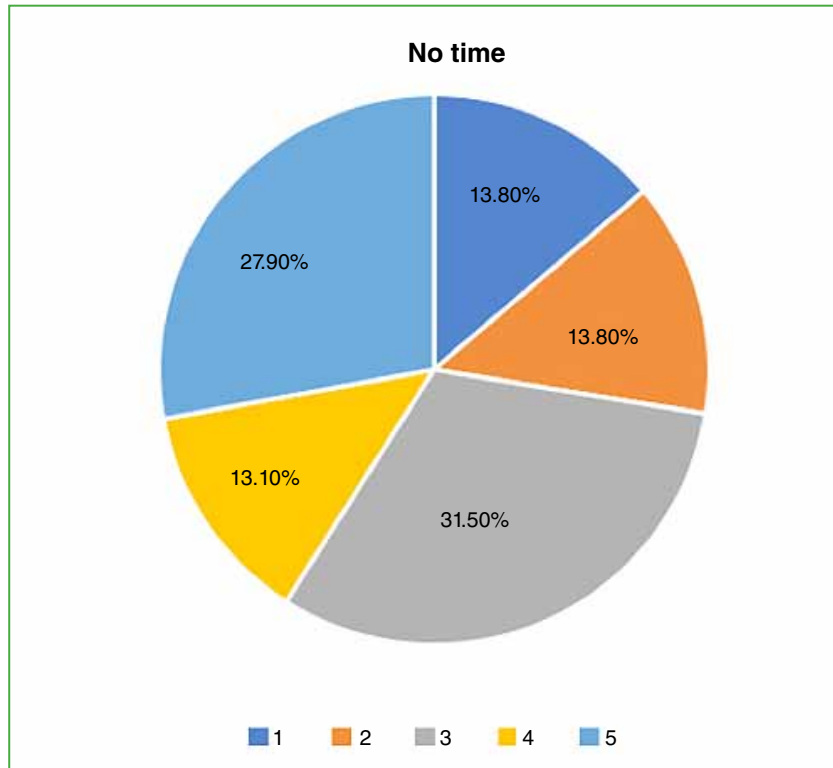


Figure 7. I do not have time.

Finally, regarding the responses to question 6 (common to all participants), none of the five items received fewer than 50% of maximum-interest responses (value 5 on the Likert scale). Tables 2-6 detail the responses to each item of question 6 according to the Likert scale.

**Table 2.** Interest in receiving training in study design (1 = least interested; 5 = most interested)

Interest in design	Frequency	%
1	37	7.90
2	30	6.40
3	84	18.00
4	57	12.20
5	259	55.50

**Table 3.** Interest in receiving training in scientific writing (1 = least interested; 5 = most interested)

Interest in writing	Frequency	%
1	42	9
2	22	4.70
3	67	14.30
4	67	14.30
5	269	57.60

**Table 4.** Interest in receiving training in statistics (1 = least interested; 5 = most interested)

Interest in statistics	Frequency	%
1	48	10.30
2	38	8.10
3	94	20.10
4	49	10.50
5	238	51.50

**Table 5.** Interest in receiving training in patient database development (1 = least interested; 5 = most interested)

Interest in database development	Frequency	%
1	39	8.40
2	28	6
3	77	16.50
4	66	14.10
5	257	55

**Table 6.** Interest in receiving external (non-financial) support for research (1 = least interested; 5 = most interested)

Interest in support	Frequency	%
1	39	8.40
2	21	4.50
3	69	14.80
4	63	13.50
5	275	58.90

## DISCUSSION

This study sought to describe interest in scientific research by analyzing responses from 467 orthopedic surgeons in Argentina, as well as to characterize the level of training they have received in this area, the barriers they face in conducting research (or in choosing not to), and their perceived needs and interests related to research education.

The first noteworthy finding of this survey is that, regardless of age, most respondents expressed strong interest in research. However, despite this interest reported by 83% of surgeons, 65% have not been able to publish; in other words, only one-third have published at least once. The low publication rate in developing countries such as ours has already been described. In 2011, Higgins et al. reported the results of a survey of physicians from 13 Latin American countries and found that, although most participants were interested in research, only one-third were involved in a project at that time.<sup>2</sup> This demonstrates that, although interest in scientific research is high in Latin America, significant “barriers” to its development persist.<sup>2,7</sup>

In 2017, the ACTUAR group (*Asociación de Cirujanos Traumatológicos de las Américas* [Association of Trauma Surgeons of the Americas]), composed of surgeons from 13 countries in the region, analyzed the barriers to research in Latin America. Their work outlines a list of potential challenges that researchers may encounter and proposes possible solutions to overcome them.<sup>2</sup> In another study, the same group identified the main barriers to the development of a clinical research study in Mexico, which they classified into three categories: structural, logistical, and intrapersonal.

Although economic and structural conditions are indeed fundamental, today, with widespread access to information and increasing opportunities for collaborative research between high- and low-resource countries, many of these barriers can be mitigated. Therefore, we believe that the barriers related to the “development” of a physician-researcher (those previously described as intrapersonal) may be the most decisive. In this regard, the strong interest expressed by respondents in participating in research is encouraging. Conversely, it is concerning that only 3% reported having received any formal training in what we consider essential skills for research: methodology, scientific writing, basic statistics, and database development.

Writing a research article requires substantial personal effort, particularly in Latin America, where limited institutional incentives and the lack of financial, professional, or academic rewards coexist with a heavy daily clinical workload. When we explored the potential reasons why 65% of respondents had never published, the most common factors were the absence of a research support group and the lack of dedicated or “protected” time for research.

When we asked respondents about their interest in receiving research-related training, we found high levels of interest across most domains. The items that received the highest interest scores were: external (non-financial) support from mentors or research groups (72%), assistance with scientific writing (71%), database development (69%), study design (67.7%), and, lastly, statistics (61.5%). In our view, this highlights the need to create research support groups and to foster greater interconnection between motivated surgeons and existing research networks.

This study has limitations inherent to survey-based research with a restricted number of participants. Although the number of respondents is seemingly adequate, it is difficult to assert that it represents the full landscape of orthopedic research in the country. Furthermore, the survey did not include open-ended questions or free-text fields that would have allowed respondents to elaborate on specific issues, and thus reflects only the aspects directly assessed.

## CONCLUSIONS

This study highlights the low number of publications produced by orthopedic surgeons in Argentina today. At the same time, it reveals the strong interest expressed by respondents in participating in research studies. A lack of formal training, insufficient knowledge of basic research principles, and the absence of support groups were identified as potentially modifiable barriers in both the short and long term.

We emphasize the need to design future educational initiatives aimed at strengthening research-related training while simultaneously fostering connections between interested physicians and local or international research support networks.

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# Anterolateral Approach With Lateral Epicondyle Osteotomy in Tibial Plateau Fractures: Functional and Radiological Results at 6-Month Follow-Up

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## ABSTRACT

**Introduction:** In tibial plateau fractures, achieving anatomical reduction of the articular surface is essential, and adequate visualization through an appropriate approach is indispensable to accomplish this. The aim of this study is to describe the surgical technique of the anterolateral approach with lateral epicondyle osteotomy and to report the functional and radiological outcomes in a series of patients with a minimum follow-up of 6 months. **Materials and Methods:** Over a 24-month period, nine anterolateral approaches with lateral epicondyle osteotomy were performed in five women and four men (mean age 40.1 years; range 18–62) presenting with lateral tibial plateau fractures involving the posterior sector. The mean follow-up was 13 months (range 6–24). **Results:** Radiographic assessment included evaluation of bone healing and comparison of condylar width, medial proximal tibial angle, and tibial slope with the contralateral knee. All fractures consolidated radiographically. No cases of nonunion or displacement of the osteotomy bone block were observed. Clinical and functional outcomes were assessed using the Knee Injury and Osteoarthritis Outcome Score (KOOS) and the Rasmussen score. Outcomes were good to excellent in all cases, with a mean KOOS score of 82. **Conclusion:** The anterolateral approach with lateral epicondyle osteotomy provides excellent visualization of the posterior aspect of the lateral tibial plateau, facilitating anatomical reduction of articular fragments. It is a valid and reproducible option that does not require special patient positioning and minimizes the risk of neurovascular injury.

**Keywords:** Knee; tibial plateau fractures; surgical approach; lateral femoral epicondyle osteotomy.

**Level of Evidence:** IV

## Abordaje anterolateral con osteotomía del epicóndilo en fracturas de platillo tibial. Resultados funcional y radiológico a los 6 meses de seguimiento

## RESUMEN

**Introducción:** En las fracturas de platillo tibial, uno de los requisitos fundamentales es la reducción anatómica de la superficie articular, su visualización con un abordaje correcto es indispensable para resolverlas. El objetivo de este estudio es detallar la técnica quirúrgica de este abordaje, y comunicar los resultados funcionales y radiográficos en una serie de casos con un seguimiento de 6 meses. **Materiales y Métodos:** En 24 meses, se efectuaron 9 abordajes anterolaterales con osteotomías del epicóndilo lateral en 5 mujeres y 4 hombres (edad promedio 40.1 años; rango 18-62), que tenían fracturas de platillo tibial lateral con compromiso del sector posterior. El seguimiento promedio fue de 13 meses (mín. 6, máx. 24). **Resultados:** Se realizó una evaluación radiográfica, donde se constató la consolidación ósea. Se midieron el ancho condilar, el ángulo tibial proximal medial y la pendiente tibial, comparativas con la rodilla contralateral. No hubo casos de pseudoartrosis o desplazamiento del taco óseo de la osteotomía. Se llevó a cabo una evaluación clínica y funcional con las escalas *Knee Injury and Osteoarthritis Outcome Score* (KOOS) y de Rasmussen. Los resultados fueron buenos/excelentes en todos los casos, con un puntaje KOOS promedio de 82.

**Conclusión:** El abordaje anterolateral permite una óptima visualización y reducción de los fragmentos de la superficie articular, es una opción válida y reproducible para el cirujano, ya que no requiere un posicionamiento especial del paciente y minimiza el riesgo de lesión neurovascular.

**Palabras clave:** Rodilla; fracturas de platillo tibial; abordaje quirúrgico; osteotomía del epicóndilo femoral lateral.

**Nivel de Evidencia:** IV

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## INTRODUCTION

The fundamental objective in the treatment of tibial plateau fractures is to restore the joint surface and axial alignment through anatomical reduction and absolute stability, thereby enabling early mobilization.<sup>1,2</sup>

Proper visualization of the articular surface through an appropriate surgical approach is essential for managing these fractures.<sup>3-5</sup>

The extended anterolateral approach with epicondyle osteotomy provides enhanced exposure of the lateral tibial plateau articular surface, allowing for accurate fragment reduction.<sup>6</sup> This has been correlated with improved clinical and radiographic outcomes.

The objectives of this article are to describe the surgical technique of the extended anterolateral approach with epicondyle osteotomy for lateral tibial plateau fractures with posterior involvement, and to report the functional and radiological outcomes obtained in a series of patients treated with this technique.

## MATERIALS AND METHODS

Over a 24-month period (2022–2024), 20 patients with tibial plateau fractures were admitted to our hospital. The study included patients presenting with lateral tibial plateau fractures with posterior involvement, according to the Schatzker and Kfuri classification,<sup>7</sup> with or without associated medial plateau involvement, and an *American Society of Anesthesiologists* (ASA) score of III or lower.<sup>8</sup>

Exclusion criteria were: ipsilateral lateral femoral condyle fracture, isolated medial tibial plateau fracture, external tibial plateau fractures with anterolateral involvement only, soft-tissue compromise at the planned approach site, and ASA score greater than IV.

Patients remained hospitalized for an average of 7 days prior to surgery. During this period, 7 were placed in transcalcaneal skeletal traction and 2 in external fixation, both applied on the day of emergency admission.

A total of nine lateral approaches with lateral epicondyle osteotomies were performed in five women and four men (mean age 40.1 years; range 18–62). Mean follow-up was 13 months (min. 6, max. 24).

Written informed consent was obtained from all participants. The study protocol was approved by the Ethics Committee of Hospital “Prof. Dr. Alejandro Posadas” and conducted in accordance with the Declaration of Helsinki.

### Surgical Technique

The patient is placed in the supine position with the knee flexed to 90° on the surgical table. An anterolateral approach is performed from the femoral epicondyle to Gerdy’s tubercle, which may be extended as needed by the surgeon (Figures 1 and 2).



**Figure 1.** Dermographic marking on the anterolateral aspect of the knee from the lateral epicondyle to Gerdy’s tubercle.



**Figure 2.** Incision along the previous marking, with possible extension proximally or distally as needed.

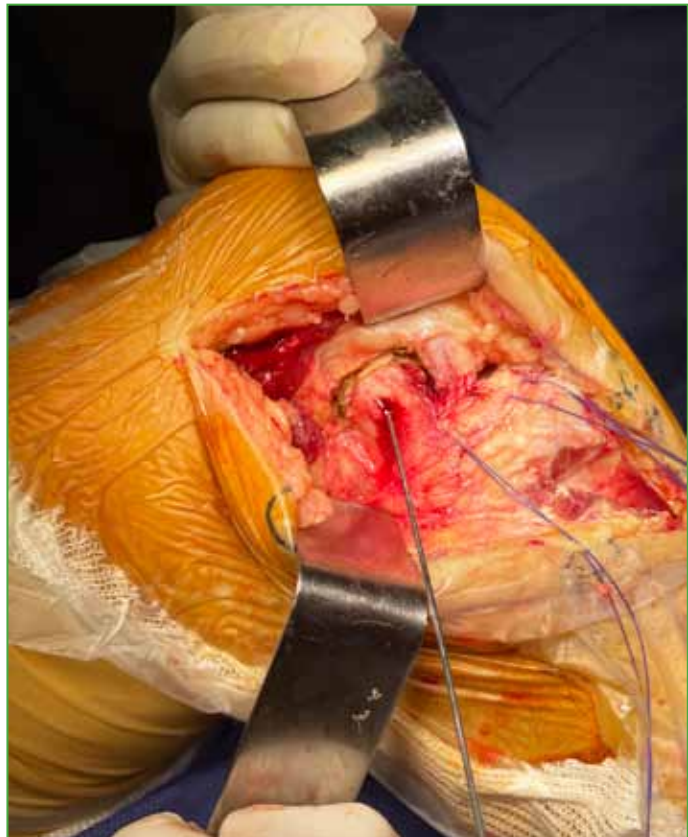
A longitudinal incision is made through the iliotibial band, and the anterolateral muscles of the proximal tibia are sectioned. The lateral meniscus is identified, a submeniscal incision is carried out, it is repaired with sutures, and then elevated proximally to expose the anterolateral region of the tibial plateau.

The approach is then extended through a lateral epicondyle osteotomy. The insertions of the lateral collateral ligament and the popliteus tendon are identified in the epicondylar area (Figure 3). A rectangular area approximately 3 cm long  $\times$  2 cm wide (including both insertions) is outlined using electrocautery. This creates a larger bone block and decreases the risk of fracture during fixation.

Including the popliteus insertion also increases the visualization area.<sup>2</sup> A 3.5-mm cannulated drill bit is used to create a hole at 30° proximally and 30° anteriorly in the center of the marked rectangle, preparing the bone block for later reinsertion (Figure 4).



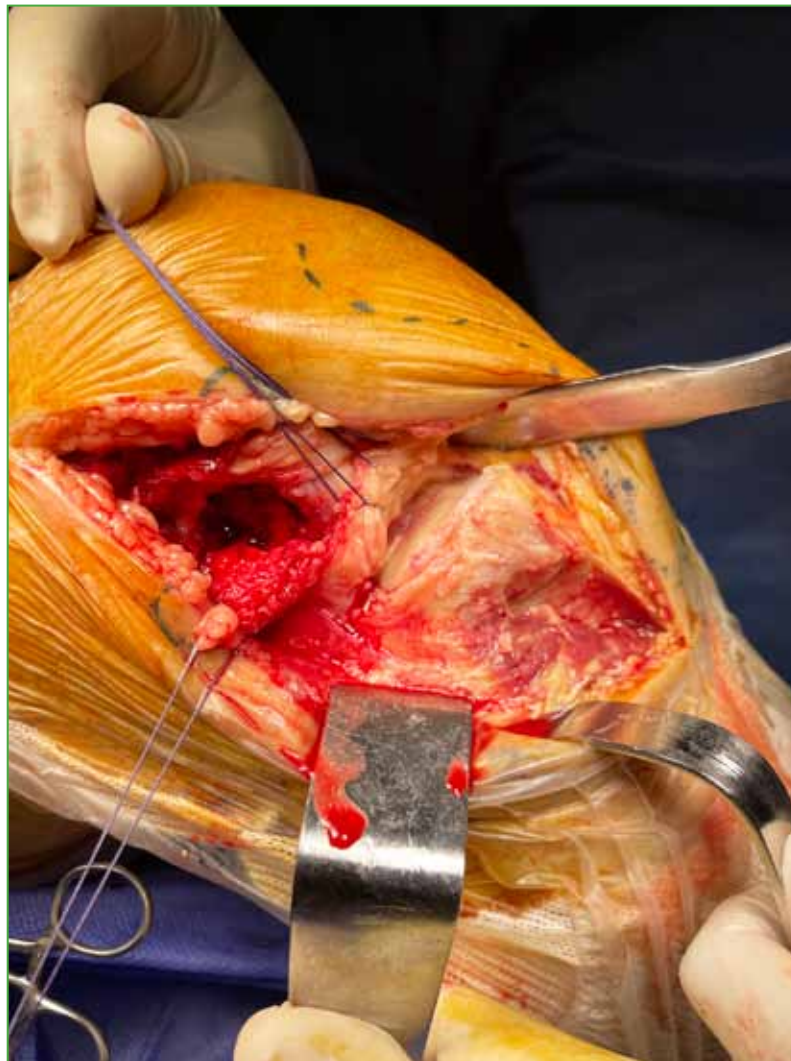
**Figure 3.** Identification of the insertions of the lateral collateral ligament and popliteus tendon in the epicondylar region.



**Figure 4.** Delimitation of the osteotomy area and placement of a guide pin for a cannulated drill bit at the center of the marked zone.

Osteotomy of the previously marked area is then completed, to a depth of approximately 1 cm. The bone block is gently released, taking care to avoid injury to the articular surface of the lateral femoral condyle.

By applying internal rotation and varus stress to the limb, a wide portion of the articular surface of the lateral tibial plateau is exposed, including medial intercondylar and posterolateral sectors (Figure 5).



**Figure 5.** Completed epicondyle osteotomy, repaired proximally, with meniscal elevation and exposure of the lateral tibial plateau articular surface.

The articular fragments are then reduced and elevated. Temporary stabilization is achieved with Kirschner wires, followed by compression with 4.5-mm cannulated screws and placement of an anatomical proximal tibial plate in an anti-shear configuration.

After stabilization, the epicondylar bone block is reinserted into its bed using a 4.5-mm cannulated screw, with or without a washer, depending on compression needs. The meniscus is repaired, and the wound is closed (Figure 6).



**Figure 6.** Reinsertion of the bone block into its bed following completion of osteosynthesis.

## RESULTS

Patients remained hospitalized for an average of 3 days (min. 1, max. 4) after surgery. Postoperative follow-ups were performed once a week during the first month and subsequently at weeks 6, 8, 12, and 16.

No wound complications or signs of surgical site infection were observed in this series. Radiographic and CT evaluations confirmed bone union.

Condylar width, the medial proximal tibial angle, and tibial slope were measured and compared with the contralateral knee, all of which fell within normal parameters. All patients had <2 mm of articular depression, except for one patient with a 3-mm depression. No cases of nonunion or displacement of the epicondylar osteotomy bone block were observed (Figures 7 and 8).



**Figure 7.** 25-year-old patient involved in a traffic accident. Schatzker–Kfuri V PM + PL fracture. **A.** AP knee radiograph. **B.** Lateral knee radiograph. **C.** Axial CT scan of the knee. **D.** Coronal CT scan of the knee. **E.** Postoperative AP radiograph of the knee. **F.** Postoperative lateral radiograph of the knee.



**Figure 8.** 18-year-old patient in a motorcycle–car accident. Schatzker–Kfuri II AL + PL fracture. **A.** AP knee radiograph. **B.** Lateral knee radiograph. **C.** Axial knee CT scan. **D.** Computed tomography of the knee, coronal section. **E.** Computed tomography of the knee, sagittal section. **F.** Postoperative AP view of the knee. **G.** Postoperative lateral view of the knee.

All patients were able to bear full weight at 5 months postoperatively. Clinical and functional assessment was performed using the *Knee Injury and Osteoarthritis Outcome Score* (KOOS) and the Rasmussen scale.<sup>9,10</sup> Outcomes were good to excellent in all cases, with a mean KOOS score of 82 (Table).

## DISCUSSION

Seventy percent of tibial plateau fractures involve the lateral plateau. A poor reduction rate of 77% has been reported in the postero-central quadrant, followed by 50% in the posterolateral quadrant.<sup>11</sup> For this reason, adequate visualization of the joint surface is essential to achieve an appropriate reduction. The posterior sector of the lateral tibial plateau can be accessed through several approaches, each with its benefits and limitations, and none universally preferred.

We use the extended anterolateral approach with epicondyle osteotomy when the posterior portion of the lateral plateau is involved, as it provides several advantages.<sup>6</sup>

Positioning the patient supine eliminates the need for intraoperative repositioning.

Luo et al. describe the “floating position,” initially placing the patient prone to perform a posterior approach, mobilizing the gastrocnemius from medial to lateral to expose the entire posterior surface of the proximal tibia, and then turning the patient supine, when necessary, to stabilize the anterior columns.<sup>12</sup> Another prone alternative is the intergastrocnemius anatomic approach described by Zublin et al., which allows medial or lateral mobilization of the neurovascular bundle according to the surgeon’s needs.<sup>13</sup>

**Table.** Results of functional and radiological evaluations.

Patient	Age	Gender	Type of fracture Schatzker- Kfuri	KOOS	Rasmussen	Follow-up	Condylar width	Collapse	MPTA	Slope
						(months)				
1	62	F	II AL+PL	70.8	Good	6	Normal	2 mm	91	6
2	58	M	II PL	81.6	Excellent	9	Normal	2 mm	88	5
3	24	M	II AL+PL	93.3	Excellent	18	Normal	No	88	5
4	45	F	II PL	91.8	Excellent	7	Normal	2 mm	88	3
5	40	F	II AL+PL	86.2	Good	7	Normal	2 mm	88	7
6	18	F	II AL+PL	95.9	Excellent	16	Normal	No	87	5
7	25	F	V PL+PM	71.9	Good	14	Fair	2 mm	88	7
8	37	F	II AL+PL	69.4	Excellent	24	Normal	2 mm	89	5
9	52	M	II PL	76.7	Excellent	16	Normal	3 mm	87	7
Average	40.1			82.0	Good/ Excellent	13.0				

F = female; M = male; A = anterior; P = posterior; L = lateral; M = medial; KOOS = Knee Injury and Osteoarthritis Outcome Score; MPTA = medial proximal tibial angle.

Lobenhoffer et al. and Carlson propose a direct posterolateral approach in the prone position, protecting the common peroneal nerve. Although this provides access to the posterolateral quadrant, the distal working window is limited because the anterior tibial artery crosses from posterior to anterior approximately 5 cm below the joint line, and visualization of the articular surface is generally restricted.<sup>14,15</sup>

Frosch et al. also place the patient prone and use a posterolateral approach through two windows, anterior and posterior, without requiring fibular osteotomy.<sup>16</sup>

A major advantage of our approach is the reduced risk of injury to critical structures such as the peroneal nerve or the popliteal neurovascular bundle.

The epicondyle osteotomy can be reinserted easily and provides inherent stability that facilitates early motion. In our series, there were no cases of nonunion of the osteotomy block.

Brilhaut et al. reported a 7.6% rate of nonunion of the bone block in a series of patients undergoing lateral femoral epicondyle osteotomy for severe valgus deformity.<sup>17</sup>

Solomon et al. described a fibular head osteotomy involving the proximal tibiofibular joint. Beyond increasing the risk of nerve injury, the subsequent reduction and fixation of the fibula may introduce additional risk of nonunion.<sup>18</sup>

As a limitation, our approach does not allow placement of a buttress plate on the posterior cortex of the proximal tibia, as accessing the posterior metaphysis for osteosynthesis is challenging.

Cho et al. use a 2.7-mm belt-shaped reconstruction plate to fix posterolateral fragments, providing absolute stability to the entire proximal tibial ring.<sup>19</sup>

We chose the KOOS scale because it is age-independent and reproducible across all age groups, acknowledging that other tools (such as the Lysholm Score, the *Oxford Knee Score*, and the *Knee Society Score*) are more appropriate for evaluating ligament surgeries or knee arthroplasties.<sup>9,20-22</sup>

The mean KOOS score in our series was 81.9, similar to the 82.9 reported by Van Dreumel et al. in their cohort of 71 patients with medium- to long-term follow-up.<sup>23</sup>

We believe our approach is conventional and familiar to orthopedic surgeons, who generally view it as a natural extension of the anterolateral approach. It reduces surgical time and avoids additional soft-tissue disruption. Furthermore, it can be combined with a posteromedial or anteromedial approach when required by the fracture pattern.

This study has limitations: it is a case series with a limited number of patients. Although short-term functional and radiological outcomes are excellent, longer follow-up is necessary to accurately assess final outcomes.

## CONCLUSIONS

The extended anterolateral approach with epicondyle osteotomy for fractures involving the posterior sector of the lateral tibial plateau allows optimal visualization and reduction of the articular surface fragments. It is a valid and reproducible option for the surgeon, as it is a familiar approach, does not require a special patient position, and minimizes the risk of neurovascular injury. The short-term functional and radiographic results are excellent.

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# Characterization of Preceding Fragility Fractures in Patients With Hip Fractures: A Retrospective Analysis of 200 Cases

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## ABSTRACT

**Introduction:** Osteoporosis is a disease characterized by decreased bone density that increases the risk of fractures, particularly in older adults. The objectives of this study were to document the frequency of fragility fractures preceding a hip fracture, the prevalence of each type of fracture, and the percentage of patients diagnosed and treated for osteoporosis prior to sustaining a hip fracture. **Materials and Methods:** A retrospective study was conducted in patients aged >65 years who underwent surgery for hip fracture between 2022 and 2023 at a single site, with a minimum follow-up of 12 months. Variables analyzed included age, sex, fracture type and treatment, prior diagnosis of osteoporosis, and the anatomical sites of preceding fragility fractures. **Results:** Two hundred patients were included (159 women and 41 men; mean age 83.04 years). Sixty patients (30%) had sustained a fragility fracture before the hip fracture. The most common locations were the contralateral hip (9%), spine (8%), and distal radius (6.5%). Of these patients, 48.33% had a prior diagnosis of osteoporosis. **Conclusions:** Thirty percent of patients experienced fragility fractures (also referred to as sentinel fractures) prior to a hip fracture. Implementing preventive strategies for diagnosis and treatment in this population is crucial to reduce the risk of subsequent fractures and improve quality of life.

**Keywords:** Osteoporosis; fragility fractures; hip fracture.

**Level of Evidence:** IV

## Caracterización de las fracturas por fragilidad previas a una fractura de cadera. Estudio retrospectivo de 200 casos

## RESUMEN

**Introducción:** La osteoporosis es una enfermedad caracterizada por la pérdida de densidad ósea que aumenta el riesgo de fracturas, especialmente en adultos mayores. Este estudio tiene como objetivos documentar la frecuencia de las fracturas por fragilidad previas a una fractura de cadera, la prevalencia de cada tipo de fractura y el porcentaje de pacientes con osteoporosis diagnosticada y tratada antes de la fractura de cadera. **Materiales y Métodos:** Se realizó un estudio retrospectivo en pacientes >65 años, operados por fractura de cadera entre 2022 y 2023, en un único Centro y que cumplieron un seguimiento mínimo de 12 meses. Se analizaron variables, como edad, sexo, tipo de fractura y tratamiento, diagnóstico previo de osteoporosis, antecedentes de localización de fracturas por fragilidad. **Resultados:** Se incluyó a 200 pacientes (159 mujeres y 41 hombres, edad promedio 83.04 años), 60 (30%) tenían fracturas por fragilidad previas a la fractura de cadera. Las localizaciones más comunes eran: cadera contralateral (9%), columna vertebral (8%) y radio distal (6,5%). El 48,33% de estos pacientes tenía diagnóstico de osteoporosis. **Conclusiones:** El 30% sufrió fracturas por fragilidad, también llamadas fracturas centinela, antes de una fractura de cadera. La implementación de estrategias de diagnóstico y tratamiento preventivos en estos pacientes es crucial para reducir el riesgo de nuevas fracturas y mejorar la calidad de vida.

**Palabras clave:** Osteoporosis; fracturas por fragilidad; fractura de cadera.

**Nivel de Evidencia:** IV

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## INTRODUCTION

Due to increased life expectancy and the resulting aging population, osteoporosis has become a global epidemic.<sup>1,2</sup> Despite pharmacological advances in the prevention and management of this disease over recent decades, the incidence of fragility fractures in older adults continues to rise.<sup>1,3</sup> It is estimated that osteoporosis causes approximately 9 million fractures per year worldwide, a figure that has a substantial impact on healthcare systems.<sup>4</sup>

Fragility fractures are characterized by their occurrence spontaneously or following low-energy trauma in patients with osteoporosis. They most frequently involve the spine, hip, wrist, proximal humerus, and pelvis.<sup>3</sup> Numerous studies have attempted to identify predisposing factors for these injuries. Some of the most common include age, female sex, postmenopausal status, body mass index, use of estrogen and vitamin D supplements, and a prior history of fracture.<sup>3</sup> Regarding the latter, Haentjens et al. reported that, in postmenopausal women, a distal radius or vertebral fracture doubles the risk of sustaining a hip fracture. In another similar report, approximately half of the patients who sustained a hip fracture were found to have a history of a fragility fracture.<sup>3,5</sup> Consequently, a fragility fracture, also referred to as a sentinel fracture, has long been considered a warning sign. Early diagnosis and treatment of osteoporosis therefore become essential to prevent subsequent fractures.<sup>3,4,6</sup>

In developing countries such as ours, preventive treatments are either infrequently administered or entirely absent, and osteoporosis consequently remains underdiagnosed and undertreated.<sup>7</sup>

Based on this background, we hypothesized that a considerable number of fragility fractures occur prior to hip fractures in our setting. Therefore, the objectives of this retrospective study were: 1) to determine the frequency of fragility fractures preceding hip fractures treated at a single center; 2) to identify the anatomical distribution of these fractures; and 3) to determine the percentage of patients who had a prior diagnosis or treatment of osteoporosis before sustaining a hip fracture.

## MATERIALS AND METHODS

A retrospective, descriptive, observational study was conducted to evaluate all patients consecutively operated on for hip fractures and recorded in our department's database between 2022 and 2023.

Inclusion criteria were: age >65 years; diagnosis of medial or lateral hip fracture; surgical treatment; and a minimum clinical follow-up of 12 months. Exclusion criteria were: fractures caused by high-energy mechanisms (e.g., traffic accidents, falls from height); fractures associated with underlying diseases affecting bone quality, such as rheumatoid arthritis or cancer; chronic corticosteroid therapy; and failure to complete the minimum follow-up period for reasons other than death.

Fragility fractures were defined according to the World Health Organization as fractures occurring from trauma insufficient to fracture a normal bone, resulting from compressive or torsional forces.<sup>5</sup>

### Variables Analyzed

The following variables were analyzed: sex, age at the time of the hip fracture, type of hip fracture (medial or lateral), and type of treatment (osteosynthesis or arthroplasty). In addition, it was recorded whether the patient had a prior diagnosis of osteoporosis (based on bone mineral densitometry), whether they were receiving treatment, and the specific medication prescribed. A history of previous fractures and their anatomical location was also documented based on the medical record review, radiological archive, and targeted patient questioning.

### Statistical Analysis

The collected data were entered into an Excel spreadsheet. Continuous variables are expressed as median and range, and categorical variables as frequency and percentage.

## RESULTS

Fifteen of the 215 patients identified in the initial search were excluded (7 due to high-energy trauma, 5 for failing to meet the minimum follow-up requirement, and 3 for fractures related to cancer or rheumatoid arthritis).

The study population consisted of 200 patients (159 women and 41 men) with 200 hip fractures. The median age at the time of the hip fracture was 83.04 years (range 65–99). Eighty-five patients were treated with arthroplasty and 115 with osteosynthesis (Table 1).

**Table 1.** Patient data from the series

Age	83.04 years (range 55-99)
Gender	Male 41 (20.5%)
	Female 159 (79.5%)
Type of fracture	Medial 111 (55.5%)
	Lateral 89 (45.5%)
Treatment	Osteosynthesis 115 (57.5%)
	Arthroplasty 85 (42.5%)
Osteoporosis	68 (34%)
Treatment	84 (42%)

Sixty-eight patients had osteoporosis confirmed by densitometry, and 84 were receiving pharmacological treatment, which consisted, ordered by frequency, of: calcium plus vitamin D (25 cases), calcium alone (16 cases), vitamin D alone (14 cases), vitamin D plus bisphosphonates (10 cases), zoledronate (6 cases), bisphosphonates alone (5 cases), calcium plus zoledronate (5 cases), and calcium plus bisphosphonates (3 cases).

### Previous Fragility Fractures

Thirty percent of the 200 patients had sustained at least one prior fragility fracture; 12 patients (6%) had sustained two fractures, and 3 patients (1.5%) had sustained three previous fragility fractures. The most frequent locations were the contralateral hip (9%, 18 cases), spine (8%, 16 cases), wrist (6.5%, 13 cases), and proximal humerus (4%, 8 cases) (Table 2).

**Table 2.** Description of the fractures in the series.

Preceding fracture	Number of patients
Contralateral hip	18 (9%)
Distal radius	13 (6.5%)
Spine	16 (8%)
Proximal humerus	8 (4%)
Pelvis	6 (3%)
Elbow	3 (1.5%)
Patella	3 (1.5%)
Ankle	3 (1.5%)
Femur (supracondylar)	1 (1.4%)

The median interval between the previous fragility fracture and the hip fracture was 24 months (range 1–384). Twenty-four patients (39.3%) sustained their hip fracture within the first year; 9 (14.7%) in the second year; 3 (4.9%) in the third year; 9 (14.7%) in the fourth year; and the remaining patients beyond this timeframe. Thus, 73.6% suffered a hip fracture within 4 years of their fragility fracture.

Regarding osteoporosis diagnosis and treatment, 29 (48.33%) of the 60 patients with prior fragility fractures had a diagnosis confirmed by densitometry, and only one patient (3.44%) was not receiving pharmacological treatment.

## DISCUSSION

The main finding of our study was that 30% of patients with hip fractures had experienced a previous fragility fracture. Vertebral compression fractures and distal radius fractures were the most frequent. In our view, this highlights the importance of recognizing that encountering one of these fragility fractures, most of which are common even for general orthopedic surgeons, may represent a *sentinel fracture* for future injuries.

The identification of hip, vertebral, and wrist fractures as common fragility fractures is consistent with the findings of Lauritzen et al., and partially with those of Dang et al., who reported vertebral compression fractures and proximal humerus fractures as the most frequent.<sup>7,8</sup> In our series, proximal humerus fractures ranked fourth in frequency, with an incidence of 4%.

As noted, in our cohort, 30% of patients with hip fractures had a history of a fragility fracture, a figure lower than the 39.8% reported in an Irish population study.

The association between a fragility fracture and, specifically, a subsequent hip fracture has been widely documented. In 2019, Dang et al. evaluated more than one million patients and reported that 5.8%, 8.8%, and 11.3% of those with a prior fragility fracture sustained a new fracture within 12, 24, and 36 months, respectively.<sup>8</sup> Clinton et al. and Lauritzen et al. estimated that the risk of hip fracture is highest during the first year after a distal radius fracture (relative risk 1.9) or proximal humerus fracture (relative risk 2.7) in women aged 60–79 years.<sup>7,9</sup> Haentjens et al. also noted that Colles fractures significantly increase the risk of subsequent hip fractures in postmenopausal women. In our analysis, 10% of patients had a previous wrist or humerus fracture.<sup>10</sup>

In our series, more than 80% of patients with prior fractures were women—a percentage considerably higher than the 42.6% reported by McCarthy et al. and the 45% reported by Port et al.<sup>11</sup> This marked difference may be influenced by the fact that, in our country, according to the Morbidity and Mortality Committee of the Argentine Association of Orthopedics and Traumatology, approximately 75% of patients with hip fractures are women.

From another perspective, in a population composed mainly of elderly women (>80 years), approximately 73% of those with a fragility fracture sustained a hip fracture within the following four years.

This underscores the importance of multidisciplinary care, together with internal medicine physicians and endocrinologists, to promote actions aimed at reducing the incidence of subsequent fractures.

Finally, only 34% of the total sample had a diagnosis of osteoporosis, and 42% were receiving preventive pharmacological treatment. Among the 60 patients with a history of fragility fractures, only 48% had been formally diagnosed. This highlights the need to intensify not only diagnosis but also preventive treatment in high-risk groups.

The limitations of this study are inherent to its retrospective design and relatively small sample size, which make the analysis susceptible to confounding factors. Additional limitations include the high proportion of women in the cohort, which restricts generalizability to male patients, and the fact that the study was conducted at a single healthcare center in a specific geographic region, limiting extrapolation to the general population.

To our knowledge, this is the first study in Argentina to examine various types of fragility fractures and their association with subsequent hip fractures. The clinical implications of these findings reinforce the importance of proactive evaluation and management of osteoporosis in patients with fragility fractures, particularly in women over 65 years of age. Studies with larger populations are needed to determine the predictive value of these sentinel fractures in the broader national population.

## CONCLUSIONS

Thirty percent of women over 65 who sustain a fragility fracture may suffer a hip fracture within the following four years. It is essential to implement appropriate preventive and therapeutic strategies to mitigate this risk, thereby optimizing patients' quality of life and reducing the associated economic burden.

Conflicts of interest: The authors declare no conflicts of interest.

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# Tibial Plateau Fractures Schatzker Type II–III Treated With Impacted Bone Allograft or Rafting Technique: Is Filling the Void Necessary? A Comparative Cohort Study of 80 Patients

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## ABSTRACT

**Introduction:** Schatzker type II and III tibial plateau fractures require techniques that stabilize and maintain the articular surface. The objective of this study was to compare the use of impacted bone allograft and the rafting technique, evaluating secondary displacement and postoperative function. **Materials and Methods:** We conducted a retrospective, comparative review of all patients with Schatzker type II and III tibial plateau fractures consecutively treated between January 2015 and December 2020 using either the rafting technique (RT) or impacted bone graft (IBG). Loss of articular reduction (defined as >2 mm of secondary depression) was assessed, along with clinical and radiographic outcomes using the Rasmussen score and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). **Results:** Eighty patients were included: 39 treated with RT and 41 with IBG. Two patients in each group experienced loss of articular reduction during follow-up. The Rasmussen clinical score was excellent or good in 93.75% of the series, with no significant differences between groups; likewise, no significant differences were found in the WOMAC score. The radiological Rasmussen score was excellent or very good in 96.25% of patients, again with no differences between groups. **Conclusion:** The results suggest comparable performance between impacted bone allograft and the rafting technique in maintaining reduction and achieving functional outcomes in Schatzker type II–III tibial plateau fractures.

**Keywords:** Tibial plateau fracture; tibial plateau depression; rafting technique; bone allograft.

**Level of Evidence:** III

**Fracturas de platillo tibial tipo II-III de Schatzker tratadas con aloinjerto óseo impactado o técnica de rafting. ¿Es necesario llenar el vacío? Estudio de cohortes comparativo en 80 pacientes**

## RESUMEN

**Introducción:** Las fracturas de platillo tibial tipos II y III requieren técnicas que estabilicen y mantengan la superficie articular. El objetivo de este estudio fue comparar el uso de aloinjerto óseo impactado con la técnica de *rafting*, evaluando el desplazamiento secundario y la función posoperatoria. **Materiales y Métodos:** Se evaluó, de forma retrospectiva y comparativa, a todos los pacientes con fracturas de platillo tibial tipos II y III de Schatzker tratados consecutivamente con la técnica de *rafting* o injerto óseo impactado, entre enero de 2015 y diciembre de 2020. Se analizaron la pérdida de reducción articular (definida como hundimiento >2 mm) y los resultados clínicos y radiológicos mediante las escalas de Rasmussen y WOMAC. **Resultados:** La serie tenía 80 pacientes, 39 tratados con técnica de *rafting* y 41, con injerto óseo impactado. Dos pacientes del grupo con técnica de *rafting* y 2 del otro grupo tuvieron una pérdida de reducción articular durante el seguimiento. El puntaje clínico de Rasmussen fue excelente o bueno en el 93,75% de la serie, sin diferencias significativas entre los grupos. Tampoco hubo diferencias significativas en el

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puntaje WOMAC. El puntaje radiológico fue excelente o muy bueno en el 96,25% de los pacientes, sin diferencias entre los grupos. **Conclusión:** Los resultados sugieren un rendimiento similar en el mantenimiento de la reducción y los resultados funcionales utilizando aloinjerto óseo impactado o la técnica de *rafting* en fracturas de la meseta tibial tipos II y III de Schatzker.

**Palabras clave:** Fractura de la meseta tibial; fractura-depresión; técnica de *rafting*; aloinjerto óseo.

**Nivel de Evidencia:** III

## INTRODUCTION

Tibial plateau fractures account for 1% of all fractures in adults and between 5–8% of lower limb fractures.<sup>1</sup> Joint depression is an important component of lateral tibial plateau fractures.<sup>2</sup> According to the Schatzker classification, the main types are II (fracture plus depression) and III (pure depression).<sup>3</sup> Effective treatment includes elevation of the osteochondral fragment and stable fixation to provide structural support.<sup>4</sup>

Traditionally, autologous bone grafting is recommended to fill the subchondral bone defect and prevent collapse of the osteochondral fragment after initial joint reduction.<sup>5,6</sup> However, this procedure requires a second surgical approach, causing pain in a previously uninjured area and increasing the risk of infection.<sup>7–11</sup> Alternative strategies, such as bone allografts, bone substitutes, or subchondral graft screws, have reduced donor-site morbidity.<sup>2,11–15</sup>

While bone allografts and substitutes support the joint surface by filling the defect, the rafting technique maintains the articular surface through subchondral screw placement.<sup>2,15</sup> To date, biomechanical studies have not found significant differences in overall construct stiffness, nor has the superiority of any technique been confirmed.<sup>2</sup>

Therefore, the aim of this study was to analyze secondary fragment displacement and functional outcomes following surgery using either impacted bone allograft or rafting techniques without bone grafting for Schatzker type II and III tibial plateau fractures. Our hypothesis was that none of the techniques would demonstrate superior results.

## MATERIALS AND METHODS

The databases of three referral centers were retrospectively reviewed to identify all tibial plateau fractures treated with open reduction and internal fixation using either impacted bone allograft or a rafting technique between January 2015 and December 2020.

The study was conducted after approval by the institutional and ethics review boards of each participating institution.

Inclusion criteria were: age >18 years, tibial plateau articular depression  $\geq 3$  mm, and Schatzker type II or III fractures.

Exclusion criteria were: open fractures, subacute fractures (>3 weeks after injury), fractures with isolated posterolateral involvement requiring a posterolateral plate, concomitant lower-limb injuries affecting rehabilitation, and postoperative follow-up of less than 12 months.

Preoperative evaluation included anteroposterior and lateral radiographs, as well as a CT scan of the injured knee. Fractures were classified according to the Schatzker system.<sup>3</sup>

The following data were collected: sex, age, diabetes, obesity (body mass index >30), smoking status, fracture type (Schatzker II or III), implants used (cortical or cannulated screws, plates), bone union, and postoperative complications.

## Surgical Technique

Patients were operated on a radiolucent table under spinal anesthesia. The anterolateral approach to expose the lateral tibial plateau was performed with the patient in the supine position. A submeniscal arthrotomy was used to visualize the lesion and directly assess the reduction. In fractures with pure depression, the osteochondral fragment was reduced with forceps through a cortical window. For type II fractures, the cortical fracture line was opened and the depressed fragment was elevated en bloc using an osteotome. Fracture reduction was monitored with fluoroscopy in all cases.



**Figure 1.** **A and B.** Schatzker type II fracture in a 56-year-old woman. **C and D.** Computed tomography of the knee showing a centrally depressed fragment associated with a shear component. **E and F.** After open reduction, the depressed fragment was fixed with three 3.5-mm subchondral screws (rafting technique) placed proximal to the precontoured anti-shear plate.

After reduction, preliminary fixation was performed with Kirschner wires. In the rafting technique group (Figure 1), definitive fixation was achieved with 3.5-mm subchondral screws placed through the plate when its design allowed adequate subchondral positioning. When this was not possible, the screws were placed proximally outside the plate.

In the other procedure, the articular surface was restored with impacted bone allograft introduced through a distal window; two cannulated screws (4.5 or 6.5 mm) were then inserted, followed by additional impaction and filling with allograft to occupy the metaphyseal defect (Figure 2).



**Figure 2.** **A and B.** Schatzker type III fracture in a 61-year-old man. **C and D.** Computed tomography of the knee demonstrating anterolateral joint depression. **E and F.** The depressed fragment was reduced through a cortical window and fixed with two cannulated screws. Impacted allogeneic bone graft was used to fill the defect, and an anti-shear plate was applied.

In type II fractures, a low-profile locking plate was used as a buttress, whereas in type III fractures its use was left to the discretion of the operating surgeon.

All patients followed the same postoperative rehabilitation protocol. Beginning on postoperative day 2, knee and ankle flexion–extension exercises were initiated. Weight bearing was restricted for 4 weeks, followed by partial weight bearing and progression to full weight bearing at approximately 8–10 weeks postoperatively. Clinical and radiological follow-up visits were scheduled at 3 and 6 weeks, 3, 6, and 12 months, and annually thereafter.

For analysis, patients were divided into two groups according to treatment: rafting technique or impacted bone allograft.

### Clinical and Radiological Analysis

At the last postoperative follow-up, the Rasmussen criteria were used for the clinical and radiological assessment.<sup>16</sup> This system evaluates clinical outcomes (pain, walking ability, range of motion, and stability) and rates them as excellent ( $\geq 27$  points), good (26–20 points), fair (19–10 points), or poor (9–6 points). Functional outcomes were determined using the WOMAC (*Western Ontario and McMaster Universities Arthritis Index*) questionnaire through a telephone interview at the end of the study.<sup>17</sup>

Radiological findings (articular depression, alignment, widening, and osteoarthritis) were classified as excellent (18 points), good (17–12 points), fair (11–6 points), or poor ( $< 6$  points). Articular depression was measured by drawing the tibial anatomical axis and a perpendicular line at the level of the medial plateau, determining the height difference with the injured plateau at the point of greatest depression. Measurements were performed using the Fujifilm Pack digital system. This assessment was carried out both in the immediate postoperative period and at the final radiological follow-up, with particular attention to significant loss of reduction ( $> 2$  mm).

### Statistical Analysis

Quantitative variables are reported as mean and standard deviation or median and range, depending on their distribution. Qualitative variables are expressed as frequency and percentage. Comparative analyses between treatment groups were conducted using Fisher's exact test, the Mann–Whitney U test, or the  $\chi^2$  test, according to the nature of the variable. A p-value  $< 0.05$  was considered statistically significant.

All analyses were performed using SPSS software, version 23 (IBM; Chicago, Illinois, USA).

## RESULTS

Of the 92 patients identified, 12 were excluded (3 with open fractures, 1 with a non-acute fracture, 3 with isolated posterolateral involvement, 2 with ipsilateral femur or tibia fractures, and 3 lost to follow-up). The final cohort consisted of 80 patients: 39 (48.75%) treated with the rafting technique and 41 (51.25%) with impacted bone allograft. The general characteristics of the overall sample and each treatment group are presented in [Table 1](#).

**Table 1.** General characteristics, complications, and follow-up

	Total (n = 80)	Rafting (n = 39)	IBA (n = 41)	p
Male, n (%)	47 (58.75)	28 (71.79)	19 (46.34)	0.01
Age, mean (range)	49.6 (25-85)	49.3 (25-77)	51.7 (28-85)	0.12
Diabetes, n (%)	14	7	7	0.99
BMI $> 30$ , n (%)	20	11	9	0.60
Smokers, n (%)	13	7	6	0.76
Schatzker type, n (%)				
II	48 (60.0)	19 (48.72)	29 (70.73)	0.07
III	32 (40.0)	20 (51.28)	12 (29.27)	
Complications (%)	4 (5)	2 (5.13)	2 (4.87)	0.99
Follow-up, mean (range)	24.9 (12-51)	24.6 (12-44)	25.2 (12-51)	0.23

BMI = body mass index.

Among preoperative variables, a significant difference was found only in sex distribution between groups ( $p = 0.01$ ). In the rafting group, a median of 3 screws outside the plate was used. In the impacted bone allograft group, the median graft volume was 45 cc (range 35–75).

### Clinical Outcomes

A total of 93.75% ( $n = 75$ ) of patients achieved excellent or good outcomes according to the Rasmussen clinical score, with no significant differences between groups (Table 2).

**Table 2.** Clinical outcomes - Rasmussen

	Total	Rafting (n = 39)	IBA (n = 41)	p
Excellent, n (%)	62 (77.50)	31 (79.48)	31 (75.6)	0.08
Good, n (%)	13 (16.25)	6 (15.38)	7 (17.1)	
Fair, n (%)	5 (6.25)	2 (5.12)	3 (7.3)	
Poor, n (%)	0	0	0	
Pain, SD	4.21 ± 0.64	4.05 ± 0.75	4.36 ± 0.69	0.07
Gait, SD	4.45 ± 0.63	4.43 ± 0.59	4.46 ± 0.67	0.84
Range of motion, SD	4.49 ± 0.73	4.30 ± 0.59	4.63 ± 0.76	0.76
Stability, SD	4.92 ± 0.47	5.0 ± 0.0	4.85 ± 0.65	0.16

SD = standard deviation.

Sixty-eight of the 80 patients were successfully contacted by telephone (84.6% of the rafting group and 82.9% of the allograft group) to complete the WOMAC questionnaire. The mean WOMAC score was  $14.3 \pm 2.64$  in the rafting group and  $15.1 \pm 1.98$  in the impacted allograft group, with no significant difference between them ( $p = 0.25$ ).

### Radiological Outcomes

Overall, 96.25% ( $n = 77$ ) of patients obtained excellent or good radiological outcomes. No significant differences were found in any of the radiographic parameters assessed.

Four patients (5%), two in each group, presented loss of articular reduction between the immediate postoperative period and the final follow-up (defined as >2 mm depression) (Table 3).

**Table 3.** Radiological outcomes - Rasmussen

	Total	Rafting (n = 39)	IBA (n = 41)	p
Excellent, n (%)	50 (62.5)	24 (61.5)	26 (63.4)	0.76
Good, n (%)	27 (33.7)	14 (35.9)	13 (31.7)	
Fair, n (%)	3 (3.7)	1 (2.6)	2 (4.9)	
Poor, n (%)	0			
Joint depression, SD	2.40 ± 0.57	2.33 ± 0.57	2.43 ± 0.53	0.43
Varus-Valgus, SD	3.85 ± 0.48	3.92 ± 0.27	3.78 ± 0.61	0.18
Condylar widening, SD	3.81 ± 0.47	3.87 ± 0.33	3.75 ± 0.58	0.28
Osteoarthritis, SD	3.60 ± 0.73	3.51 ± 0.85	3.68 ± 0.60	0.30
Loss of reduction, n (%)	4 (5.0)	2 (5.12)	2 (4.87)	0.86

SD = standard deviation.

## DISCUSSION

The main finding of this study was that neither technique proved superior for the treatment of Schatzker type II and III tibial plateau fractures with respect to postoperative loss of reduction or functional outcomes. These results support our initial hypothesis.

Over the past decade, additional factors, such as joint stability, meniscal preservation, and coronal alignment, have been identified as critical determinants of outcomes in tibial plateau fractures, partly due to their relationship with joint congruency.<sup>18</sup> However, recent studies have shown that even a 2-mm articular collapse may correlate with increased knee stiffness and poorer clinical outcomes.<sup>19, 20</sup> Thus, anatomical reduction of the joint surface and stable fixation remain the cornerstones of treatment.<sup>19, 20</sup>

Traditionally, in cases of pure depression or fracture-depression patterns, elevation of the depressed fragment followed by filling the metaphyseal defect with autologous bone graft has been recommended to prevent secondary collapse.<sup>5,6</sup> Nevertheless, donor-site morbidity associated with autologous graft harvesting is well documented. In response, alternative strategies, such as the use of allograft or bone substitute, have been developed, with excellent reported outcomes.<sup>7-11</sup>

Conversely, some authors have demonstrated that filling the void is not essential for construct stability.<sup>2</sup> Mechanical support of the reduced osteochondral fragment via subchondral screw placement (“rafting technique”) represents a viable option to prevent collapse.<sup>21</sup> Various technical modifications have been described, including the “trapped screw configuration,” “magic screw,” interferential “metaphyseal screw,” and subchondral plating.<sup>21-26</sup> Regardless of the technique, screws must be positioned sufficiently close to the joint to ensure intimate contact with the osteochondral fragment.<sup>22</sup>

Kulkarni et al.<sup>27</sup> reported outcomes in 38 patients with Schatzker type II fractures treated with rafting fixation using 3.5-mm screws placed through a locking plate. After a mean follow-up of 22.8 months, 94% of patients achieved excellent or very good Rasmussen scores, and only one patient experienced loss of reduction, findings consistent with those in our series.

In the present study, comparison between allograft impaction and rafting demonstrated that both methods effectively maintained articular reduction, with excellent or good radiological outcomes based on Rasmussen criteria.

Although pure depression patterns occur more frequently in osteoporotic bone and therefore are more prevalent in older individuals, the mean age in both groups of our series was similar and consistent with previous reports.<sup>1,19,22,23</sup>

A statistically significant difference favoring male patients was found in the rafting technique group. This may be explained by the fact that one of the centers predominantly treats patients who sustain work-related injuries.

To our knowledge, this is the first study in our setting to compare a series of patients with Schatzker type II and III fractures treated either with impacted bone allograft or with the rafting technique without bone graft or any other substitute.

We acknowledge the limitations of this study. The first is its retrospective design, in which patients were not randomized to one technique or the other, a factor that would have strengthened our findings. Another limitation is the relatively small number of patients per group, which may have affected the analysis and contributed to the lack of statistical significance; however, compared with previous reports, this represents one of the largest cohorts per group. Additionally, the number, direction, and position of screws, whether through or outside the plate, were not standardized. Finally, the follow-up period was insufficient to assess the potential development of post-traumatic osteoarthritis.

## CONCLUSIONS

The results suggest comparable performance between impacted bone allograft and the rafting technique in maintaining reduction and functional outcomes in patients with Schatzker type II and III tibial plateau fractures. Depending on fracture characteristics, patient factors, and local resources, these findings allow the surgeon to choose either of the two fixation strategies with the expectation of achieving similarly favorable radiological and clinical outcomes.

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Conflicts of interest: The authors declare no conflicts of interest.

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# Diaphyseal Fractures of the Humerus Treated With the MultiLoc® Nail: Mid-Term Results

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## ABSTRACT

**Introduction:** Several satisfactory therapeutic options exist for diaphyseal humeral fractures. The MultiLoc® humeral intramedullary nail is a straight implant that offers multiple proximal locking configurations. The type and extent of proximal locking can be adapted to the fracture pattern and to more complex biomechanical requirements. **Objective:** To describe the radiographic and clinical-functional outcomes of patients with diaphyseal humeral fractures treated with a straight MultiLoc® intramedullary nail, along with associated complications and their management. **Materials and Methods:** Sixty-four patients with AO type 1.2 humeral fractures treated with a MultiLoc® nail and with a minimum clinical and radiographic follow-up of 18 months were included. Variables analyzed included clinical progression using the DASH score, return to pre-injury activity, and radiographic evaluation. **Results:** The mean DASH score after more than 18 months was 41. The average time to return to pre-injury activity was 3.1 months. Nine patients reported pain at the nail entry site; in seven cases, pain resolved with rehabilitation, while the remaining two presented proximal nail protrusion that required implant removal after fracture consolidation. The consolidation rate was 96.87%. **Conclusion:** The use of straight nails with angular stability in diaphyseal humeral fractures yields excellent mid-term clinical and radiographic outcomes.

**Keywords:** Humeral fracture; diaphyseal; intramedullary nail; osteosynthesis.

**Level of Evidence:** IV

## Fracturas diafisarias de húmero tratadas con un clavo MultiLoc®. Resultados a mediano plazo

## RESUMEN

**Introducción:** Existen diferentes opciones terapéuticas satisfactorias para las fracturas diafisarias de húmero. El clavo endomedular de húmero MultiLoc® es un implante recto que ofrece numerosas opciones de bloqueo proximal. El tipo y la extensión del bloqueo proximal se pueden adaptar al tipo de fractura y a los requerimientos biomecánicos más complejos. **Objetivo:** Describir los resultados radiográficos y clínico-funcionales de pacientes con fractura diafisaria de húmero tratadas con un clavo endomedular recto MultiLoc®, sus complicaciones y posibles soluciones. **Materiales y Métodos:** Se incluyó a 64 pacientes con fracturas de húmero tipo AO 1.2. tratadas con un clavo MultiLoc®, y un seguimiento clínico y radiográfico no inferior a 18 meses. Las variables analizadas fueron: la evolución clínica con el puntaje DASH, el retorno a la actividad previa a la lesión y la evaluación radiográfica. **Resultados:** El puntaje DASH promedio luego de más de 18 meses fue de 41. El tiempo promedio hasta retornar a la actividad previa a la lesión fue de 3.1 meses. Nueve pacientes refirieron dolor en la región de la puerta de entrada del clavo; el dolor remitió con la rehabilitación en 7 de ellos y los 2 restantes presentaron una protrusión proximal del clavo que requirió el retiro del implante una vez consolidada la fractura. La tasa de consolidación fue del 96,87%. **Conclusión:** El uso de los clavos rectos con estabilidad angular en fracturas diafisarias de húmero logra excelentes resultados clínicos y radiográficos a mediano plazo.

**Palabras clave:** Fractura de húmero; diafisaria; clavo endomedular; osteosíntesis.

**Nivel de Evidencia:** IV

## INTRODUCTION

Humeral fractures are commonly attributed to falls from standing height and high-energy trauma in younger patients. They represent 1–3% of all fractures of the body, and 13–25% are diaphyseal.<sup>1-3</sup>

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Surgery is generally reserved for displaced, unstable, or complex patterns, although the ideal treatment remains controversial.<sup>4</sup> Shortening of up to 3 cm and angular or rotational deformities  $<30^\circ$  typically have no significant clinical impact and are well tolerated functionally.<sup>3,5</sup>

Several treatment options exist: nonoperative management (useful in selected cases), open reduction and internal fixation with plates (either conventional or minimally invasive), and intramedullary nailing.

The MultiLoc® humeral intramedullary nail (DePuy-Synthes, Warsaw, USA) is a straight nail that offers multiple proximal locking options. The type and extent of proximal locking can be adapted to the fracture pattern and more demanding biomechanical requirements.<sup>6</sup> Its straight design increases stability proximally, creating a safe zone between the nail entry portal and the lateral segment of the humeral head, thereby reducing the risk of iatrogenic fractures in that area.<sup>7</sup> This same design also allows entry through the muscular portion of the supraspinatus, avoiding the tendinous or avascular footprint.

The aim of this study was to evaluate radiographic and clinical–functional outcomes in patients with diaphyseal humeral fractures treated with a straight intramedullary nail providing angular stability and MultiLoc® multidirectional screws, as well as to assess associated complications and potential solutions.

## MATERIALS AND METHODS

A retrospective, descriptive, observational case series was conducted. Between 2015 and 2020, 77 patients diagnosed with a diaphyseal humeral fracture were evaluated. Follow-up was achieved in 64 of them. All patients were treated with a straight MultiLoc® intramedullary nail.

Inclusion criteria were: 1) diaphyseal humeral fractures, 2) age  $>18$  years, 3) minimum follow-up of 18 months, 4) open fractures, 5) use of a MultiLoc® nail, and 6) pathological fractures.

Exclusion criteria were: 1) fractures at the junction of the middle and distal thirds, 2) diaphyseal fractures extending proximally into the surgical neck, 3) vascular or nerve injuries, 4) use of plate fixation.

Eligible fracture patterns included transverse, short oblique spiral, and comminuted fractures involving the region from the surgical neck to the junction between the middle and distal thirds.

Preoperatively, all patients underwent anteroposterior and lateral radiographs including the shoulder and elbow to characterize the fracture pattern, malalignment and displacement, classification, joint involvement, and for preoperative planning (Figure 1). Computed tomography was not routinely obtained and was reserved for cases with suspected delayed union or nonunion.

### Description of the Surgical Technique

All patients were operated on in the beach-chair or supine position on a radiolucent table. A 2-cm skin incision was made from the anterolateral edge of the acromion, extending distally toward the deltoid insertion. The supraspinatus tendon was split in line with its fibers, preserving both tendon margins with Vicryl® 1.0 sutures.

The entry point was created just posterior to the long head of the biceps tendon, aligned with the intramedullary canal on anteroposterior and lateral humeral radiographs.

Intramedullary canal reaming systems were used.

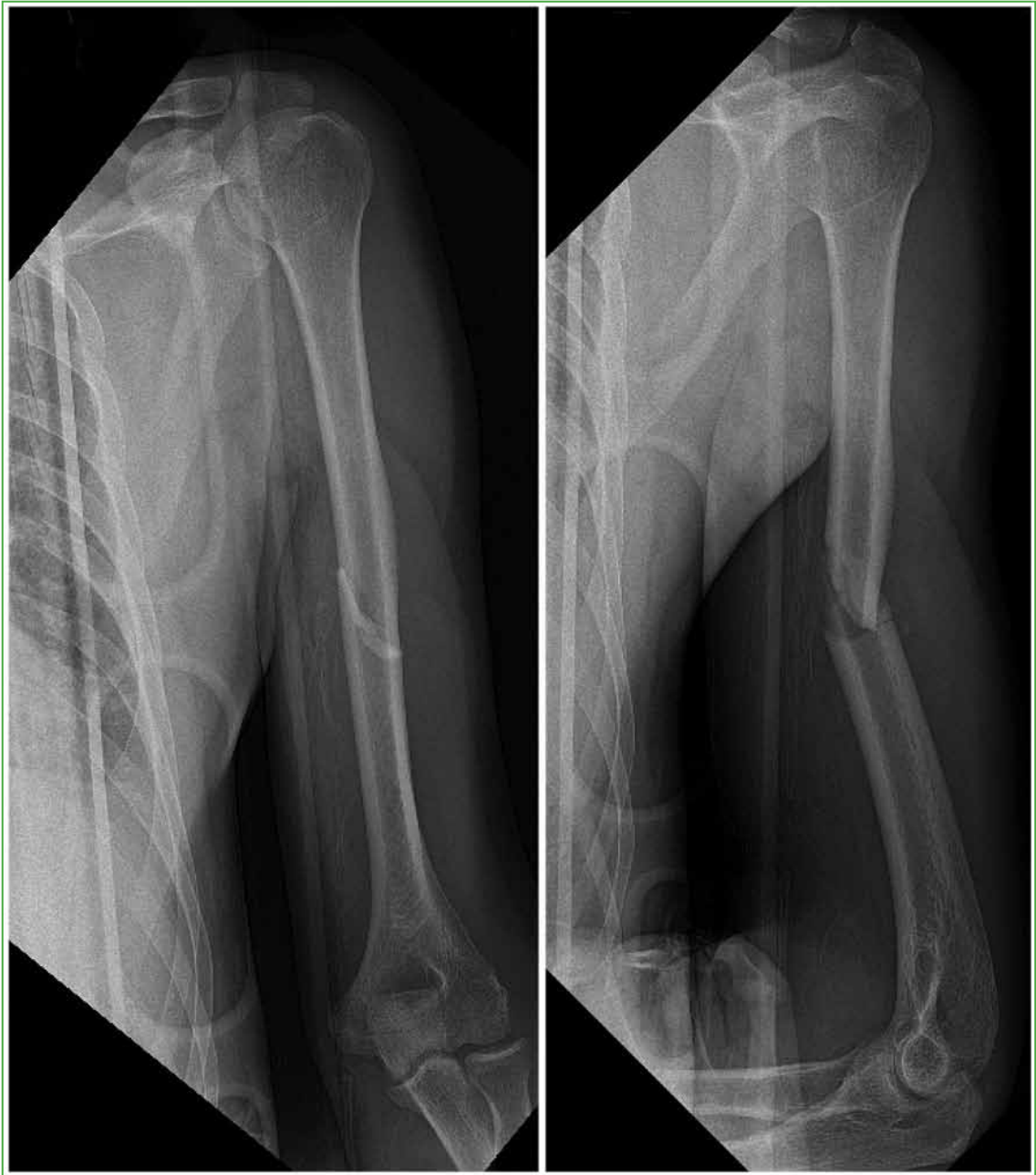
Depending on the fracture pattern, the most appropriate reduction technique was selected. In cases with a third fragment, wire cerclages or interfragmentary screws placed outside the nail were used to simplify fragment handling. In transverse fractures, compression at the fracture site was achieved by impaction through the elbow.

Proximal fixation consisted of four locking points (three screws in the humeral head and one in the neck region), while two or three distal locking screws were used depending on the case.

After completing fixation, the supraspinatus tendon, deltoid, subcutaneous tissue, and skin were closed in separate layers.

When optimal alignment could not be achieved, particularly in fractures with a third fragment or multifragmentary patterns, additional assistance was provided using positional screws placed percutaneously under fluoroscopic guidance, positioned tangentially to improve fragment alignment and contact. This technique was used in eight patients.

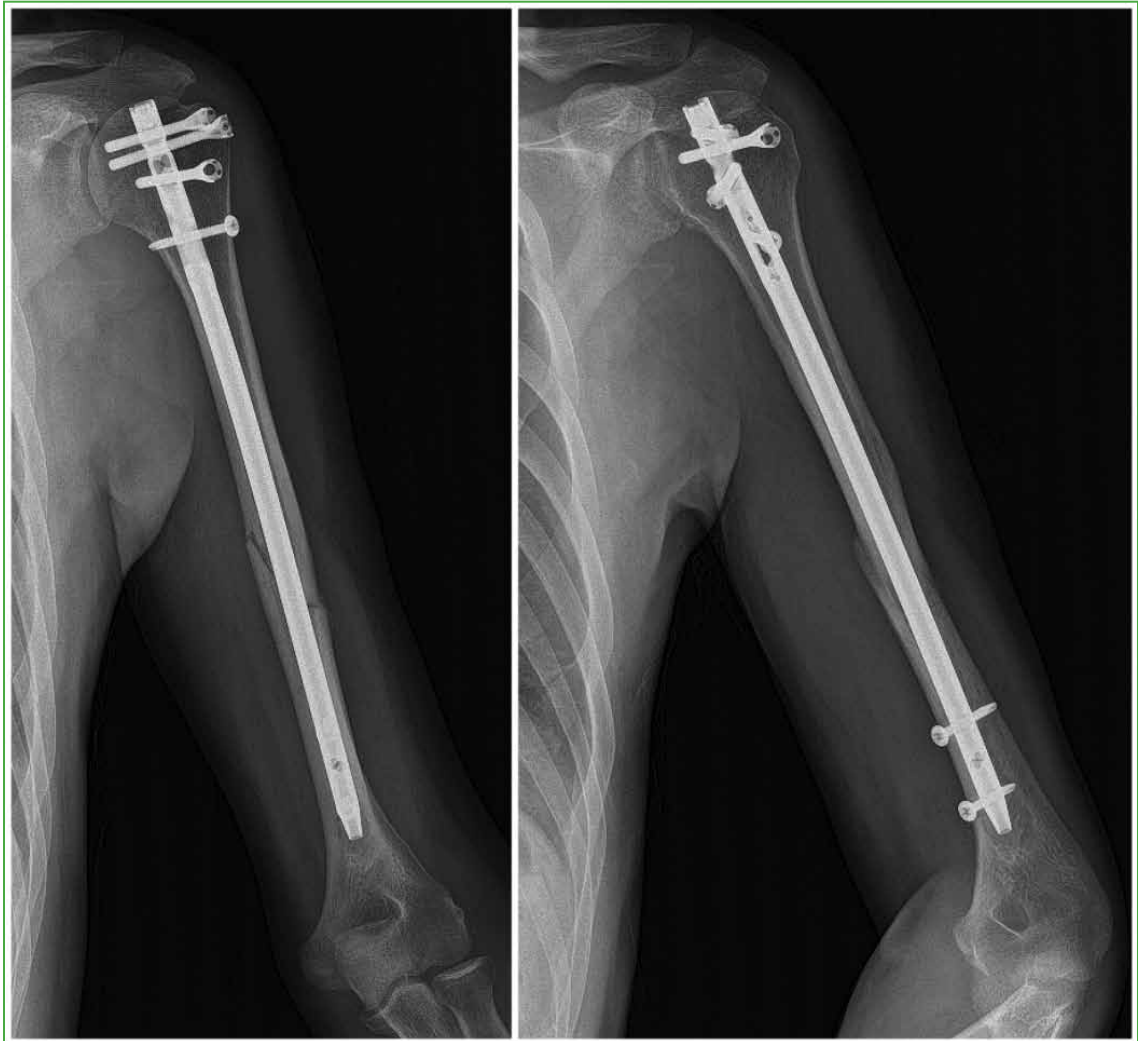
Reduction was considered satisfactory when no rotational defect was present, cortical step-off was  $<25\%$  of the diaphyseal diameter, and shortening was  $<1$  cm (in comminuted patterns).



**Figure 1.** Anteroposterior and lateral radiographs of the humerus showing a diaphyseal humeral fracture.

### Postoperative Protocol

All patients were initially immobilized with a Vietnam sling for two weeks. Wrist pronosupination and wrist/elbow flexion-extension exercises were initiated 24 hours after surgery. Assisted pendulum exercises using the contralateral limb began during the second week. Active shoulder mobility was started in the third week. Unrestricted anti-gravity activity was permitted six weeks postoperatively, and weight-bearing activities and strengthening exercises were introduced at 12 weeks. Mean clinical and radiographic follow-up was 18 months (range 12–24). Radiographs were obtained immediately postoperatively, at 15 and 45 days, and at 3, 6, 12, and 18 months (Figure 2).



**Figure 2.** Postoperative anteroposterior and lateral radiographs of the humerus.

### Variables Analyzed

The following variables were analyzed: demographic data (sex, age), affected side, fracture type according to the AO/ASIF classification and the Gustilo classification for open fractures, mechanism of injury, injured side, time from injury to surgery, operative time, length of hospital stay, postoperative follow-up, return to previous activities, radiographic union, complications, and the DASH (*Disability of the Arm, Shoulder and Hand*) questionnaire score.

The DASH questionnaire was administered 18 months after surgery and consists of 30 items, each with response options scoring up to 5 points. Total scores range from 0 (no disability) to 100 (severe disability). The weighting is distributed as follows: 50 points for function, 40 for pain, and 10 for alignment.

### Statistical Analysis

For quantitative variables, a normality test was applied. When normally distributed, mean and standard deviation were used as summary measures; otherwise, the median and interquartile range were reported.

Categorical variables are presented as frequency and percentage, with 95% confidence intervals.

Student's t-test was used for quantitative variable comparisons, with a significance level set at 0.05. Statistical analyses were performed using the Statistix 8.0 (Chicago, IL, USA) software package.

## RESULTS

Thirteen of the 77 patients with diaphyseal humerus fractures were excluded for not meeting the inclusion criteria. The final series consisted of 64 patients. A detailed description is provided in [Tables 1 and 2](#).

Forty-four patients were women and twenty were men, with a mean age of 63 years (range 21–95). Thirty-six fractures occurred in the left arm and twenty-eight in the right arm ([Table 1](#)).

Regarding the mechanism of injury, 50 fractures resulted from a fall from standing height; six from gunshot wounds; four from motor-vehicle accidents (car/motorcycle); two from a fall from a ladder; one from a fall from height (>1 m); and one from a fall from a horse.

Nine fractures were open: six due to gunshot wounds, two due to a fall from standing height, and one due to a vehicle accident. All were classified as Gustilo-Anderson type IIIA. These patients underwent debridement and placement of an AO-type tubular external fixator in the emergency department until definitive surgery. The AO/ASIF fracture types were as follows: 17 A1; 13 A2; 9 A3; 10 B1; 7 B2; 1 B3; 1 C1; 2 C2; and 4 C3 ([Table 2](#)).

**Table 1.** Description of the sample

Variables		Results	
Age, mean (SD; range)		63	(±18; 21-95)
Gender, % (n)	Female	44	(68.8)
	Male	20	(31.3)
Side, % (n)	Right	28	(43.8)
	Left	36	(56.3)
Dominant arm, % (n)		28	(43.8)
AO classification, % (n)	A (simple)	39	(60.9)
	B (wedge)	18	(28.1)
	C (multifragmentary)	7	(10.9)
Open fracture, % (n)		3	(4.7)
Trauma, n (%)	High energy	14	(21.9)
	Low energy	50	(78.1)
Associated comorbidities, % (n)		51	(79.7)

SD = standard deviation.

**Table 2.** AO Classification.

Classification	Results n (%)	
12A1	17	(26.6)
12A2	13	(20.3)
12A3	9	(14.1)
12B1	10	(15.6)
12B2	7	(10.9)
12B3	1	(1.6)
12C1	1	(1.6)
12C2	2	(3.1)
12C3	4	(6.3)

The mean time from injury to definitive fixation was 10 days (range 2–34). The mean hospital stay was 3.37 days (range 2–25).

### Radiographic Outcomes

Satisfactory reduction was observed in 48 radiographs; proximal nail protrusion in 2 cases; diaphyseal step-off in 2; diastasis at the fracture site in 1; and rotation of the distal humeral segment in 1 case. Two patients developed nonunion. The overall union rate was 97%.

### Clinical Outcomes

The mean DASH score after more than 18 months of follow-up was 41 (range 30–90) (Figure 3).



**Figure 3.** Photographs illustrating shoulder mobility 6 months after surgery.

The average time to return to pre-injury activity was 3.1 months (range 2–6).

Nine patients reported pain at the nail entry site. In seven of them, the pain resolved with rehabilitation; the remaining two had proximal nail protrusion requiring implant removal after fracture union. The overall fracture union rate was 98.7%.

### Complications

Seven complications occurred: two nonunions, both requiring reoperation to achieve healing, two superficial wound infections, successfully treated with debridement and antibiotics, two cases of proximal nail protrusion, requiring removal after consolidation, and one radial nerve neuropraxia, which recovered spontaneously without surgical intervention (Table 3).

The two nonunions were treated either by nail exchange using a larger-diameter implant plus bone graft, or by nail removal followed by plate osteosynthesis with bone grafting. Both cases ultimately achieved union.

**Table 3.** Description of treatment and evolution

Variables	Results
Days of surgical delay, median (range)	10.5 (2-34)
Days of hospitalization, median (range)	3.37 (2-25)
Surgical time (min), median (range)	120 (60-290)
Nail diameter (mm), median (range)	8.5 (7-9.5)
Nail length (mm), median (range)	240 (160-285)
Poor reduction, n (%)	6 (9.4)
Postoperative pain, n (%)	25 (39.1)
Entry-site pain, n (%)	9 (14.1)
Postoperative DASH score, median (range)	41 (30-90)
Return to previous activities (months), median (range)	3 (1-6)
Radiographic consolidation (months), median (range)	3 (2-5)
Implant removal, n (%)	2 (4.7)
Complications, n (%)	7 (7.8)

DASH = *Disability of the Arm, Shoulder, and Hand*.

## DISCUSSION

Our results support the efficacy of the MultiLoc® nail in the treatment of diaphyseal humeral fractures, demonstrating high union rates, a low incidence of complications, and good medium-term functional outcomes.

The surgical indications for humeral fractures remain a matter of debate, particularly in elderly patients. Locked plates were long considered the gold standard for treatment; however, their use in older patients has been associated with wound complications.<sup>8</sup> For this reason, new-generation intramedullary nails have become an increasingly attractive alternative.

Current evidence shows that high union rates can be achieved with both plates and nails. Plates inserted using minimally invasive techniques tend to yield lower rates of nonunion compared with open reduction and internal fixation, and overall consolidation rates are similar when comparing intramedullary nailing with plating.<sup>9</sup>

Intramedullary nails may be associated with a lower incidence of iatrogenic radial nerve injury compared with extensive open approaches that expose the nerve directly, although this advantage is not absolute and remains technique-dependent. Minimally invasive nailing has emerged as an option that reduces direct manipulation of the nerve and decreases soft-tissue morbidity, with a lower risk of nonunion and fewer soft-tissue complications compared with open plating.<sup>10</sup>

Earlier generations of humeral nails, such as the Proximal Humeral Nail (PHN, Synthes), fell out of favor for two major reasons: the limited number of proximal locking screws, which allowed pivoting of the humeral head, and the lateral entry point through the greater tuberosity, which increased the risk of tuberosity fracture and supraspinatus injury.<sup>6,7</sup>

Persistent shoulder pain following humeral nailing has been a common criticism of the technique. Its etiology is multifactorial and may be related to a prominent nail protruding above the humeral head, iatrogenic supraspinatus injury (reported as unhealed in up to 80% of cases<sup>7</sup>), subacromial impingement, shoulder stiffness, or malreduction of the humeral head.<sup>8-10</sup>

Dilisio et al.<sup>11</sup> evaluated rotator cuff injury rates associated with humeral nails and concluded that straight-design nails with a medial entry point reduce the risk of cuff damage. In our series, only 2 patients (3.12%) reported

pain at the entry site due to nail protrusion. We believe these findings are consistent with those of Dilisio et al., as the straight design of the nail allows entry through the muscular—not tendinous—portion of the supraspinatus, thereby avoiding Codman's avascular zone. Moreover, our surgical technique involves a clean approach through the muscle belly, and during entry, the reamers are used in reverse and at low speed until reaching the humeral cortex, further minimizing iatrogenic injury.

Lopez et al.<sup>7</sup> compared the use of a straight nail and an anatomical nail for humeral fractures. They reported a reoperation rate of 42% with anatomical nails and 11.5% with straight nails. In our study, the reoperation rate was 6.24% (2 due to protrusion and 2 due to pseudoarthrosis), which supports the lower reoperation rate described by the authors with the use of straight nails.

Nolan et al.,<sup>12</sup> using the Polarus nail, reported a 94% consolidation rate but also a 50% rate of defective healing due to loss of reduction. These authors concluded that the nail's more lateral entry point makes it unable to resist the deforming forces of the humerus, which may lead to loss of reduction and varus collapse. In addition, this entry point traverses the rotator cuff in a hypovascular zone, resulting in chronic pain and loss of mobility. In our series, we used a straight nail and positioned the patient supine with interscapular support to prevent the acromion from interfering with nail insertion.

The rate of rotator cuff healing failure after humeral nailing can reach 80%.<sup>7</sup>

In our experience, the use of this type of nail offers several advantages over other implants, including the possibility of performing minimally invasive surgery, shorter operative time, minimal bleeding, adequate stability at the fracture site, and the potential for early mobilization. Disadvantages include cost, the learning curve, and potential complications inherent to the method (infection, delayed union, pseudoarthrosis, radial nerve injury).

This study has certain limitations, such as its retrospective design, population variability, and the absence of a control group treated with a different method. Strengths include the sample size (to our knowledge, the largest reported in Argentina) and the use of a widely accepted evaluation scale.

We agree with Belangero et al.<sup>2</sup> that appropriate patient selection and precise surgical technique are fundamental for achieving good outcomes, regardless of the osteosynthesis method employed.

## CONCLUSIONS

The use of intramedullary nails for diaphyseal humeral fractures is a safe and reliable method. Our results show that straight nails with angular stability provide excellent medium-term clinical and radiographic outcomes. The low incidence of pain at the entry site and of rotator cuff injury does not appear to represent a limitation to their use.

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# Ultrasound Assessment and Clinical Correlation of the Pronator Quadratus Muscle After Its Repair in the Treatment of Distal Radius Fractures

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## ABSTRACT

**Introduction:** Repair of the pronator quadratus in distal radius fractures treated with volar plates is controversial, particularly given its proposed protective role against implant-related complications. **Objective:** To assess, through ultrasound, the impact of pronator quadratus reinsertion in patients with distal radius fractures treated with volar plates. **Materials and Methods:** Forty-two patients were analyzed: 28 with pronator quadratus reinsertion (Group I) and 14 without reinsertion (Group II). Evaluations included friction between the flexor tendons and the plate, quality of the interposing tissue, changes in the flexor tendons, and clinical signs of friction. **Results:** The distance between the plate and the tendons was <2 mm in 42.9% of cases. In Group I, 45% exhibited tendon friction, 10% had fibrosis of the separating tissue, 80% had mild tendon attrition, and 20% severe attrition. In Group II, 71% exhibited friction, 36.4% had tissue fibrosis, 45.5% had mild attrition, and 54.5% severe attrition. The quality of the separating tissue was superior in Group I, with better preservation of contractile muscle and less fibrosis, findings associated with lower functional impairment and reduced tendon friction. Ultrasound abnormalities did not always correlate with clinical symptoms. **Conclusions:** Repair of the pronator quadratus improves the quality of the separating tissue between the flexor tendons and the volar plate, favoring preservation of contractile muscle. Although no differences were observed in tendon friction or rupture rates, the findings suggest a protective effect.

**Keywords:** Distal radius fracture; pronator quadratus repair; volar plate; open reduction and internal fixation; tendon friction; tendon rupture.

**Level of Evidence:** III

## Evaluación ecográfica y correlación clínica del músculo pronador cuadrado luego de su reparación en el tratamiento de fracturas de radio distal

## RESUMEN

**Introducción:** La reparación del pronador cuadrado en fracturas de radio distal tratadas con placas volares es controvertida por su supuesto efecto protector frente a complicaciones del implante. **Objetivo:** Evaluar ecográficamente el impacto de la reinsertión del pronador cuadrado en pacientes con fractura de radio distal tratados con placas volares. **Materiales y Métodos:** Se analizó a 42 pacientes: 28 con reinsertión (grupo I) y 14 sin reinsertión (grupo II). Se evaluaron la fricción entre los tendones flexores y la placa, la calidad del tejido separador, los cambios en los tendones flexores y los signos clínicos de fricción. **Resultados:** La distancia entre la placa y los tendones fue <2 mm en el 42,9%. En el grupo I, el 45% tenía fricción tendinosa; el 10%, fibrosis del tejido separador; el 80%, atrición leve de los tendones y el 20%, severa. El 71% del grupo II tenía fricción; el 36,4%, fibrosis del tejido separador; el 45,5%, atrición leve y el 54,5%, severa. La calidad del tejido separador fue superior en el grupo I, con mejor preservación del tejido contráctil y menor fibrosis, asociado a menor deterioro funcional y fricción tendinosa. No siempre se correlacionaron las alteraciones ecográficas con la fricción clínica. **Conclusiones:** La reparación del pronador cuadrado mejora la calidad del tejido separador entre tendones y la placa, con predominio de músculo contráctil. Aunque no hubo diferencias en la fricción o rotura tendinosa, los resultados sugieren un efecto protector.

**Palabras clave:** Fractura de radio distal; reparación de pronador cuadrado; placa volar; reducción abierta con fijación interna; fricción tendinosa; rotura tendinosa.

**Nivel de Evidencia:** III

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## INTRODUCTION

Distal radius fractures are the most common fractures of the upper limb and account for 18% of all fractures in adults older than 65 years.<sup>1,2</sup> Open reduction and internal fixation with a volar locking plate has become the preferred surgical treatment, as it provides better functional outcomes and lower complication rates compared with techniques such as external fixation or percutaneous fixation.<sup>3,4</sup> However, the traditional surgical approach requires detaching the pronator quadratus muscle from its radial insertion to optimize fracture exposure and facilitate plate placement.<sup>5,6</sup>

Complications associated with volar plates include neurovascular injury, infection, complex regional pain syndrome, fracture, and soft-tissue problems such as flexor tendon irritation or rupture.<sup>7,8</sup> Between 0.3% and 5.6% of patients develop tendon rupture, with an incidence of approximately 1.5% in some studies. The flexor pollicis longus tendon is most commonly affected, followed by the flexor digitorum profundus.<sup>9-11</sup> These injuries are associated with factors such as improper plate positioning, screw prominence, implant design, and loss of fracture reduction.<sup>12</sup>

Currently, there is controversy regarding the relevance of repairing the pronator quadratus muscle with respect to functional outcomes and complication rates. Although some authors suggest that pronator quadratus repair provides a protective layer between the flexor tendons and the plate, no comparative study to date has demonstrated a reduction in tendon rupture rates after repair.<sup>4,13-15</sup> Nevertheless, in a pilot study, Swigart et al. reported that up to 83% of North American hand surgeons routinely repair the pronator quadratus.<sup>16</sup>

Ultrasound studies have shown greater retraction and reduced length of the pronator quadratus muscle, along with a shorter distance between the flexor tendons and the plate, when the muscle is not repaired. These findings may reflect areas of tendon-implant conflict, supporting the need for further research to assess a potential protective effect.<sup>17,18</sup>

We hypothesized that patients undergoing open reduction and internal fixation with reinsertion of the pronator quadratus muscle would demonstrate significant ultrasound differences in flexor tendon quality and in the muscle tissue superficial to the plate compared with patients in whom the pronator quadratus was not reinserted.

The aim of this study was to evaluate ultrasound findings in patients treated at our center with open reduction and internal fixation for distal radius fractures, with specific emphasis on closure of the pronator quadratus muscle. A secondary objective was to compare these findings with those of a control group in which the pronator quadratus muscle was not repaired.

## MATERIALS AND METHODS

This retrospective study began with a thorough review of the medical records in our hospital's database. Forty-two patients with extra-articular distal radius fractures classified as AO 23-A2 underwent open reduction and internal fixation using the same type of implant (volar plate) between March 2020 and March 2022.

All procedures were performed by the same surgical team at our center. Patients with a history of radiocarpal joint injections, neurological disorders, previous wrist infections, or <2 years of follow-up were excluded. The study design included two groups:

Group I: patients with extra-articular distal radius fractures treated with osteosynthesis using a volar distal radius plate, with reinsertion of the pronator quadratus using interrupted Vicryl® 3.0 sutures to ensure complete coverage of the volar plate.

Group II: patients with extra-articular distal radius fractures treated with osteosynthesis using a volar distal radius plate, without reinsertion of the pronator quadratus.

The decision to repair the pronator quadratus muscle was made intraoperatively based on muscle viability, structural integrity, and the feasibility of achieving a tension-free anatomical repair. If the muscle was torn, had tissue loss, or showed clear degenerative changes, repair was not performed.

Both groups followed a strict immobilization protocol with a forearm-palmar plaster splint for the first 2 weeks. After this period, and provided wound conditions allowed, sutures were removed. Patients were then protected for an additional 2 weeks using an intermittent rigid wrist immobilizer, which could be removed for rehabilitation

and personal hygiene. During this phase, patients were encouraged to perform active flexion-extension exercises of the fingers and metacarpophalangeal joints, as well as pinch-type grasping with all digits.

All patients completed an 8-week rehabilitation protocol supervised by upper-limb specialists. This included assisted passive wrist range of motion exercises during the first week, followed by active range of motion without resistance or weight bearing. All fractures were treated with the same implant: an anatomical titanium plate with a fixed-angle locking system (Pro-Anatomic®, South America Implants S.A., Canning, Buenos Aires, Argentina). Anatomical reduction was confirmed both in the immediate postoperative period and during late follow-up.

### Analysis of Imaging Studies

Radiological evaluation included anteroposterior and lateral wrist projections obtained both in the immediate postoperative period and at 12-month follow-up. In all cases, acceptable fracture reduction was confirmed, defined as volar tilt 0°–11°, radial inclination >20°, and ulnar variance between –2 and +2 mm.<sup>19–22</sup> To assess volar implant prominence and its potential implications for flexor tendon friction, Soong's classification was applied in all postoperative radiographic assessments.

A Toshiba Xario 200 ultrasound system (18-MHz linear transducer) was used to evaluate the interaction between the flexor tendons and the implant. To ensure objectivity, initial ultrasound assessments were performed on the volar aspect of the wrist with the hand in anatomical position. Dynamic examinations were then conducted, asking patients to actively flex and extend their fingers to identify any areas of tendon conflict. All ultrasound studies were performed by a diagnostic imaging specialist who was not part of the surgical team and was blinded to whether pronator quadratus repair had been performed.

A standardized imaging protocol was applied to all patients, including the following parameters (Table 1):

**Table 1.** Diagnostic imaging protocol.

Ultrasound Operated side	Flexor friction	Yes		No	
	Quality of tissue separating plate from flexors	Contractile muscle		Fibrosis	
	Minimum plate–flexor distance (mm)	0	0–2	2–4	4 or more
	Flexor tendon quality	Normal		Mild Attrition	Severe Attrition
Ultrasound Non-operated side	Flexor friction	Yes		No	
	Quality of tissue separating radius from flexors	Contractile muscle		Fibrosis	
	Minimum radius–flexor distance (mm)	0	0–2	2–4	4 or more
	Flexor tendon quality	Normal		Mild Attrition	Severe Attrition

- Flexor friction: Yes / No
- Quality of the tissue interposed between the plate and the flexors: contractile muscle vs. fibrosis
- Minimum plate–flexor distance (mm): 0, 0–2, 2–4, or >4
- Flexor tendon quality: normal, mild degeneration, or severe degeneration. Mild degeneration was defined as the presence of atrophic tendon changes, quantified by measuring tendon thickness at the volar lip of the distal radius. Severe degeneration was defined as attritional changes associated with tendon thinning, fibrillation, focal intratendinous alterations, or tendon rupture.<sup>23</sup>

Ultrasound evaluation was performed in all patients in both groups, and findings were subsequently compared.

At completion of the rehabilitation protocol, functional outcomes were assessed using the *Disabilities of the Arm, Shoulder and Hand* (DASH) questionnaire. Scores for all patients were recorded as part of postoperative clinical follow-up.

### Statistical Analysis

A descriptive and comparative study was conducted. The distribution of quantitative variables was assessed using the Shapiro–Wilk test. When variables showed normal distribution and homogeneity of variances (evaluated using Levene’s test), they were expressed as mean  $\pm$  standard deviation and compared using Student’s *t* test for independent samples. When these assumptions were not met, variables were expressed as median and interquartile range and compared using the Mann-Whitney *U* test. For each variable, the measurement method used is specified.

Qualitative variables are expressed as absolute and relative frequencies (%). Given the small sample size, Fisher’s exact test was used for all between-group comparisons. A *p* value  $<0.05$  was considered statistically significant. Statistical analyses were performed using IBM SPSS Statistics®, version 26.0.

### Surgical Technique

All patients were operated on at our center by the same surgical team, under regional anesthesia and in the supine position, with the arm supported on a radiolucent table to facilitate intraoperative fluoroscopic assistance.

Using the modified Henry approach, the fracture site was exposed and the pronator quadratus muscle was carefully elevated in an “L”-shaped fashion.<sup>24,25</sup> After identifying the fracture, reduction was achieved (directly or indirectly) and temporarily stabilized using Kirschner wires under fluoroscopic control. In all cases, an anatomical titanium volar plate with a fixed-angle locking system (Pro-Anatomic®) was used, corresponding to the implant available at our institution during the study period. Although this type of plate does not allow for screw redirection, which may influence its placement relative to the watershed line, its design allowed adequate reduction of the fracture in all cases.

Based on treatment of the pronator quadratus, patients were divided into two groups: Group I: repair of the pronator quadratus muscle using interrupted Vicryl® 3-0 sutures, ensuring full coverage of the plate after fracture stabilization. Group II: no repair of the pronator quadratus muscle.

It is important to note that in some cases the pronator quadratus exhibited pre-existing injuries, such as partial tears or discontinuity, likely related to the initial trauma. Additionally, in older patients, signs of muscular degeneration with fatty infiltration were observed, which made repair difficult or unfeasible.

## RESULTS

Forty-two patients were analyzed [mean age, 52.9 years ( $\pm 19.4$ )]. Most were women (66.7%), and involvement was slightly more frequent in the right upper limb (52.4%). The most relevant finding was the significant difference in the quality of the tissue interposed between the radius and the flexor tendons (Table 2).

**Table 2.** Summary of patients included in the series.

Variables	(n = 42)
Age (n, SD)	52.9 ± 19.4
Sex (n, %)	
Male	14 (33.3)
Female	28 (66.7)
Side (n, %)	
Left	20 (47.6)
Right	22 (52.4)
Flexor friction (n, %)	
Yes	24 (57.1)
No	18 (42.9)
Quality of separating tissue (n, %)	
Contractile muscle	32 (76.2)
Fibrosis	10 (23.8)
Flexor tendon quality (n, %)	
Mild attrition	26 (61.9)
Severe attrition	16 (38.1)
Plate-tendon distance (n, %)	
0 mm	2 (4.7)
0-2 mm	18 (42.9)
2-4 mm	(38.1)
>4 mm	6 (14.3)
Pronator quadratus treatment (n, %)	
Reinsertion	28 (66.7)
No reinsertion	14 (33.3)

All patients in Group I (with repair) and only 29% of Group II had viable contractile tissue; the remaining 71% corresponded to fibrotic tissue ( $p < 0.001$ ). Clinical flexor tendon friction was present in 45% of Group I and 71% of Group II, a difference that reached statistical significance ( $p = 0.042$ ). In Group I, 77.5% showed no ultrasound abnormalities and only 22.5% showed mild friction. In Group II, mild friction was observed in 43% of patients, whereas 57% had no abnormalities. In no case were ultrasound abnormalities detected without a corresponding clinical manifestation. With respect to contact between the flexor tendons and the plate, 71% of Group II had direct contact, whereas 29% had interposed muscle tissue. No direct correlation was identified between clinical friction and the presence of tissue interposition. Overall, Group I demonstrated greater preservation of contractile tissue and a lower prevalence of fibrosis compared with Group II, in which fibrotic tissue predominated and a higher incidence of clinical friction was observed (Table 3).

**Table 3.** Comparative analysis between patients with and without pronator quadratus reinsertion

Variables	With repair (n = 28)	Without repair (n = 14)	p
Clinical flexor friction n (%)			
Yes	12 (45.0)	10 (71.0)	0.156
No	16 (55.0)	4 (29.0)	0.112
Ultrasound flexor friction (n, %)			
Yes	7 (25.0)	6 (43.0)	0.34
No	21 (77.5)	8 (57.0)	0.270
Quality of separating tissue (n, %)			
Contractile muscle	28 (100)	4 (29.0)	<b>0.011</b>
Fibrosis	0 (0)	10 (71)	<b>5.28 × 10<sup>-6</sup></b>
Flexor tendon quality (n, %)			
Mild attrition	6 (22.5)	6 (43.0)	0.20
Severe attrition	8 (28.6)	8 (57.1)	
Plate-tendon distance n (%)			
0 mm	0 (0)	1 (14.3)	0.36
0-2 mm	6 (42.9)	3 (42.9)	
2-4 mm	5 (35.7)	3 (42.9)	
>4 mm	3 (21.4)	0 (0)	

Although the plates used featured a fixed-angle locking system, which limits screw redirection, postoperative assessments showed that most implants were positioned proximal to the watershed line. Only four cases were classified as Soong 1 (three in Group I and one in Group II), and no cases were classified as Soong 2.

At clinical follow-up, the mean DASH score was 14.2 (SD ± 5.8), corresponding to a mild level of disability and consistent with a favorable clinical outcome. No significant differences were found between groups ( $p = 0.187$ ). Most patients resumed their usual activities without major restrictions, and no reoperations were required.

## DISCUSSION

In this study, we compared imaging findings in patients with distal radius fractures treated with open reduction and internal fixation, differentiating between those in whom the pronator quadratus was repaired and those in whom it was not. The main difference between the two cohorts was the quality of the tissue interposed between the radius and the flexor tendons, specifically regarding coverage of the volar plate. In the repair group, viable contractile tissue was significantly more frequent, a difference that reached statistical significance compared with the non-repair group. No significant differences were found in flexor tendon friction, structural tendon quality, or minimum plate-tendon distance.

The literature regarding pronator quadratus repair after volar plate fixation remains controversial. Some studies suggest potential benefits, whereas others do not support routine repair. In a recent meta-analysis by Shi and Ren, the authors concluded that pronator quadratus repair does not improve postoperative functional scores, grip strength, pronation strength, or range of motion following volar plate fixation for distal radius fractures.<sup>14</sup>

Among complications associated with volar distal radius plates, injury of the flexor pollicis longus tendon is one of the most significant. However, in a systematic review by Azzi et al., including a large patient cohort, the incidence of this complication was reported to be below 1%. Moreover, studies such as that by Brown et al. indicate that tendon ruptures can occur even when the pronator quadratus is repaired, despite the theorized protective effect against tendon-implant friction.<sup>26</sup>

Although the limited sample size of our study did not allow us to confirm a protective effect of pronator quadratus repair, it is worth noting that no tendon injuries were observed in any patient. Larger studies will be required to determine whether the contractile tissue identified overlying the plate after pronator quadratus repair contributes to a protective effect by reducing flexor tendon contact with the implant and lowering rupture rates.

This study has several limitations, including the small number of cases, limited follow-up, and the potential for information bias due to reliance on the accuracy of medical records. Nonetheless, it also has meaningful strengths: the inclusion of a control group allowed for more robust comparisons, and the use of a blinded sonographer, unaware of whether the pronator quadratus had been repaired, significantly reduced assessment bias.

## CONCLUSIONS

In the postoperative ultrasound assessment, significant differences were observed between the groups. In Group I, the tissue interposed between the flexor tendons and the plate was of higher quality, with more viable contractile muscle and less fibrosis compared with Group II, a difference that reached statistical significance. Clinical flexor tendon friction was also lower in the repair group, supporting the potential protective role of the pronator quadratus.

Although no differences were identified in tendon rupture or functional outcomes (DASH scores), the preservation of viable contractile tissue may contribute to reducing tendon friction. However, this hypothesis could not be definitively confirmed due to the small sample size and limited follow-up period.

Future studies with larger cohorts, multivariate analyses, and eventually randomized controlled trials will be required to more accurately determine the clinical impact of pronator quadratus reinsertion on preventing implant-related complications and on functional wrist outcomes.

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# Evaluation of the Schatzker-Kfuri Classification of Tibial Plateau Fractures Using Radiographs and Computed Tomography: Comparison Between an Expert Observer and the ChatGPT-4o Model

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## ABSTRACT

**Introduction:** Artificial intelligence was formally introduced in 1956, and since then, platforms trained on large datasets have been developed to generate increasingly accurate outputs. The Kfuri-Schatzker classification of tibial plateau fractures enables more precise analysis, particularly when CT imaging is integrated. This study compared the diagnostic accuracy of the ChatGPT-4o model with that of expert evaluators. **Materials and Methods:** A retrospective observational study was conducted to compare the interpretations of an expert observer with those generated by ChatGPT-4o. A dataset of 45 expert-published case reports including radiographs and CT scans from databases such as PubMed, Elsevier, and SciELO was used to refine the prompt guiding ChatGPT-4o's analysis. Six additional case reports of tibial plateau fractures, none previously provided to the model, were selected for evaluation. ChatGPT-4o analyzed each case and proposed a classification according to the Schatzker-Kfuri system. Its responses were compared with the expert diagnoses reported in the literature. **Results:** ChatGPT-4o correctly classified all the cases analyzed. In bicondylar fractures, the model accurately identified components of subsidence, shear (split) pattern, and epiphyseal-diaphyseal dissociation. Cohen's kappa coefficient was 1.00, indicating perfect agreement.

**Conclusion:** The ChatGPT-4o model demonstrated high diagnostic accuracy in classifying tibial plateau fractures using the Schatzker-Kfuri system, achieving agreement comparable to that of an expert evaluator.

**Keywords:** Artificial intelligence; tibial plateau; Schatzker-Kfuri classification.

**Level of Evidence:** III

## Evaluación de la clasificación de las fracturas de platillo tibial según Schatzker-Kfuri utilizando radiografías y tomografía. Comparación entre el observador experto y el modelo ChatGPT-4o

## RESUMEN

**Introducción:** La inteligencia artificial fue presentada formalmente en 1956, luego, se crearon plataformas con un conjunto de información para obtener el resultado apropiado. La clasificación de fracturas de platillo tibial de Kfuri y Schatzker permite hacer un análisis más preciso, especialmente al integrar cortes tomográficos. En este estudio, se comparó la capacidad diagnóstica del modelo ChatGPT-4o con la evaluación del panel de expertos. **Materiales y Métodos:** Estudio retrospectivo, observacional para comparar la interpretación del observador experto y la del ChatGPT-4o. Se recopilaron 45 reportes de caso publicados por expertos con radiografías y tomografías, en distintas bases de datos, como PubMed, Elsevier, SciELO, que se usaron para mejorar el análisis del ChatGPT-4o. Se seleccionaron 6 reportes de caso de fractura de platillo tibial, que no se habían cargado previamente en la plataforma para analizar la interpretación del ChatGPT-4o en base al Prompt creado antes. El modelo ChatGPT-4o analizó cada uno de los casos y propuso una clasificación basada en el sistema de Schatzker-Kfuri. Las respuestas fueron contrastadas con la información obtenida de reportes de casos. **Resultados:** El ChatGPT-4o clasificó correctamente los casos analizados. Los componentes de hundimiento, trazo de cizallamiento (*split*) y disociación epifisodiafisaria fueron identificados, con precisión, en

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los casos bicondilares. Asimismo, se utilizaron medidas de concordancia kappa de Cohen: 1.00, lo cual se interpreta como concordancia perfecta. **Conclusión:** El ChatGPT-4o tuvo una alta capacidad diagnóstica en la clasificación de fracturas de platillo tibial según Schatzker-Kfuri, equiparable a la de un experto.

**Palabras clave:** Inteligencia artificial; platillo tibial; clasificación de Schatzker-Kfuri.

**Nivel de Evidencia:** III I

## INTRODUCTION

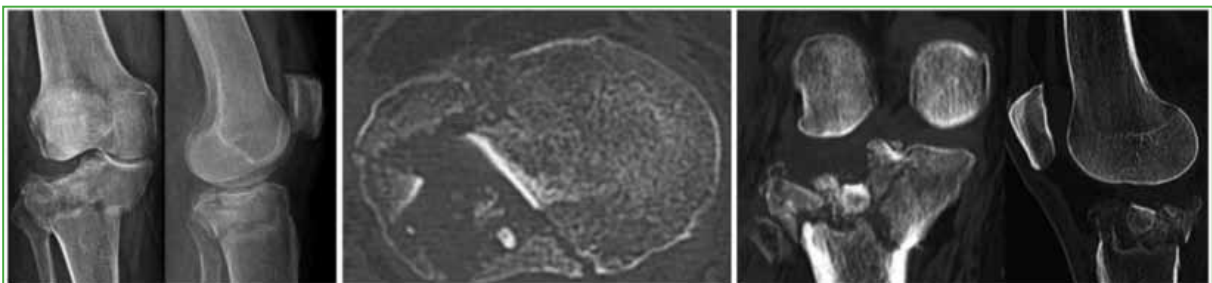
Artificial intelligence (AI) was formally introduced in 1956.<sup>1</sup> Over the years, increasingly sophisticated computer programs have been developed for use in various fields, including orthopedics and traumatology. However, current platforms require an appropriate prompt or set of information to produce accurate outputs.<sup>2</sup>

In traumatology and orthopedics, tibial plateau fractures represent a significant diagnostic and therapeutic challenge. The Schatzker classification, created in 1979 and widely used in orthopedic practice, categorizes fractures of the tibial plateau. More recently, a three-dimensional evaluation model based on computed tomography (CT) was developed to better define the anatomical involvement of plateau quadrants, giving rise to the Schatzker-Kfuri classification in 2018.<sup>3</sup> This system allows differentiation between unicondylar, bicondylar, and epiphyseal-diaphyseal dissociation fractures and has improved surgical planning.

The objective of this study was to compare the ability of the multimodal language model ChatGPT-4o to classify tibial plateau fractures using both radiographs and CT images with that of expert case reports published in the literature.

## MATERIALS AND METHODS

A retrospective, observational study was conducted to compare the interpretation of an expert observer with that of ChatGPT-4o. To create the prompt, 45 case reports published in databases such as PubMed, Elsevier, and SciELO were included. These reports contained anteroposterior and lateral knee radiographs and axial, coronal, and sagittal CT scans of the knee. Case reports with incomplete CT series or without complete radiographs were excluded. Thus, the 45 expert-validated case reports with radiographs and CT scans were used to improve the accuracy of ChatGPT-4o's interpretive performance. Prior to uploading, the images were organized in the following order: anteroposterior knee radiograph, lateral radiograph, and axial, coronal, and sagittal CT slices of the tibial plateau (Figure).



**Figure.** Sequence of radiographic and CT images used for interpretation by the platform.

Additional content was incorporated into the prompt, including anatomical descriptions, basic traumatology concepts, examples of split or shear fractures, depression patterns, combined fracture mechanisms, and fractures with epiphyseal- diaphyseal extension.

Descriptive information and corresponding illustrations were progressively uploaded until the AI model prompt was complete. Subsequently, 45 case reports in DICOM format were uploaded to further refine the model's interpretive capability. Finally, six expert case reports not previously included were used for the evaluation phase. Each of the six reports represented a different fracture pattern included in the classification system.

ChatGPT-4o sequentially analyzed each image set and proposed a classification based on the Schatzker-Kfuri system. The proposed classification was recorded and compared with the reference classification documented in the original case reports. A classification was considered correct when it matched the expert-reported classification exactly.

## RESULTS

All six cases were correctly classified by the model. The following fracture patterns were accurately identified:

Pure depression (type III)

Lateral split/shear (type I)

Bicondylar fracture without dissociation (type V)

Epiphysiodiaphyseal dissociation (type VI)

Medial column involvement (type IV)

Depression with lateral split (type II)

A summary of the comparison is shown in the [Table](#).

The analysis of the six expert-described case reports compared with the ChatGPT-4o interpretation demonstrated complete agreement based on both radiographic and three-dimensional assessment. Importantly, the study yielded a Cohen's kappa coefficient of 1.00, which is interpreted as perfect agreement.

**Table.** Results of expert case reports compared with the Schatzker-Kfuri classification generated by ChatGPT-4o.

Case	Schatzker classification	Schatzker-Kfuri classification	ChatGPT-4o classification	Affected quadrants	Concordance
1	IV	IV - PM	Schatzker IV	PM	Correct
2	II	II - AL	Schatzker II	AL	Correct
3	V	V - AL + PM	Schatzker V	AL + PM	Correct
4	I	I - AL (pure <i>split</i> )	Schatzker I	AL (pure <i>split</i> )	Correct
5	VI	VI - AL + PM + (epiphyseal-diaphyseal dissociation)	Schatzker VI	AL + PM + epiphyseal-diaphyseal dissociation	Correct
6	III	III - AL (pure depression)	Schatzker III	AL (pure depression)	Correct

AL = anterolateral; PM = posteromedial.

## DISCUSSION

The results of this study are consistent with recent publications demonstrating the growing potential of artificial intelligence in the diagnosis of articular fractures. In particular, studies by Mohammadi et al.<sup>4</sup> and Van der Gaast et al.<sup>5</sup> have shown that models such as ChatGPT-4o can achieve accuracy levels comparable to those of specialist radiologists in interpreting radiographs. Similar findings have been reported in resource-limited settings, where the addition of three-dimensional CT reconstruction significantly improved diagnostic interpretation, as described by Markhardt et al.<sup>6</sup> Furthermore, recent reviews on AI in orthopedic surgery emphasize the need for comparative studies against expert clinicians to establish the validity of AI-based image interpretation. Gyftopoulos et al.,<sup>7</sup> and Kuo et al.<sup>8</sup> evaluated the predictive performance of deep-learning models for classifying tibial plateau fractures

and demonstrated promising applicability in real clinical scenarios. Additional contributions from Giordano et al.,<sup>9</sup> Singh Sidhu et al.,<sup>10</sup> Cai et al.,<sup>11</sup> Liu et al.,<sup>12</sup> Martinez and Cayon,<sup>13</sup> and De Cicco et al.<sup>14</sup> offer complementary evidence regarding surgical approaches, associated fracture patterns, and functional prognosis that could eventually be incorporated into automated models for classification and therapeutic planning.

Kuo et al.<sup>8</sup> also reported that AI performance exhibits a sensitivity and specificity approximately 3% lower than that of physicians, although the differences were not statistically significant. Likewise, Alenazi et al.<sup>15</sup> highlight that AI can be a valuable adjunct to clinical judgment, particularly in environments with limited specialist availability.

The Schatzker–Kfuri classification represents a greater interpretative challenge than traditional radiographic systems, as it incorporates tomographic and three-dimensional information. Despite this, the model in our study was able to identify fracture patterns in each quadrant with high precision and to correctly recognize the presence or absence of metaphyseal-diaphyseal dissociation.

Overall, our findings demonstrate that, when provided with appropriate visual guidance and a structured analytical approach, multimodal language models can serve as useful adjuncts in orthopedic education and diagnostic support in traumatology.

## CONCLUSIONS

The ChatGPT-4o model correctly classified all six cases of tibial plateau fractures according to the three-dimensional Schatzker-Kfuri classification, achieving complete agreement with an expert observer. This paves the way for the use of AI as a tool for clinical decision support, particularly in training or diagnostic validation settings.

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# Irreducible Knee Dislocation Associated with Interposition of Medial Structures: A Case Report

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## ABSTRACT

We report the case of a patient with an irreducible knee dislocation, multiligamentous injuries, and patellar dislocation following a fall into a ravine. The clinical examination revealed a positive dimple sign. Multiple attempts at closed reduction were unsuccessful, requiring an open reduction to expose and release the interposed structures, including the medial capsule, the patellofemoral ligament, and the vastus medialis oblique. A knee immobilizer was applied, and definitive surgery was deferred until soft-tissue conditions improved, at which time a staged multiligament reconstruction was performed, addressing the anterior and posterior cruciate ligaments and the posteromedial corner, with a favorable outcome. **Conclusion:** Closed reduction should be attempted initially; however, if the medial structures remain entrapped, urgent open reduction is required. Ligament reconstruction is indicated when multiple ligaments are compromised, and the approach to anterior cruciate ligament reconstruction should be individualized based on the patient's age, physiological status, and physical activity level. A thorough neurological and vascular evaluation is essential due to the risk of serious complications. This case is reported to highlight this uncommon presentation and the importance of open reduction to achieve proper alignment.

**Keywords:** Knee dislocation; dimple sign; vastus medialis.

**Level of Evidence:** IV

## Luxación irreductible de rodilla asociada a interposición de estructuras mediales: reporte de un caso

## RESUMEN

Se presenta a un paciente con luxación irreductible de rodilla, lesiones de múltiples ligamentos y luxación de rótula tras caer por un abismo. Tiene el signo del hoyuelo. Se intentaron varios métodos de reducción cerrada sin éxito, lo que requirió una reducción abierta para exponer y liberar las estructuras interpuestas, inclusive la cápsula medial, el ligamento rotulofemoral y el vasto medial oblicuo. Se colocó un inmovilizador de rodilla y se esperó hasta que los tejidos blandos mejoraran para realizar una reconstrucción de múltiples ligamentos en un segundo tiempo, abordando los ligamentos cruzados anterior y posterior, y la esquina posteromedial; el resultado fue favorable. **Conclusiones:** Se recomienda, en primera instancia, la reducción cerrada, pero si las estructuras mediales de la rodilla no se liberan, es necesaria la reducción abierta de emergencia. La reconstrucción ligamentaria se indica cuando hay compromiso de múltiples ligamentos, y la elección del abordaje del ligamento cruzado debe individualizarse considerando la edad, el estado fisiológico y las actividades físicas del paciente. Además, es crucial realizar una evaluación neurológica y vascular exhaustiva ante el riesgo de complicaciones graves. Se comunica este caso para destacar este cuadro inusual y la importancia de una reducción abierta para lograr una reducción adecuada.

**Palabras clave:** Luxación de rodilla; signo del hoyuelo; vasto medial.

**Nivel de Evidencia:** IV

## INTRODUCTION

Knee dislocations are injuries that may occur as a result of either high- or low-energy trauma. They are characterized by a high rate of neurovascular involvement and by the loss of contact between the articular surfaces of the knee, which leads to multidirectional instability and is associated with multiple ligament injuries.<sup>1</sup>

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Several classifications for knee dislocations have been described. The first is based on the direction of tibial displacement relative to the femur. Known as the Kennedy classification, published in 1963, it describes five trauma mechanisms: anterior (40%), posterior (33%), lateral (18%), medial (4%), and rotational (4%), the latter being associated with irreducible dislocations.<sup>2,3</sup> The Schenck classification, on the other hand, categorizes these injuries from KD-I to KD-V, according to the number of ligaments involved and the presence of a periarticular fracture.<sup>4</sup> This system was modified by Yu et al. in 1995, who added the designations “C” and “N” to indicate associated arterial or nerve injuries, respectively.<sup>5</sup>

The incidence of popliteal artery injury ranges from 10% to 40%, being more frequent in anterior and posterior dislocations.<sup>6</sup> In anterior dislocations, the popliteal artery is prone to intimal injury due to a traction mechanism, whereas in posterior dislocations, the artery may be completely transected from the tibia, as it is anchored proximally at the adductor hiatus and distally at the arch of the soleus muscle.<sup>6,7</sup> Moreover, peroneal nerve injuries are common, with reported incidence rates ranging from 20% to 45%.<sup>8</sup>

## CLINICAL CASE

A 27-year-old male farmer residing in a rural area, with no relevant medical history, suffered a traffic accident after falling into a ravine while riding a motorcycle, resulting in trauma to his right shoulder and knee. He initially sought care at a rural hospital, where marked edema, ecchymosis, and a positive dimple sign were identified in the right knee. He also had limited range of motion in both the shoulder and the knee. As X-rays were not available, he was referred to a hospital with orthopedic services. There, initial radiographs were obtained (Figures 1 and 2), documenting a diaphyseal humeral fracture that was immobilized with a sugar-tong splint. In addition, a posterolateral knee dislocation and a lateral patellar dislocation were diagnosed. Two orthopedic surgeons attempted three reductions under sedation (no anesthesia was available), successfully reducing the patella but not the knee. It was decided that the patient required transfer to a trauma center for urgent open reduction and to rule out an associated vascular injury. The knee was immobilized with a bivalved hip-to-foot splint and he was referred.



**Figure 1.** Anteroposterior knee radiograph showing posterolateral knee dislocation and lateral dislocation of the patella.



**Figure 2.** Lateral knee radiograph demonstrating posterior translation of the tibia relative to the femoral condyles.

At the initial evaluation at the trauma center, 8 hours had elapsed since the accident. The immobilization was removed to assess the soft tissues, and a medial dimple sign was observed (Figure 3).

Radiographs showed widening of the medial joint space consistent with medial instability. Further imaging was obtained with magnetic resonance imaging (Figures 4 and 5) to evaluate possible interposed tissues or structures, and with CT angiography (Figure 6) to rule out vascular injury given the time elapsed since trauma. Marked edema was noted in the medial soft tissues, including the capsule and medial structures in the intercondylar region, along with persistent knee subluxation. Vascular compromise was ruled out, with preservation of the femoropopliteal vascular bundle.

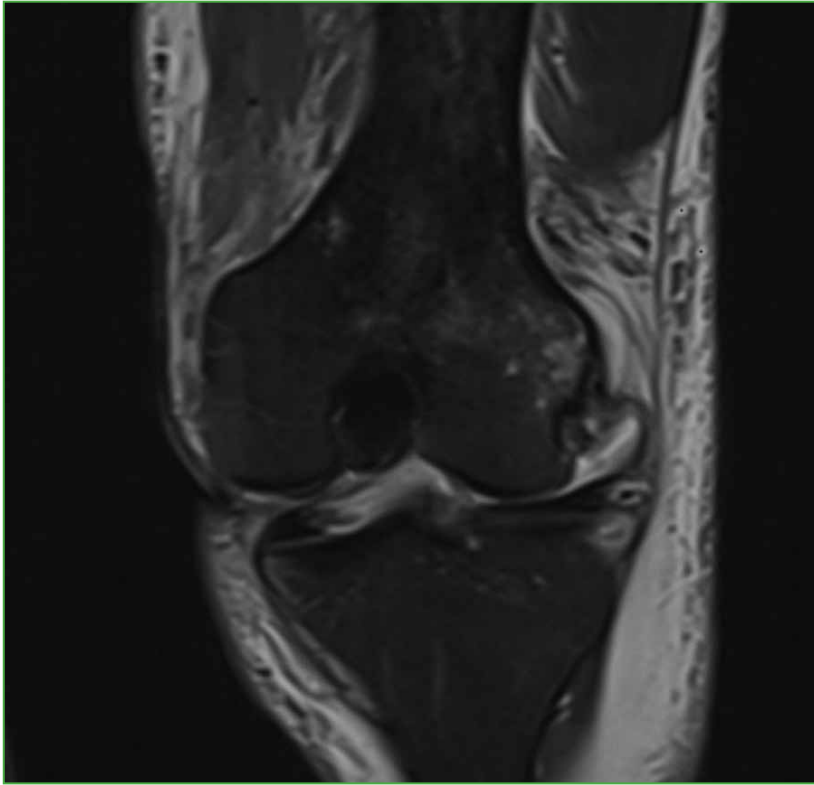
The decision was made to take the patient to the operating room and attempt closed reduction, which was unsuccessful. Therefore, an open reduction was performed.

A longitudinal medial approach was carried out, and the extensor mechanism was released to evaluate the articular surface of the patella and increase exposure. The medial femoral condyle was found to be completely denuded. Careful flap dissections were performed to improve visualization despite the everted patella. Through valgus maneuvers, the relevant structures were identified and localized. Attempts were made to remove the interposed meniscus, medial retinaculum, and capsule using levering techniques with different instruments, but this was unsuccessful due to tension within these structures despite reduction maneuvers. Therefore, the capsule and the patellofemoral ligament were sectioned to release the femorotibial and intercondylar space, achieving clinical reduction and congruency of the knee. Copious irrigation with saline solution was performed, followed by capsular repair and suturing of the medial patellofemoral ligament and medial retinaculum. Stability was reassessed,

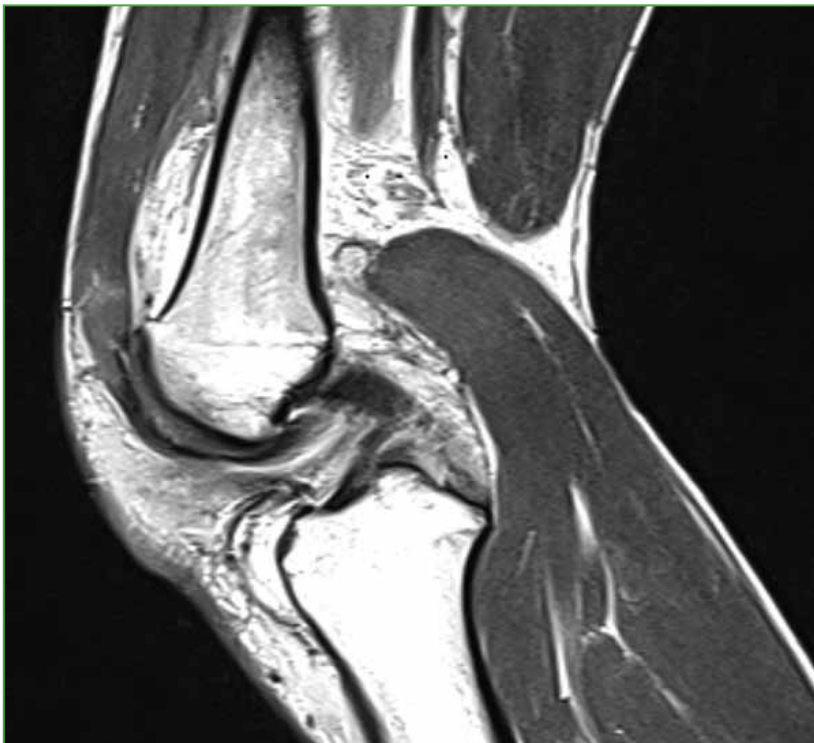
and the knee did not redislocate with deep flexion or extension. No chondral lesions were observed in the patella or trochlea. The medial meniscus was found to be impinged but without body or root tears; therefore, no further management was required. An articulated knee brace was applied, postoperative radiographs were obtained (Figure 7), and delayed ligament reconstruction was scheduled for 3 weeks later. During that procedure, the anterior cruciate ligament was reconstructed with an allograft; the posterior cruciate ligament was reconstructed using a single-bundle allograft technique; and the posteromedial corner was reconstructed using the LaPrade technique. At 4-week follow-up, knee range of motion was 10° to 90° of flexion. The patient continues with physical therapy.



**Figure 3.** Dimple sign and ecchymosis in the anteromedial region of the knee.



**Figure 4.** Coronal knee MRI showing interposition of medial structures and loss of joint congruency, with subluxation.



**Figure 5.** Sagittal knee MRI demonstrating marked edema of the medial region and interposition of medial structures.



**Figure 6.** Sagittal knee CT angiography confirming absence of vascular compromise and integrity of the femoropopliteal bundle.



**Figure 7.** Postoperative anteroposterior knee radiograph showing adequate joint congruency, preserved joint spaces, and postoperative soft-tissue changes.

## DISCUSSION

The incidence of knee dislocations is very low, representing less than 0.02% of all orthopedic emergencies and less than 0.5% of all joint dislocations. However, these figures may be underestimated due to underreporting, as at least 60% of knee dislocations reduce spontaneously when they occur.<sup>9,10</sup> Although it is a rare clinical entity, the fact that it is irreducible (that is, the interposition of capsuloligamentous structures between the femoral condyles associated with a knee dislocation) makes it an even more uncommon condition, one that is associated with high rates of sequelae and long-term complications when not diagnosed and treated in a timely and appropriate manner.<sup>11</sup>

Most irreducible knee dislocations are posterolateral. Tibial displacement occurs due to a generally high-energy valgus force with the knee flexed, associated with simultaneous rotational forces on the tibia and femur in opposite directions, which push the medial femoral condyle through the anteromedial capsule and retinaculum. Subsequent interposition of the medial retinaculum, the medial collateral ligament, the vastus medialis, or the medial meniscus can give rise to the “pucker sign” or “dimple sign,” a characteristic finding on physical examination and present in up to 83% of irreducible knee dislocations.<sup>12,13</sup>

An important aspect of this type of knee dislocation is the involvement of the medial capsuloligamentous complex and its interposition between the femoral condyles during severe valgus stress, which confers its characteristic irreducibility. Early clinical diagnosis and open reduction, with or without arthroscopic debridement, are essential to reduce the risk of soft-tissue compromise in this condition. Prompt restoration of joint congruity, verification of adequate distal perfusion, and exclusion of vascular injury, one of the potential complications, are urgent priorities.<sup>14</sup>

Fortunately, in this case, no skin complications occurred. However, it is important to note that the dimple sign is a key clinical indicator suggesting irreducibility of the dislocation and the need for timely open reduction, as attempts at closed reduction may cause further skin injury, and delays in diagnosis and treatment may lead to skin necrosis.<sup>12-14</sup>

The literature on this condition is limited, and the authors of published cases to date have proposed different surgical approaches, without reaching a general consensus, particularly with regard to repair of the anterior and posterior cruciate ligaments.<sup>15</sup>

After reduction, the appropriate timing for ligament reconstruction remains controversial. Indications for external fixation in cases of acute knee dislocation include inability to maintain the reduction, a history of vascular injury, and open dislocation. There are very few data comparing external fixation with a hinged knee immobilizer prior to multiligament reconstruction.<sup>9,16,17</sup> In a study conducted at the Mayo Clinic, eight knees placed in external fixation after reduction were compared with twenty-three knees managed with a brace after reduction, and no statistically significant differences were found in Lysholm scores or mean International Knee Documentation Committee (IKDC) scores after 27 months of follow-up.<sup>18</sup> Interestingly, patients managed with an immobilizer had better ranges of motion at long-term follow-up than those treated with external fixation; however, this may be attributable to more complex injuries requiring external fixation.

Although a few cases treated with arthroscopic debridement or arthroscopic reduction have been reported, open reduction is the treatment of choice.<sup>19</sup> In the case presented, the medial retinaculum, medial capsular structures, and the medial patellofemoral ligament were found to be interposed and were clearly visualized, as was a substantial portion of the distal vastus medialis obliquus muscle. Several structures can become trapped within the joint space and prevent knee reduction; among them, the medial retinaculum and adjacent structures are the most frequently involved. Other causes of irreducible knee dislocation include intra-articular patellar dislocation or lateral knee dislocation with entrapment of the posterolateral capsule in the lateral compartment.

In cases of dislocation involving multiple ligaments, these ligaments should be repaired or reconstructed early. The literature recommends performing a second procedure within the first 3 to 4 weeks, followed by 2 weeks of immobilization, preferably using a hinged immobilizer to control the range of joint motion.<sup>20,21</sup>

Complications are common, and the knee rarely returns to its pre-injury state. Patients often develop stiffness, loss of range of motion, and an increased risk of early osteoarthritis.<sup>16,21,22</sup> According to a systematic review published in 2022 by Malik et al., based on 114 cases of irreducible knee dislocation, the complication rate was 14.4%, with skin necrosis and joint stiffness being the most frequent (6.7% and 4.8%, respectively). Other less common complications included compartment syndrome and surgical site infection (one case each).<sup>1,22</sup>

No data were found regarding the incidence of multiple ligament injuries associated with irreducible knee dislocation, likely due to its unusual presentation.

## CONCLUSIONS

The medial dimple sign is pathognomonic of irreducible knee dislocation and must be recognized promptly. Closed reduction should be attempted only once to avoid further skin damage; if the medial structures of the knee

remain entrapped, emergency open reduction is indicated, given the high association with vascular injuries. Ligament reconstruction is recommended when multiple ligaments are involved, and the choice of cruciate ligament reconstruction should be individualized according to the patient's age, physiological status, and physical activity demands. In addition, a thorough neurological and vascular assessment of the affected limb is essential due to the risk of severe associated complications.

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# Osteoplastic Reconstruction of the Thumb: Technique and Outcomes After More Than 6 Years of Follow-Up

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## ABSTRACT

The thumb accounts for 40% of hand function, and its loss requires reimplantation or reconstruction. Although reimplantation is the ideal treatment, alternative options are necessary when it fails. Osteoplastic reconstruction constitutes a less complex and less invasive option. We present the case of a 58-year-old man who underwent osteoplastic thumb reconstruction following a failed reimplantation after a metacarpophalangeal (MCP) amputation. The surgical technique, clinical outcomes, and radiological findings after more than 6 years of follow-up are described. **Conclusions:** Osteoplastic reconstruction using an iliac crest graft and an inguinoabdominal flap is a safe and effective option for thumb reconstruction after failed MCP-level amputations. It provides good functional outcomes and is reproducible in settings without access to more complex reconstructive techniques.

**Keywords:** Thumb reconstruction; traumatic amputation; inguinoabdominal flap; iliac crest graft.

**Level of Evidence:** IV

## Reconstrucción osteoplástica del pulgar. Técnica y resultado luego de más de 6 años de seguimiento

## RESUMEN

El pulgar representa el 40% de la función de la mano, y su pérdida requiere un reimplante o reconstrucción. Aunque el reimplante es el tratamiento ideal, existen alternativas ante el fracaso. La reconstrucción osteoplástica es una opción menos invasiva. Se presenta un caso de reconstrucción osteoplástica del pulgar tras un reimplante fallido en un hombre de 58 años con amputación metacarpofalángica. Se detallan la técnica quirúrgica, los resultados clínicos y radiológicos tras 6 años de seguimiento. **Conclusiones:** La reconstrucción osteoplástica con injerto de cresta ilíaca y colgajo inguinoabdominal es una opción segura y eficaz para la reconstrucción del pulgar tras amputaciones metacarpofalángicas fallidas, ofrece buenos resultados funcionales y es replicable en entornos sin acceso a tratamientos más complejos.

**Palabras clave:** Reconstrucción de pulgar; amputación traumática; colgajo inguinoabdominal; injerto de cresta ilíaca.

**Nivel de Evidencia:** IV

## INTRODUCTION

The thumb contributes approximately 40% of hand function; therefore, its complete loss at the metacarpophalangeal level, or Lister's group 4,<sup>1</sup> requires restoration or reconstruction.

The requirements for a functional thumb are stability, adequate length, mobility, sensibility, and absence of pain.<sup>1-3</sup>

Although replantation is the best option, when it is not possible or when it fails, several reconstructive alternatives exist. The current gold standard is free vascularized toe-to-hand transfer. However, this is a technically demanding procedure and requires amputating part or all of a healthy toe, which may be unacceptable to some patients.<sup>2-4</sup>

Other reconstructive options include deepening of the first web space (phalangization), transposition (pollicization) of another finger, and osteoplastic reconstruction.<sup>1,2</sup>

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The aim of this article is to report our experience with osteoplastic reconstruction as an alternative for thumb loss at the metacarpophalangeal level (group 4) in patients who declined toe-to-hand transfer. The technique used, as well as the clinical and functional outcomes after more than 6 years of follow-up, are described.

## CLINICAL CASE

A 58-year-old male pharmacist presented with a traumatic amputation of the thumb at the metacarpophalangeal level, with a failed replantation attempt, in his dominant hand. Because he declined reconstruction using a toe-to-hand transfer, osteoplastic reconstruction was proposed (Figure 1).



**Figure 1.** AP (A) and oblique (B) radiographs of the affected hand in the emergency setting (thumb amputation).

## Technical Details

### First Stage

1) **Marking of the donor area for the inguinoabdominal flap:** the vascular pedicle was identified, and the flap was planned according to the surface area required to cover the neothumb.

2) **Harvesting of the iliac crest flap:** a structural iliac crest graft was obtained and shaped to match the dimensions of the contralateral thumb.

3) **Fixation of the iliac crest graft:** the graft was stabilized to the remaining base of the proximal phalanx using wire cerclage in the coronal and sagittal planes of the metacarpophalangeal joint, supplemented with temporary Kirschner wires. If tendon remnants are present, a tenoplasty may be performed; this was not required in our patient (**Figure 2**).



**Figure 2.** AP (A) and oblique (B) follow-up radiographs of the affected hand. Iliac crest graft plus wire cerclage.

4) **Coverage of the graft with the tubulized flap:** the bony graft of the neothumb was covered with the tubulized inguinal flap, with maximal thinning of the adipose layer.

**Second Stage**

1) **Flap division:** three weeks after the first stage, the inguinal flap was divided, yielding a reconstructed neothumb.

**Reoperations:** Debulking procedures are required to reduce flap volume when excess abdominal fat is present. In this case, two subsequent reoperations were performed.

After 6 years of clinical and radiological follow-up, the patient reports no pain or subjective limitations for work or sports activities (DASH [*Disabilities of the Arm, Shoulder and Hand*] score 19/100; PRWE [*Patient-Rated Wrist Evaluation*] score 43/100). He uses a strong modified tip-to-tip pinch, with full closure of the remaining four fingers. Grip strength is 75% compared with the contralateral hand, measured with a Jamar dynamometer. He has anesthesia over the flap area, without contact-related injuries (Figure 3).



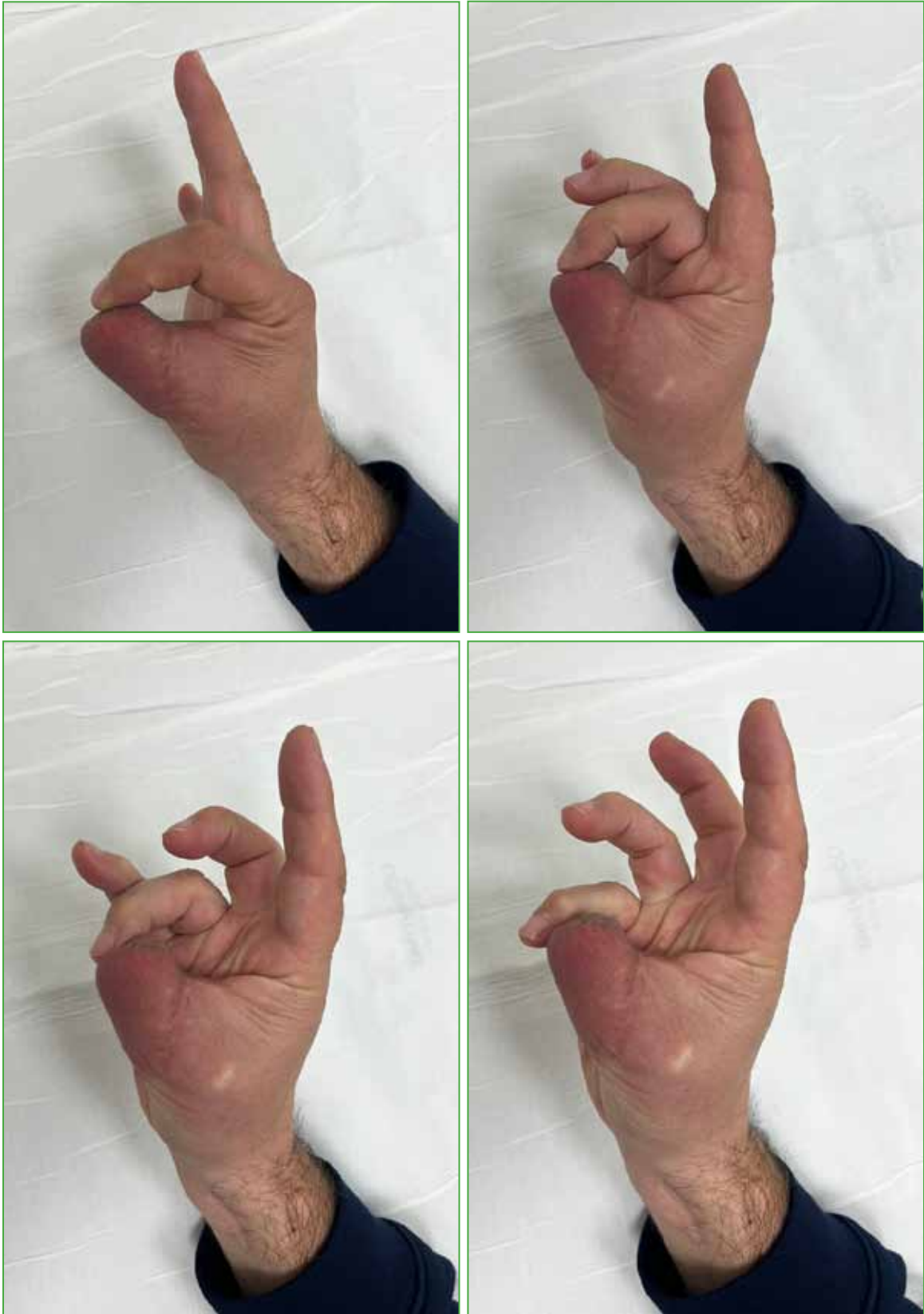
**Figure 3.** Clinical follow-up 6 years after surgery.

Radiographs show partial bone remodeling due to resorption, with a 10% loss of graft length, without clinical implications or fragility-related findings (Figure 4).

It is worth noting that the modified pinch is functional with all fingers, allowing adequate opposition and stability of the neothumb during precision tasks. This grasping ability is demonstrated in Figure 5, which shows correct functional integration of the reconstructed thumb in both fine pinch and power maneuvers.



Figure 4. Radiographic follow-up 6 years after surgery.



**Figure 5.** Clinical follow-up 6 years after surgery. Functional modified tip-to-tip pinch.

## DISCUSSION

Reconstruction of the thumb after traumatic amputation at the metacarpophalangeal joint is essential due to the crucial function this digit provides. The case presented required a critical decision regarding the most appropriate reconstructive technique. Although free vascularized transfer of a toe to the hand is considered the gold standard procedure for thumb reconstruction, the patient declined this option, mainly due to concerns about sacrificing a healthy toe. This led to choosing osteoplastic reconstruction as an alternative.

Osteoplastic reconstruction, as described in our patient, is documented as a viable technique and one that is less demanding than toe-to-hand transfer. Graham et al. emphasize that osteoplastic reconstruction remains a preferred option in settings where resources are limited or when patients wish to avoid more invasive microsurgical procedures.<sup>1,2</sup> In this case, the decision to select this technique was consistent with these indications, as it provides a functional solution without the need to sacrifice a toe.

In the 6-year long-term follow-up, the results are favorable: the patient maintains significant functionality, is pain-free, and exhibits good adaptation to work and sports activities. These findings are consistent with published reports indicating that although osteoplastic reconstruction may result in partial loss of graft length due to bone remodeling, this generally does not compromise long-term function.<sup>4</sup> In our case, the 10% loss of graft length had no significant clinical repercussions, reaffirming the robustness of this technique in providing long-term stability and functionality.

The literature also mentions possible complications, such as venous congestion, delayed wound healing, and bone resorption, that may affect outcomes. However, no major complications occurred in this case, suggesting that meticulous surgical planning and appropriate patient selection are key factors for success.

Anesthesia in the flap area and the need for subsequent debulking procedures to reduce flap volume were appropriately managed, in line with previously reported challenges regarding excess tissue in inguinoabdominal flap reconstructions.<sup>4</sup>

Regarding functional outcomes, the patient achieved 75% of grip strength compared with the contralateral hand and used a modified tip-to-tip pinch. These results are comparable to those reported in other osteoplastic reconstruction studies. The DASH (19/100) and PRWE (43/100) scores reflect moderate impairment in daily activities but with significant functional adaptation, similar to that described in other published case series.<sup>4</sup>

## CONCLUSIONS

Osteoplastic reconstruction using an iliac crest graft and an inguinoabdominal flap represents a safe and effective option for thumb reconstruction following failed metacarpophalangeal amputations. The technique provides functional clinical results ranging from good to excellent and can be replicated in settings lacking the capacity to perform more complex microsurgical procedures.

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# Open Reduction and Internal Fixation as Management of a Complex Scapular Fracture in a Polytraumatized Child: Case Report

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## ABSTRACT

Scapular fractures in children are rare and typically result from high-energy trauma. Conservative treatment is usually the preferred approach, and surgical intervention is uncommon. In adults, surgery has demonstrated better short-term functional outcomes, but its benefits in the pediatric population remain unclear. Determining which pediatric patients may benefit from osteosynthesis is challenging due to the lack of available evidence. However, the presence of complications and certain imaging measurements may help guide management. The objective of this report is to describe the case of a child who underwent surgical treatment for a complex scapular fracture and to highlight the usefulness of the glenopolar angle as a criterion for decision-making in these patients. Alterations in the glenopolar angle and other radiographic parameters may be useful in identifying patients who could benefit from surgical management, as well as in predicting complications and postoperative outcomes. Nevertheless, further studies are needed to validate these findings over the long term and to better establish their diagnostic and prognostic value.

**Keywords:** Scapula; pediatrics; bone fractures; open reduction; surgical management.

**Level of Evidence:** V

## Reducción abierta y fijación interna como manejo de una fractura compleja de escápula en una niña con politraumatismos. Reporte de un caso

## RESUMEN

Las fracturas de escápula son raras en los niños y se producen por mecanismos de alta energía. El tratamiento de elección es conservador y la cirugía es poco frecuente. Se ha comprobado que, con la cirugía, se logra un mejor resultado funcional a corto plazo en los adultos, pero se desconoce qué ocurre en los niños. Es difícil definir qué pacientes se beneficiarán con la osteosíntesis, pues no hay bibliografía al respecto. Sin embargo, la presencia de complicaciones y algunas mediciones en los estudios por imágenes pueden ser útiles para definir un mejor manejo. El objetivo de esta presentación es comunicar el caso de una niña operada por una fractura de escápula y mostrar la utilidad del ángulo glenopolar como criterio para definir el manejo en estos pacientes. El tratamiento quirúrgico para estas fracturas ha logrado mejores resultados a corto plazo. La alteración del ángulo glenopolar y otros criterios podrían ser útiles para definir el beneficio de la cirugía, las complicaciones y los resultados posoperatorios, pero se necesitan estudios que permitan validar estos resultados a largo plazo, su rendimiento diagnóstico y el pronóstico.

**Palabras clave:** Escápula; pediatría; fracturas óseas; reducción abierta; manejo quirúrgico.

**Nivel de Evidencia:** V

## INTRODUCTION

Scapular fractures are uncommon in children; therefore, clinical experience in treating them is limited, and the literature consists mostly of case reports, unlike in adults. Most of these fractures result from high-energy mechanisms, particularly traffic accidents, polytrauma, seizures, and high-energy falls.<sup>1-3</sup> Multiple fracture patterns have been described due to their association with closed thoracic trauma. The most frequently affected site is the coracoid process, followed by fractures of the body (mainly the infraspinous portion), the acromion, and the glenoid.<sup>1-5</sup>

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However, the main challenge lies in management, as conservative treatment with immobilization has traditionally been the approach of choice,<sup>6-8</sup> and cases requiring surgery have been rare.<sup>2</sup> In the few surgically treated cases reported, arbitrarily defined criteria, such as instability,<sup>9-11</sup> medial displacement of the glenoid surface >10 mm, intra-articular involvement, comminution, and floating shoulder,<sup>13</sup> have been extrapolated from adult parameters to guide treatment.<sup>14,15</sup> Currently, it remains unclear in which scenarios surgical management provides long-term benefits, especially considering the differences in the immature pediatric skeleton and the lack of dedicated research in pediatric traumatology.<sup>1</sup>

According to published cases, surgically treated patients show a lower incidence of complications, shorter hospital stays,<sup>16</sup> better short-term functional outcomes, and shorter follow-up periods than those treated conservatively.<sup>17,18</sup> Therefore, despite the limited and largely expert-opinion-based indications, the available evidence encourages considering operative management in selected cases.

We report the case of a girl with a displaced extra-articular fracture of the scapular body with marked compromise of the glenopolar angle, who underwent surgery due to persistent significant functional limitation in the context of multiple trauma (triplanar distal tibial fracture, Torode and Zieg type III pelvic fracture, and closed thoracoabdominal trauma).

The aim of this case report is to highlight the usefulness of the glenopolar angle and fracture displacement as criteria for identifying pediatric patients who may benefit from surgery, given the lack of consensus in this population and the implications for short-term postoperative outcomes.

The patient and her legal guardian provided informed consent for publication of this case.

## CLINICAL CASE

An 11-year-old girl with no significant medical history presented with multiple trauma following a traffic accident. She sustained several associated injuries: grade 2 friction burns involving 12% of her body surface area; a triplanar fracture of the right ankle; a type III pelvic fracture according to the Torode and Zieg classification (opening of the left sacroiliac joint and widening of the pubic symphysis); and a complex displaced fracture of the right scapular body. She also suffered severe traumatic brain injury and closed thoracoabdominal trauma, which required a prolonged hospital stay to manage her injuries and critical condition.

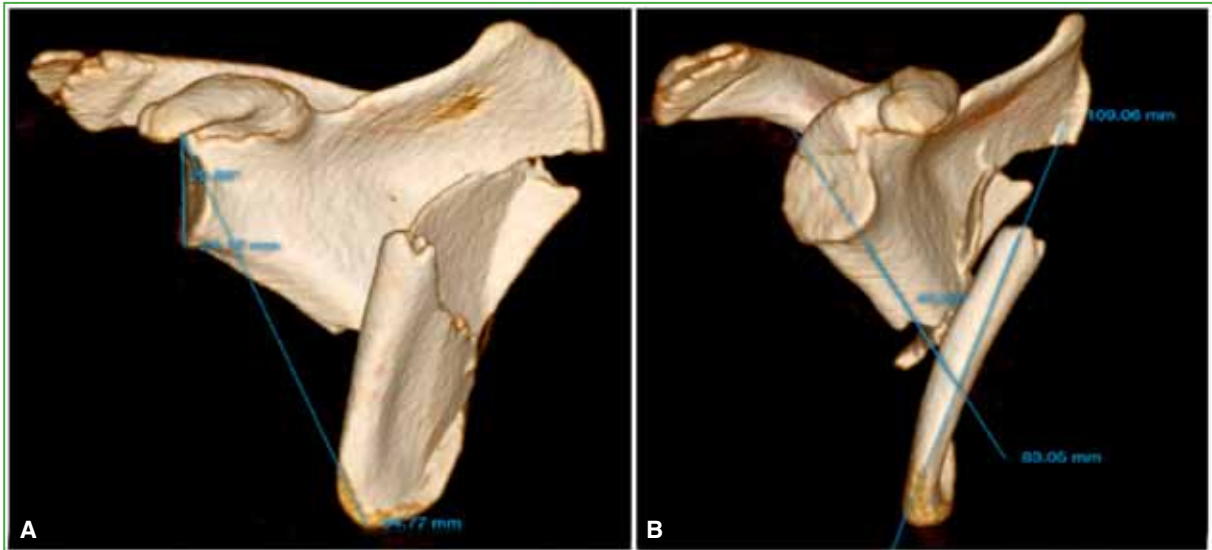
On physical examination at admission, her general condition was poor, with a brief loss of consciousness lasting several minutes, somnolence, edema in the proximal third of the arm, and a 0.5-cm wound on the left shoulder with abrasions, ecchymosis, and tenderness on palpation. No signs of distal neurovascular injury were noted. Shoulder flexion was limited to 50°, while internal rotation was fully preserved.

Radiographs ([Figure 1](#)) revealed a displaced fracture of the right scapular body with two fragments.



**Figure 1.** Anteroposterior, lateral, and axillary shoulder radiographs obtained at admission. A displaced fracture of the scapular body is observed, with two fragments, mild comminution, angulation, and loss of continuity of the lateral border, without articular involvement.

A computed tomography scan with three-dimensional reconstruction (Figure 2) showed a markedly compromised glenopolar angle measuring  $20.88^\circ$ . Comminution of the scapular body was also identified, along with displacement of the lateral wall with a  $45^\circ$  inclination and medialization.



**Figure 2.** Computed tomography of the scapula with three-dimensional reconstruction. **A.** Measurement of the glenopolar angle. **B.** Measurement of the body inclination angle.

A consultation was requested with shoulder surgery and pediatric orthopedic specialists, who agreed that the patient would benefit from surgical fixation due to the high risk of instability, the possibility of correcting the deformity, and the expectation of improved functional recovery using compression and locking plates.

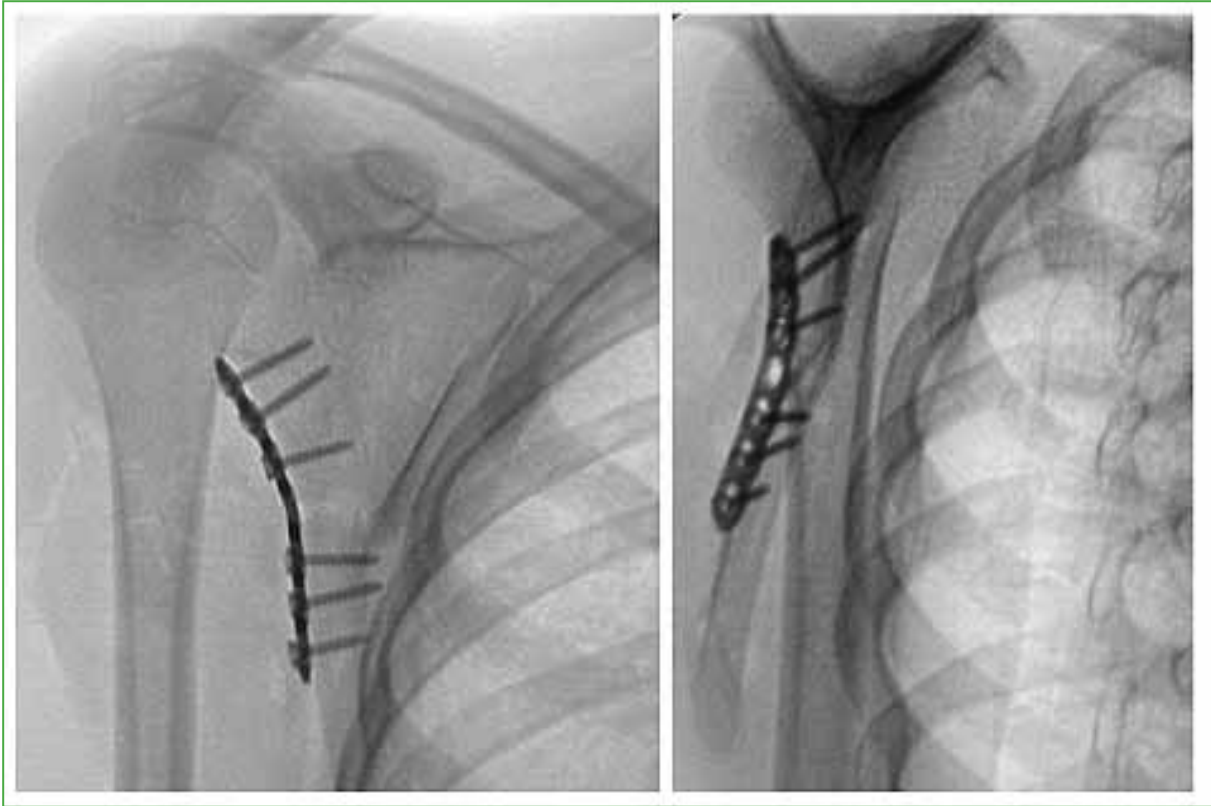
### Surgical Technique

General anesthesia was administered, and the patient was placed in the left lateral decubitus position. A longitudinal incision was made along the lateral border of the scapula, dissecting through the infraspinatus and teres minor muscles. Intraoperatively, multifragmentary involvement of the glenoid at the superior and posterior rim was identified (Figure 3).



**Figure 3.** Images illustrating the planning and minimally invasive incision (Brody approach) used for fixation of the extra-articular scapular body fracture affecting the lateral border. The suprascapular neurovascular bundle is visible coursing through the spinoglenoid notch.

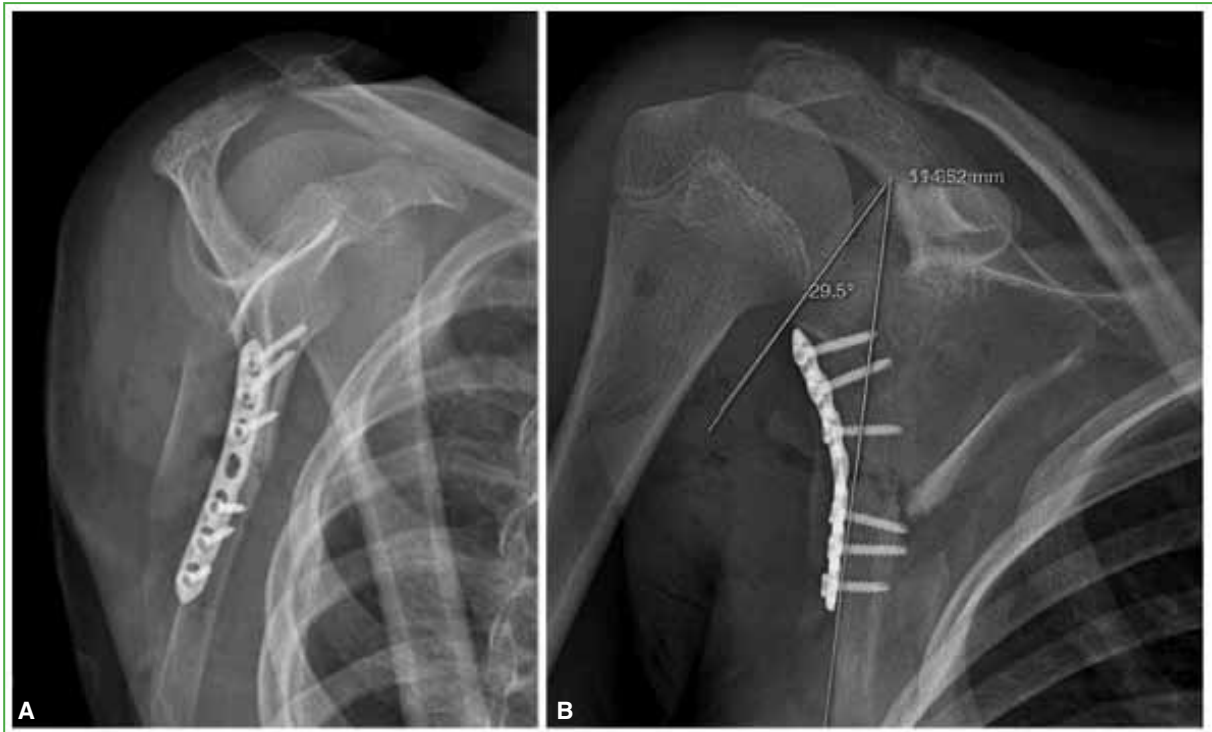
The fragments were mobilized by releasing the abundant bone callus with signs of consolidation, in order to improve fragment mobility at the fracture site and restore the length of the scapular lateral border. Reduction was achieved using reduction forceps, with provisional fixation using Kirschner wires to align the superior and inferior fragments. Together, these steps facilitated correction of the lateral wall angle, which was definitively fixed using a pre-contoured plate proximally and cortical screws along the lateral border (Figure 4).



**Figure 4.** Intraoperative fluoroscopic images guiding the procedure. The lateral wall deformity was corrected by improving fragment alignment with a straight, pre-molded 7-hole compression plate positioned proximally and secured with three proximal and three distal 2.4-mm cortical screws.

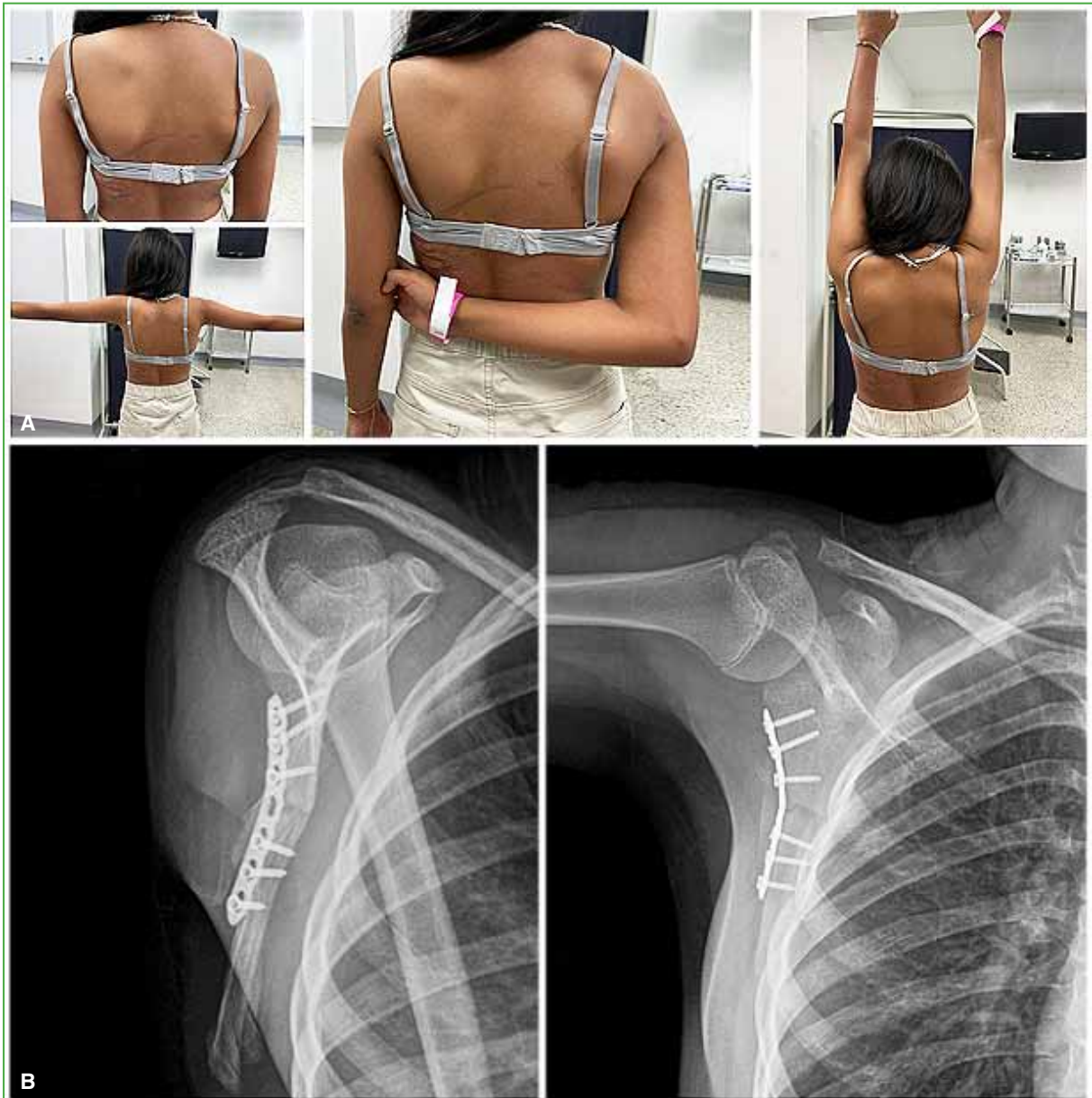
Alignment, reduction, and implant positioning were confirmed using intraoperative fluoroscopy. Adequate screw angulation was achieved, with no intra-articular placement. The wound was closed in layers, and shoulder mobility was assessed immediately. Both passive and assisted active ranges of motion showed marked improvement. The patient continued to use an arm sling until postoperative follow-up.

Postoperative radiographs demonstrated satisfactory alignment, with anatomic reduction and appropriate positioning of the osteosynthesis hardware. The scapular body was restored along its lateral border, improving stability at the fracture site with the pre-contoured plate in place. Improved glenohumeral alignment was noted, including restoration and increase of the glenopolar angle, correction of the inclination of the distal fracture segment, and proper alignment of the scapular body relative to the preoperative lateral radiograph (Figure 5).



**Figure 5.** **A.** Lateral shoulder radiograph. Adequate positioning of the osteosynthesis material, restoring the inclination and length of the lateral border of the scapular body. **B.** Anteroposterior postoperative shoulder radiograph. Significant correction of the glenopolar angle, reaching nearly 30°, close to normal reference values.

Due to the patient's social circumstances, the first follow-up visit occurred at 3 months. Shoulder mobility was adequate, with clear improvement in both passive-assisted and active ranges of motion, and complete resolution of prior functional limitation. Radiographs showed fracture consolidation without complications, and postoperative appearance was satisfactory. Given these findings, follow-up was concluded (Figure 6).



**Figure 6.** **A.** Clinical postoperative images. Symmetrical right shoulder with acceptable scarring and full functional capacity, without limitation in abduction, adduction, elevation, external rotation, or internal rotation, with ranges of motion comparable to the contralateral side. **B.** Anteroposterior and lateral scapular radiographs. Adequate positioning of the hardware, with no signs of loosening or instability; fracture site aligned and progressing toward consolidation.

## DISCUSSION

The available literature on the management of scapular fractures in pediatric patients is scarce. Most publications consist of isolated case reports describing children treated conservatively, which generally document improvement in functional limitation but longer recovery times and a higher risk of complications.<sup>6</sup>

Several authors have proposed absolute criteria for surgical management, including open fractures, comminution, neurovascular injuries, scapulothoracic dissociation, failure of conservative treatment, and fracture-pattern-related deformities such as glenohumeral instability with glenoid malrotation. In our case, alteration of the gleno-

polar angle, the inclination angle, and displacement at the fracture site were considered indicators of instability, in association with complete functional limitation. However, the use of these criteria has only been described in adults.

The glenopolar angle was originally introduced as a radiographic prognostic criterion in patients with floating shoulder.<sup>19</sup> It is defined as the angle formed between a line connecting the superior and inferior poles of the glenoid and a line connecting the superior glenoid pole to the most inferior point of the scapular inferior angle. Although its application has not been described in the pediatric population, the measurement is reproducible and has been widely used in adults to determine which patients benefit from osteosynthesis.<sup>19,20</sup> Therefore, it is relevant to consider whether this variable may also be useful in children and to assess its value in predicting postoperative outcomes. Previous studies have suggested that lower glenopolar angle values are associated with worse rehabilitation outcomes. This implies that, at least for scapular body fractures, the glenopolar angle could serve as an objective parameter to determine whether a patient is more likely to benefit from conservative treatment or surgery. From a biomechanical standpoint, it correlates with the degree of glenohumeral instability,<sup>13</sup> one of the most commonly cited predictors of the need for surgical management in children. It could also help stratify patients into good- or poor-prognosis groups based on postoperative correction of this angle, given its association with improved functional outcomes, shorter hospital stays, and other clinical variables.

A major limitation in the use of the glenopolar angle is its substantial interobserver variability, largely due to anteroposterior rotational differences during shoulder radiography acquisition.<sup>19</sup> This underscores the need for a standardized imaging configuration that ensures proper orientation of the scapular body to achieve accurate and reproducible measurements. Three-dimensional computed tomography would therefore be the ideal tool for preoperative assessment when corrective surgery is being considered for displaced fractures.<sup>12,15,18</sup>

## CONCLUSIONS

This clinical case highlights the challenges involved in managing scapular fractures in pediatric patients. Surgical intervention, using an approach adapted to the specific anatomical, physiological, and biomechanical considerations of this age group, proved effective in achieving favorable outcomes. However, the rarity and distinctive characteristics of scapular body fractures in children contribute to the current lack of clear criteria defining when surgery is truly beneficial. Although the available literature is limited, it consistently suggests that surgical management may offer considerable advantages, particularly by enabling faster functional recovery, as demonstrated in this case. Moreover, many elements of the approach, surgical technique, and decision-making process described in the literature rely heavily on the surgeon's expertise and clinical judgment. This underscores the inherent complexity of these injuries, as optimal treatment requires careful preoperative planning and individualized strategies tailored to each patient.

Finally, alterations in measurable parameters (such as inferior fragment displacement, medial border inclination, and the glenopolar angle) may serve as objective indicators of which fractures are most likely to benefit from surgical fixation, and how correction of these parameters may predict postoperative outcomes. Long-term follow-up studies of similar pediatric cases are needed to validate these observations and to determine the practical utility of these radiographic measures in guiding clinical decision-making regarding the management of scapular body fractures in children.

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Conflicts of interest: The authors declare no conflicts of interest.

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# “Recycling Technique” for Single-Stage Metacarpal Hand Reconstruction

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## ABSTRACT

**Introduction:** We present an innovative surgical technique for reconstructing a metacarpal hand following transmetacarpal amputation. The procedure consists of lengthening the fourth ray using the second metatarsal as a non-vascularized bone graft to create a functional opposition post, complementing a second-toe transfer to the hand. This approach allows reconstruction of a metacarpal hand in a single surgical stage and with a single toe transfer, thereby avoiding complications associated with additional bone-graft donor sites. We also describe the functional and aesthetic outcomes obtained in our sole case to date. No published reports of a similar technique were identified. **Conclusions:** Harvesting the metatarsal from the donor toe facilitates improved closure of the intermetatarsal space with a lower risk of donor-site complications, while also providing a non-vascularized bone graft that serves as an opposition mass for the transferred toe. This simplifies the surgical procedure and reduces the risk of complications.

**Keywords:** Transmetacarpal amputation; hand reconstruction; toe-to-hand transfer.

**Level of Evidence:** IV

## “Técnica del reciclado” para la reconstrucción en un tiempo de una mano metacarpiana

## RESUMEN

**Introducción:** Se presenta una técnica quirúrgica innovadora para la reconstrucción de una mano con amputación transmetacarpiana, que consiste en el alargamiento del cuarto rayo mediante el uso del segundo metatarsiano a modo de injerto óseo no vascularizado para lograr una pinza oponente funcional, como complemento de la transferencia del segundo dedo del pie a la mano; esto permite resolver el desafío de reconstruir una mano metacarpiana en un tiempo quirúrgico y con una única transferencia, evitando complicaciones en otros sitios dadores de injerto óseo. Se muestran también los resultados funcionales y estéticos obtenidos en nuestro único caso hasta el momento. No se encontraron reportes bibliográficos de una técnica similar para resolver este problema. **Conclusiones:** El retiro del metatarsiano del dedo donante en el pie permite un mejor cierre del espacio intermetatarsiano con menos riesgo de complicaciones y sirve como injerto óseo no vascularizado para otorgar un macizo de oposición al dedo del pie transferido. Esto simplifica el acto quirúrgico y disminuye el riesgo de complicaciones.

**Palabras clave:** Amputación transmetacarpiana; reconstrucción de mano; transferencia de dedo del pie a la mano.

**Nivel de Evidencia:** IV


## INTRODUCTION

Trauma accounts for 80% of upper limb amputations, occurring primarily in males between 15 and 45 years of age.<sup>1,2</sup>

Amputations are classified according to the level of amputation. The most frequent are transphalangeal amputations (80%), followed by transmetacarpal amputations.<sup>1,2</sup>

Transmetacarpal amputations are classified into two types:<sup>3</sup>

- Type 1: the amputation line at the level of the long fingers lies proximal to the upper half of the proximal phalanx, and the thumb may be intact or amputated distal to the interphalangeal joint.
- Type 2 the amputation line at the level of the long fingers lies proximal to the upper half of the proximal phalanx, and the thumb is amputated proximal to the interphalangeal joint.

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We present the manner in which we managed a type 2 metacarpal hand, as a sequela of an amputation with failed replantation.

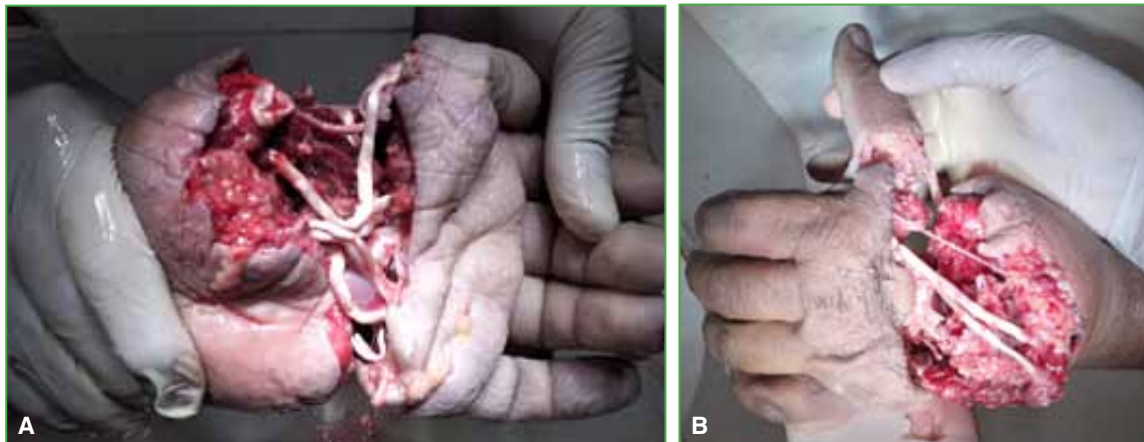
The most commonly used procedure to address this type of case involves multiple transfers performed in one or more stages,<sup>3</sup> or alternatively, the use of a non-vascularized iliac crest bone graft to lengthen a metacarpal and thus provide an opposition post.

Following these procedures, it is common for patients to experience discomfort at the donor site, whether due to pain and numbness in the iliac crest region or due to aesthetic alteration of the foot and changes in gait mechanics.<sup>4,5</sup> For this reason, removal of the second metatarsal was planned to achieve improved closure of the intermetatarsal space and thereby preserve foot biomechanics.

In this case, a toe-to-hand transfer was performed, combined with lengthening of the fourth ray using the second metatarsal as a non-vascularized bone graft to create an opposition post. Hence the name “recycling technique.” We have not found any bibliographic reports of this technique.

## CLINICAL CASE

A 32-year-old right-handed, obese male, employed in a cement factory and performing strenuous manual labor, sustained a traumatic amputation of the left hand at the transmetacarpal level (type 2) caused by a cement dosing machine (Figure 1).



**Figure 1.** Transmetacarpal amputation. **A.** Palmar view. **B.** Dorsal view.

The mechanism of injury was avulsion. The flexor and extensor tendons were avulsed from their muscle bellies. All palmar interosseous nerves were torn by traction.

Replantation was attempted 5 hours after the injury. Osteodesis of all digits was performed, together with arteriorrhaphy of the first and third interosseous arteries and a bypass using a local vein for the second interosseous artery, in addition to two dorsal venorrhaphies and one dorsal venorrhaphy of the thumb. No neurorrhaphies or tenorrhaphies were performed due to the degree of tissue damage.

Five days after replantation, cutaneous necrosis of the thumb was detected, prompting re-exploration. The thumb venorrhaphy was found to be thrombosed, and a new venous repair was performed. One week after this procedure, the thumb showed complete necrosis, and amputation was indicated; on re-exploration, the venorrhaphy was again found to be thrombosed.

The clinical course was unfavorable, with progressive necrosis of the long fingers (Figure 2). Twenty-two days after replantation, amputation of the four long digits was decided, and an inguinal flap was performed for coverage.

The inguinal flap evolved favorably and was divided after one month. Between flap division and definitive reconstruction, the patient underwent occupational therapy to prepare for the transfer, consisting of wrist mobility exercises and mirror therapy to enhance activation of the intrinsic muscles of the hand involved in grasp.



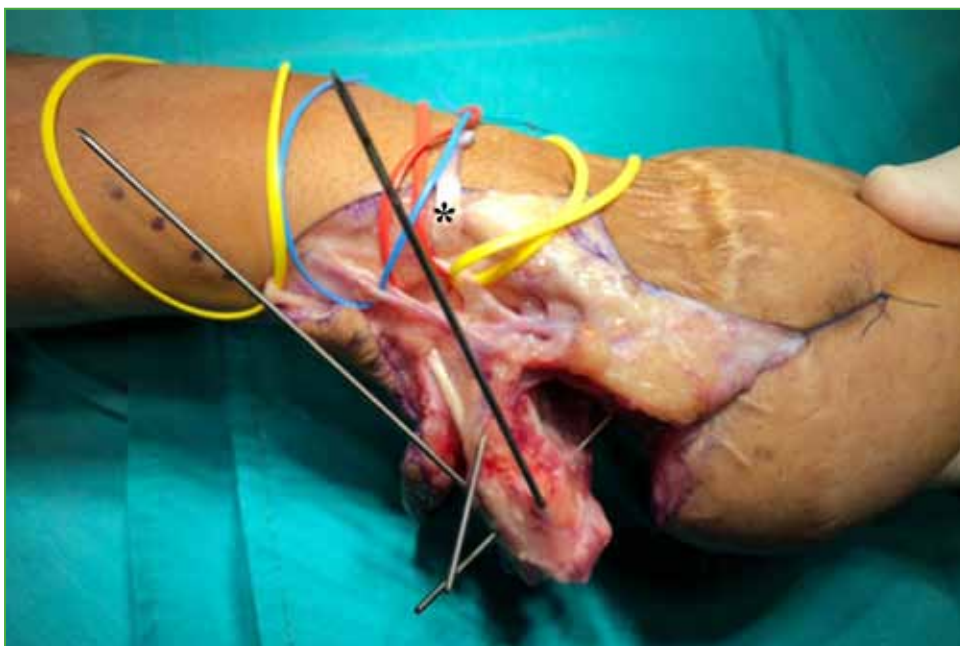
**Figure 2.** Distal necrosis following reimplantation.

### *Surgical Technique*

Six months after the initial trauma, transfer of the second toe to the hand was planned and performed for thumb reconstruction and restoration of opposition, together with lengthening of the fourth ray using a non-vascularized graft from the second metatarsal.

As a first step, the approach for stump exploration and release of the first commissure was designed.

After stump exploration, the following structures were identified dorsally: an extensor tendon, two dorsal sensory branches of the radial nerve, the radial artery on the dorsum at the level of the first compartment, and two superficial veins (Figure 3). Palmarly, a flexor tendon with limited excursion was identified (Figure 4).



**Figure 3.** Stump exploration. Dorsoradial view. The dorsal sensory branches of the radial nerve are marked with yellow loops; the radial artery with a red loop; and the dorsal vein with a blue loop. The extensor tendon is indicated with an asterisk.



**Figure 4.** Stump exploration. Palmar view. The flexor tendon is marked with an asterisk.

Release of the first commissure was performed, followed by opening and opposing of the commissure, and stabilization using a pin in the first ray and another spanning from the first to the second metacarpal.

The procedure then proceeded to the foot, where, according to the preoperative design, a dorsal approach to the second toe was carried out, identifying the pedicle (one artery and one vein), and dissecting two superficial veins and two collateral nerves (Figure 5). The toe was then disarticulated en bloc. Subsequently, the extensor and flexor tendons were transected with sufficient length to allow tenorrhaphy in the hand using the Pulvertaft technique.



**Figure 5.** Second toe, disarticulated, with its dissected pedicle marked with a red loop.

The second-toe implant in the hand was then performed. First, arthrodesis between the base of the implant's proximal phalanx and the head of the first metacarpal was carried out using pins. The microsurgical stage followed, consisting of arteriorrhaphy of the implant artery to the previously identified radial artery, two dorsal venorrhaphies, two neurorrhaphies to the dorsal sensory branches of the radial nerve, and tenorrhaphies of the flexor and extensor tendons.

The team working on the foot proceeded with resection of the second metatarsal. The second cuneiform was disarticulated. The first intermetatarsal space was then closed using pins and suturing of the plantar plate.

Finally, the inguinal flap was opened through its longitudinal palmar scar, the fourth metacarpal was exposed, and the second-metatarsal graft was positioned in slight flexion and fixed with a 3.5-mm compression screw (Figure 6), achieving good stability. The graft was then covered with the inguinal flap, thus providing the structure needed to achieve future pinch.

The patient progressed favorably during hospitalization without complications and was discharged on postoperative day 6.



**Figure 6.** Second metatarsal graft placed onto the fourth metacarpal and fixed with a 3.5-mm screw.

### *Post-surgical Rehabilitation*

An intensive Occupational Therapy protocol was prescribed in two stages:

- First post-surgical stage: controlled mobility and sensory stimulation.
- Second post-surgical stage: grasp patterns, strengthening, and integration into activities of daily living; initially one-handed skills, followed by bimanual activities.

Four months after surgery, the patient demonstrates active mobility (measured with a digital goniometer) consisting of block flexion of the metacarpophalangeal segment from 0–40° and 40° of abduction (Figure 7, Video).



**Figure 7.** Active range of motion at 4 months postoperatively. Block flexion of the metacarpophalangeal segment from 0–40° and 40° of abduction.

This range of motion allows him to pick up and transport objects of various sizes: from a 4-cm diameter cylinder, used as an adapted handle for the bimanual use of cutlery ([Figure 8](#)), to a shoelace for tying. Currently, in the late postoperative period, the patient is able to perform carpentry and painting tasks ([Video 2](#)).



**Figure 8.** Use of adapted cutlery.

He has good dorsal sensibility of the implant up to the proximal interphalangeal region; palmar sensibility has not yet returned.

The metatarsal graft shows clinical and radiographic signs of consolidation (Figure 9).



**Figure 9.** Anteroposterior and lateral radiographs of the hand at long-term follow-up, showing consolidation of the metatarsal bone graft.

There were no complications at the donor site on the foot. He is ambulating with full weight-bearing and without pain.

#### *Outcome Assessment*

According to the type of injury in this patient, outcomes can be evaluated as follows:<sup>5,6</sup>

- He is able to perform basic hand opposition using the newly created metacarpal mass. This corresponds to a pulp-to-lateral grasp.
- He is **not** able to perform a true lateral pinch.
- Aesthetic visual analogue scale: 5
- Functional visual analogue scale: 7

## DISCUSSION AND CONCLUSIONS

When reconstructing a metacarpal hand, toe-to-hand transfer is a highly valuable technique, but it requires an additional procedure to achieve functional opposition.

Complete resection of the metatarsal allows for aesthetic closure of the corresponding intermetatarsal space and reduces the risk of complications at the donor site.

“Recycling” this metatarsal as a non-vascularized bone graft represents a novel option for reconstructing an amputated hand ray. It yields good functional results and enables the patient to perform a wide range of daily activities. In our case, the patient’s aesthetic and functional perceptions were somewhat lower than the average reported in the reference series.<sup>5</sup>

This technique allows a type 2 metacarpal hand to be addressed in a single surgical stage and with the transfer of only one toe, reducing operative time and potentially lowering the complication rate.

Longer follow-up and a larger cohort are necessary to assess the long-term viability of the technique.

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# What if It All Began with a Broken Bone? Paleolithic Reflections on the Origins of Medical Care and Traumatology

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## ABSTRACT

Fractures represent one of the earliest tangible traces of medical care in prehistory. Osteological evidence from Paleolithic sites such as Shanidar (Iraq) and Krapina (Croatia) shows that individuals with severe injuries survived thanks to sustained, collective care. These healed fractures reflect not only biological responses and rudimentary immobilization practices, but also social behaviors involving support and task redistribution. This article argues that traumatology, understood as a response to visible bodily trauma, may have constituted the earliest form of organized medical practice. In an era of increasing specialization, revisiting this ethical and communal foundation reminds us that orthopedic care remains, at its core, a deliberate act of supporting and caring for others.

**Keywords:** Paleolithic; bone fractures; traumatology; healthcare; bioarchaeology.

**Level of Evidence:** V

## ¿Y si todo comenzó con un hueso roto? Reflexiones paleolíticas sobre el origen del cuidado médico y la traumatología

## RESUMEN

Las fracturas constituyen una de las primeras huellas tangibles del cuidado médico en la prehistoria. La evidencia osteológica de sitios paleolíticos, como Shanidar, en Irak, y Krapina, en Croacia, demuestra que individuos con lesiones graves sobrevivieron gracias a una atención sostenida y colectiva. Estas fracturas cicatrizadas reflejan no solo respuestas biológicas y de inmovilización rudimentaria, sino también respuestas sociales de acompañamiento y redistribución de tareas. Este artículo propone que la traumatología, entendida como reacción al trauma visible, pudo haber sido el primer gesto médico organizado. En una era de alta especialización, recuperar esa raíz ética y solidaria nos recuerda que la práctica ortopédica sigue siendo, en esencia, una decisión de cuidar y sostener al otro.

**Palabras clave:** Paleolítico; fracturas óseas; traumatología; atención de la salud; bioarqueología.

**Nivel de Evidencia:** V

*“Because not only might the history of medicine have begun with a broken bone, but in some cases, so might our own individual paths as physicians.”*

*In memory of Dr. Gustavo Argibay, an example of science, skill, and humanity.*

When we attempt to reconstruct the origins of medicine, we often imagine herbal preparations, shamanic rituals, or even the earliest trepanations. However, osteological evidence invites us to shift these hypotheses toward another phenomenon, simpler from a pathophysiological perspective, more concrete, yet equally profound: the treatment of a fracture.

A fracture is visible, painful, and functionally disabling. In a hostile environment, at the mercy of predators and dependent on constant mobility, it can be life-threatening.

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Skeletal remains recovered from Paleolithic sites show a remarkable frequency of healed fractures. According to Spikins et al.,<sup>1</sup> between 79% and 94% of the skeletons analyzed exhibit signs of bone trauma, and between 37% and 52% correspond to severe injuries. Even more striking, approximately 13–19% of these traumas occurred early in life. In contexts where a severe fracture could mean the end of an individual's usefulness to the group, these data are as surprising as they are revealing.

One of the most emblematic cases is Shanidar 1, discovered in present-day Iraqi Kurdistan. Dated between 35,000 and 70,000 years before present, he was an adult male who lived to approximately 35–40 years of age—remarkable longevity for his era—despite presenting multiple injuries, including a probable right forearm amputation, bone deformities due to infection, cranial damage, unilateral deafness, and chronic lameness.<sup>2,3</sup>

Today, such conditions would require a combination of surgery, analgesia, rehabilitation, and nutritional support, an intervention of a complexity and level of coordination far beyond simple goodwill care. In the Paleolithic, his recovery can only be explained by prolonged intervention consisting of direct care, accompaniment, and redistribution of tasks.

Some might argue that Shanidar 1 was not “cured” of all his ailments in the strict technical sense. But he survived. And survival, in that context, is sufficient proof that someone intervened in a systematic, planned, and intentional manner. As Tilley<sup>4</sup> explains, the mere fact that an individual with such a degree of disability reached adulthood requires sustained social commitment.

The methodology of the bioarchaeology of care, proposed by Lorna Tilley, provides a rigorous framework for interpreting this type of evidence. This model outlines four stages: diagnosis of the pathology, assessment of functional limitations, inference about the nature of the care provided, and analysis of the cultural context that made such care possible.<sup>4</sup>

This methodology has been applied to numerous archaeological sites. In Krapina (Croatia), dated to over 120,000 years ago, at least 11 individuals with healed fractures of the clavicles, ulnae, ribs, and skull have been documented. These injuries, as Rajković and Krklec<sup>5</sup> note, not only healed but did so under conditions that implied sustained care: wound cleaning, rudimentary immobilization, protection of the injured individual, and support throughout the recovery period. Thus, we can assert that bone injury, in these contexts, becomes a fossilized trace of collective care.

Fractures have a particular feature that makes them central to understanding the origins of medicine: they are visible. Unlike internal diseases or psychological conditions, a fracture is difficult to conceal. It usually causes immediate incapacity.

In a subsistence environment based on mobility, gathering, and hunting, an injured limb may have represented, at the same time, a threat to the survival of the group and an opportunity to exercise solidarity.

Spikins et al.<sup>1</sup> propose that care in Neanderthal communities was neither anecdotal nor solely motivated by kinship ties. It was an adaptive strategy, a way of maintaining group cohesion and making use of the non-physical abilities of injured individuals. Caring was not charity; it was social intelligence.

Within this framework, traumatology, understood as the response to visible trauma, may have been the first collective medical gesture. There were no scalpels or orthopedic splints. There were likely sticks, plant-fiber bandages, and assistance with eating, standing, and sleeping. And above all, there was time and presence.

Today we call “traumatology” a highly technical surgical specialty. Yet its etymological root (*trauma*, injury) together with its fundamental purpose, functional restoration and pain relief, connects it directly to that primordial act of supporting the fallen. A fracture remains an emergency that mobilizes us, a disruption that demands presence.

The 21st-century orthopedic surgeon has precise instruments, high-resolution imaging, and an ever-expanding technical corpus at their disposal. But their work continues to be, at its core, a response to trauma. And that response still involves not only technical intervention, but also emotional support, accompaniment, and the decision to hold.

## CONCLUSIONS

Was medicine born with traumatology? It is a possibility. In any case, there were bones that broke, and they were not abandoned. There was someone who, without knowing the word “*heal*,” tried to alleviate suffering. For the earliest form of medicine was neither science nor art, but an ethical reaction, a willingness not to leave the suffering person alone.

Understanding this not only helps us reflect on the origins of medical care; it forces us to reexamine the driving force behind our current practice. In an era of super-specialization, protocols, and efficiency, recovering that primitive gesture, the decision to be present, to support, to intervene in the face of injury, may well be the most contemporary act of all.

### Statement on the use of generative AI and AI-assisted technologies in the writing process

During the preparation of this manuscript, the author used ChatGPT-5 (OpenAI) to detect typographical errors. After using this tool, the author reviewed and edited the content as necessary and assumes full responsibility for the content of the publication.

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# Protocol for the Care of Non-Accidental Trauma in the Child and Adolescent Population: Radiological and Traumatological Aspects

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## ABSTRACT

Child and adolescent abuse is a violation of human rights and a major global public health problem affecting hundreds of millions of children and adolescents, with serious short- and long-term health consequences. One quarter of adults (22.6%) worldwide were victims of physical abuse during childhood; among them, 36.3% experienced emotional abuse and 16.3% experienced physical neglect, with no significant differences between boys and girls. However, the lifetime prevalence of childhood sexual abuse shows more marked differences, with rates of approximately 20% in girls and 8% in boys. This article describes the protocol used in our hospital for the diagnosis and management of bone injuries and compares it with the most recent systematic reviews published on the subject.

**Keywords:** Children; non-accidental trauma; radiological protocol.

**Level of Evidence:** IV

## Protocolo para la atención del trauma no accidental en la población infantojuvenil: aspectos radiológico y traumatológico

## RESUMEN

El maltrato de niños y adolescentes es una violación de los derechos humanos, además de un importante problema de salud pública mundial que afecta a cientos de millones de niños y adolescentes, y tiene graves consecuencias para la salud a corto y largo plazo. Una cuarta parte de los adultos (22,6%) del mundo sufrió abuso físico cuando eran niños; el 36,3% de ellos sufrió abuso emocional y el 16,3%, negligencia física, sin diferencias significativas entre niños y niñas, aunque la prevalencia de abuso sexual infantil a lo largo de la vida indica diferencias más marcadas (niñas alrededor del 20% y niños alrededor del 8%). Se describe el protocolo utilizado en nuestro hospital para el proceso de diagnóstico y tratamiento de las lesiones óseas, y se lo compara con las últimas revisiones sistemáticas publicadas.

**Palabras clave:** Niños; trauma no accidental; protocolo radiológico.

**Nivel de Evidencia:** IV

## INTRODUCTION

We define non-accidental trauma (NAT) as trauma sustained by a child or adolescent who has been subjected to aggression by parents or guardians, by institutions, or by society, as well as all conditions resulting from such acts that deprive them of their rights and fundamental needs and hinder their optimal development.<sup>1</sup>

There are four basic types of abuse:

- Sexual abuse
- Emotional abuse
- Physical abuse
- Neglect or maltreatment

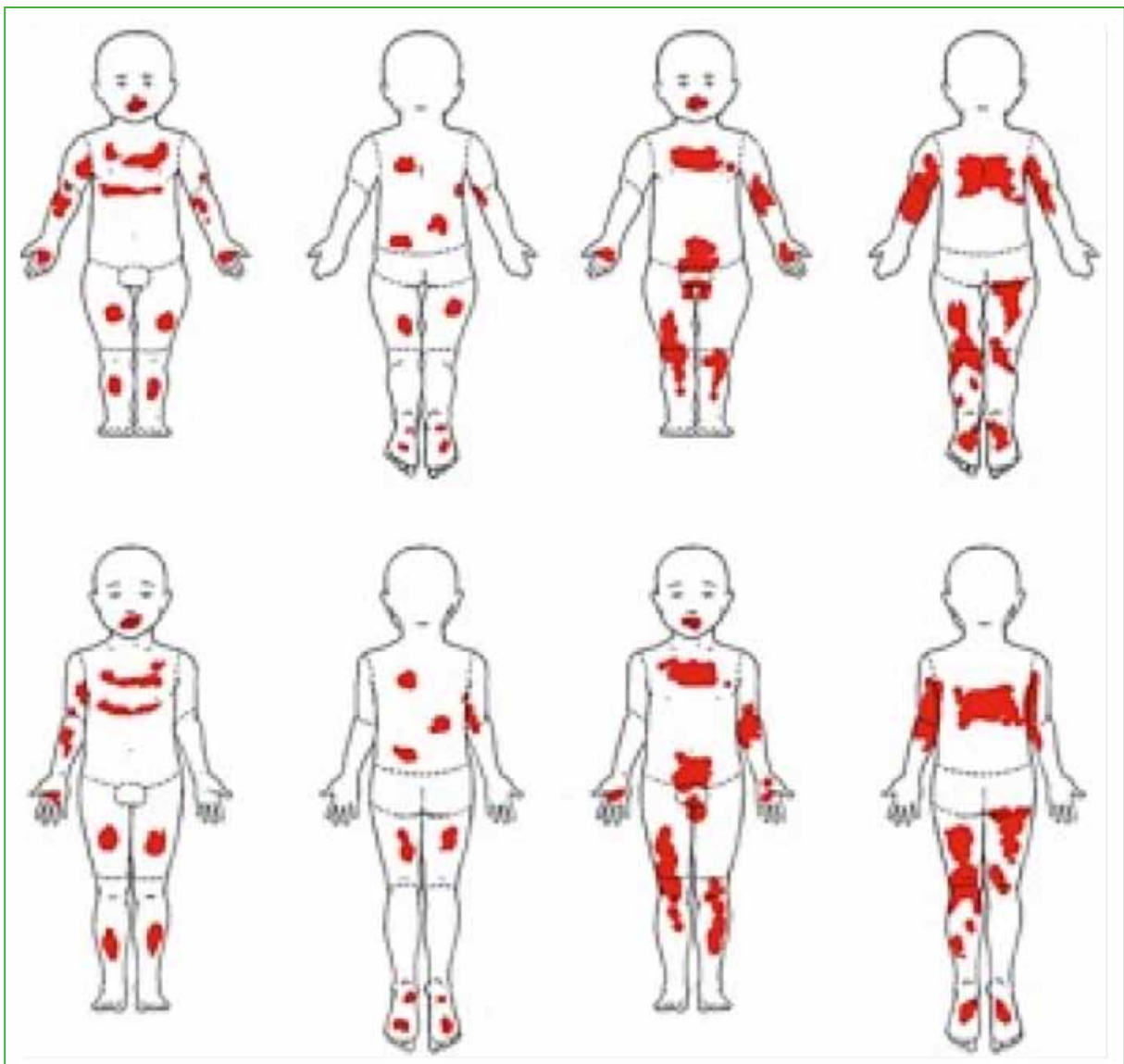
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Within these classifications, epidemiological data show that the clinical presentations prompting medical consultation are often accompanied by inconsistencies in the reported origin of the injuries and variability in how events are described. The rates of abuse by etiology are: neglect (59%), multiple types (13%), physical abuse (11%), sexual abuse (8%), emotional abuse (4%), and medical neglect (<1%).<sup>2</sup>

Although children of all ages and socioeconomic levels can suffer NAT, it occurs more frequently in the context of young first-time parents with unplanned pregnancies, in environments where substance abuse is present, in low-income families, or among parents with a history of being abused themselves.<sup>3,4</sup>

Imaging often plays an important role in detecting and documenting physical injuries. The type and extent of imaging performed in a child when abuse is suspected depend on the child's age, signs, symptoms (Figure 1), and other social considerations, such as being the twin or sibling of a physically abused infant. Establishing a diagnosis of child maltreatment requires distinguishing between anatomic and developmental variants and possible underlying metabolic or genetic conditions.<sup>5</sup>



**Figure 1.** Areas hidden by hair or clothing where attention should be paid when assessing for soft-tissue injuries.

Between January 2023 and June 2024, 766 pediatric and adolescent patients with suspected NAT were evaluated in the hospital's Medium-Risk Service.

In 15.1% of cases (81 patients), physical abuse was suspected. Twenty-five of these patients required hospitalization (30%). Indicators for hospital admission included:

Need for urgent treatment requiring inpatient care.

Need for immediate protection of the minor while awaiting a temporary home or shelter.

Need to observe family dynamics during the assessment and diagnostic phase in severe situations.

Child evaluated in the hospital emergency department before completion of the assessment and treatment phase, in cases of severe maltreatment.

Given the high frequency of this situation, the following protocol was developed.

## RADIOLOGICAL PROTOCOL FOR CHILDREN WITH SUSPECTED NAT (PEDIATRIC RADIOLOGY SERVICE)

When there is clinical suspicion, the Radiological Protocol for Children detailed in [Table 1](#) is applied.

**Table 1.** Areas to be examined and recommended projections<sup>8</sup>

Skull*	Anteroposterior and lateral; additional Towne projection if clinically indicated
Thorax	Anteroposterior including clavicles, and oblique projections of both rib cages
Abdomen	Includes pelvis and hips
Spine	Lateral projection of the cervical, thoracic, and lumbar regions
Extremities	Anteroposterior view of both humeri, both forearms, femurs, tibiae, and fibulae. Hands: anteroposterior. Feet: dorsoplantar

\*Skull radiographs should be obtained even if a CT scan has been performed.

1. In children <2 years of age, always request a skeletal survey as the preferred study. A “total body” or “baby-gram” is never indicated. If the chest radiograph raises doubts about rib injuries, consider a chest computed tomography (CT) scan.

When suspicion of NAT is high and the skeletal survey is normal, a repeat study should be performed 11–14 days later.

2. In children <1 year of age, always perform an urgent head CT scan.

3. In children >1 year with evidence of head trauma or neurological symptoms, perform an urgent head CT scan.

4. Consult with the Pediatric Radiology Service regarding the need for brain magnetic resonance imaging (MRI). Complete spine MRI and whole-body MRI should be performed 2–5 days after admission, regardless of whether the CT scan is normal. These must be interpreted by two pediatric radiologists. Follow-up brain MRI will be performed according to the initial findings and the patient's clinical evolution.

5. A skeletal survey may be indicated in children >2 years, in which case it will be performed preferentially and according to the patient's clinical presentation.

6. In a severe case with suspected NAT:

a) In twins or children <2 years, consider applying the same protocol used for the index case.

b) In siblings >2 years, imaging studies should be performed according to each child's clinical presentation.

7. In cases of thoracic or abdominal trauma, imaging studies will be decided jointly by the treating physician and the radiologist on call.

8. Deceased child: complete skeletal survey, and whole-body MRI and CT. The required radiographs are sent to the Radiology Department labeled as NAT so that all technicians know to perform, in a single session, all radiographs required by the protocol to detect possible injuries, without drawing the attention of accompanying family members.

## DISCUSSION

Fractures are the second most common sign of physical abuse (25–50%), followed by burns (20%). It is estimated that 10% of trauma cases in children <3 years of age treated in emergency departments are non-accidental, but underreporting occurs due to minimization of the situation or failure to properly investigate the causes. In many instances, these patients are evaluated by a traumatologist as the first-line clinician, without support from a multidisciplinary team.<sup>6-9</sup>

Although many publications refer to specific fracture patterns for this condition, its presentation is similar to accidental trauma. However, clinicians must remain alert to the coexistence of these injuries with soft-tissue findings such as burns or bruising; moreover, the presence of this condition accompanied by retinal injuries is pathognomonic.<sup>10</sup>

The different stages of fracture evolution are what trigger red flags.<sup>11</sup>

In 2020, the Royal College of Paediatrics and Child Health<sup>6</sup> published a systematic review of fractures resulting from non-accidental trauma, summarized as follows:

1. Abuse-related fractures are more common in children <18 months than in those >18 months.
2. Abused children are more likely to present with multiple fractures than non-abused children.
3. Rib fractures without significant trauma, birth injury, or underlying bone disease have a high predictive value for abuse.
4. Femoral fractures due to abuse are more likely in children who are not yet walking (Figure 2).
5. Mid-shaft fractures are the most common type of femoral fracture in both abuse and non-abuse situations.
6. Supracondylar humeral fractures in children are typically associated with accidental injuries, whereas the most common humeral fractures due to abuse in children <5 years of age are spiral or oblique fractures (Figure 3).
7. Humeral fractures in children <18 months are more strongly associated with abuse than humeral fractures in older children.
8. Linear fractures are the most common skull fractures in both abuse and non-abuse cases.
9. Metaphyseal fractures are more common in cases of physical child abuse than in non-abuse, and have often been described in fatal abuse scenarios.
10. Most children with classic metaphyseal lesions have additional associated injuries, which are often multiple.
11. Fractures of the pelvis, hands, feet, and sternum can occur in physical abuse and require appropriate imaging for detection.

The accuracy of radiological estimates of the time elapsed since the injury is expressed in weeks rather than days. The different healing stages visualized on the skeletal survey are used to date the fracture as follows:

1. Resolution of soft-tissue injury: 1 week
2. Formation of new subperiosteal bone: 2 weeks
3. Loss of the fracture line and formation of soft callus: 3 weeks
4. Hard callus: 3–6 weeks
5. Remodeling: more than 3 months

Radiological evaluation in suspected physical abuse includes initial and follow-up imaging studies, performed during weekly monitoring of family members, specifically to maximize the detection of occult injuries.



**Figure 2.** Femoral injury in a non-ambulatory child.



**Figure 3.** Spiral fracture due to non-accidental trauma.

Specificity is defined according to the relationship between the fracture pattern and the mechanism of trauma (Table 2).

Bone scintigraphy is a useful study for detecting rib and vertebral fractures. Repeating it 2 weeks later may help identify occult injuries, but it is reserved only for highly suspicious cases with negative radiographs at the initial consultation.<sup>12</sup>

**Table 2.** Relationship between fracture pattern and specificity<sup>13</sup>

<b>High-specificity fractures</b>
<ul style="list-style-type: none"> <li>• <b>Metaphyseal injury:</b> fracture at the junction of the metaphysis and physis (primary spongiosa). Mechanism: torsion or shear due to traction, i.e., when a child's limb is violently pulled or twisted.</li> </ul>
<p><i>Differential diagnosis:</i> subepiphyseal metaphyseal radiolucencies may also arise from systemic diseases such as rickets or leukemia.</p>
<ul style="list-style-type: none"> <li>• <b>Corner fracture:</b> small metaphyseal avulsion. A notch is visible at the metaphyseal margin without significant epiphyseal displacement.</li> </ul>
<ul style="list-style-type: none"> <li>• <b>Bucket-handle fracture:</b> involves a large segment of the metaphyseal rim; a horizontal avulsion fracture of central and peripheral components, giving the appearance of a bucket handle.</li> </ul>
<ul style="list-style-type: none"> <li>• Rib fractures, especially posterior: uncommon as accidental injuries in childhood.</li> </ul>
<ul style="list-style-type: none"> <li>• Scapular fracture: more specific for abuse when associated with ipsilateral clavicular fracture. Not to be confused with the accessory ossification center of the acromial tip.</li> </ul>
<ul style="list-style-type: none"> <li>• Sternal fracture</li> </ul>
<ul style="list-style-type: none"> <li>• Fracture of vertebral spinous processes</li> </ul>
<b>Moderate-specificity fractures</b>
<ul style="list-style-type: none"> <li>• Epiphyseal separation or epiphyseal detachment: the most common is distal humeral transphyseal separation, followed by that of the hip.</li> </ul>
<ul style="list-style-type: none"> <li>• Multiple fractures at different stages of healing, particularly bilateral</li> </ul>
<ul style="list-style-type: none"> <li>• Fractures or subluxations of vertebral bodies</li> </ul>
<ul style="list-style-type: none"> <li>• Digital fractures</li> </ul>
<ul style="list-style-type: none"> <li>• Complex skull fractures</li> </ul>
<b>Low-specificity fractures</b>
<ul style="list-style-type: none"> <li>• Clavicle fracture</li> </ul>
<ul style="list-style-type: none"> <li>• Diaphyseal long-bone fracture</li> </ul>
<ul style="list-style-type: none"> <li>• Linear skull fracture</li> </ul>

## CONCLUSION

Within our fracture series, lower-limb fractures (70%) were the most frequent, and among these, long-bone fractures (femur 60%), findings consistent with those of other published series.<sup>13,14</sup>

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# Case Resolution

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*Case Presentation on page 499.*

## ABSTRACT

We present the case of an 18-month-old boy with a displaced pelvic fracture and hip epiphysiolysis resulting from non-accidental trauma, after being dragged down a flight of stairs by his caregiver. The radiological protocol used in our institution for suspected non-accidental trauma is described, along with the diagnostic process and the orthopedic and social management implemented.

**Keywords:** Non-accidental trauma; pelvic fracture; hip epiphysiolysis; children.

**Level of Evidence:** IV

## RESUMEN

Se presenta el caso de un niño de 18 meses con una fractura desplazada de pelvis y epifisiólisis de cadera producidas por un trauma no accidental al ser arrastrado por las escaleras, por su cuidadora. Se define el protocolo radiológico utilizado en nuestra institución para los casos de trauma no accidental, su diagnóstico y los tratamientos ortopédico y social.

**Palabras clave:** Trauma no accidental; fractura de pelvis; epifisiólisis de cadera; niños.

**Nivel de Evidencia:** IV

**DIAGNOSIS:** Multiple pelvic and hip fractures due to non-accidental trauma in an 18-month-old child.

## DISCUSSION

Puncture-aspiration was performed under anesthesia to assess the degree of epiphyseal displacement<sup>1</sup> and to evacuate the joint hematoma.<sup>2</sup> Then, using a small amount of contrast medium, an arthrogram was performed, which confirmed the displacement and its instability. Magnetic resonance imaging is another modality to reach the diagnosis when instability is suspected; however, an MRI scanner should be available near or within the operating room to perform it during the same anesthetic procedure (Figures 4 and 5).

Using the Parsch technique<sup>3</sup> via a minimal Hueter approach,<sup>4</sup> the displacement of the femoral head was reduced, and a screw and a pin were placed through a minimal lateral approach under fluoroscopic guidance.

Once the hip had been drained and stabilized, another cannulated screw was inserted percutaneously to stabilize the large fragment avulsed from the iliac wing. The patient was immobilized with a hip spica cast to control the open-book component, and soft-tissue traction was applied; the patient was then placed in postoperative traction. Traction was continued for 3 weeks, and anatomical reduction of the fractures was achieved (Figures 6-8).

Figures 9 and 10 show the imaging follow-up at 6 and 24 months after removal of the osteosynthesis material.

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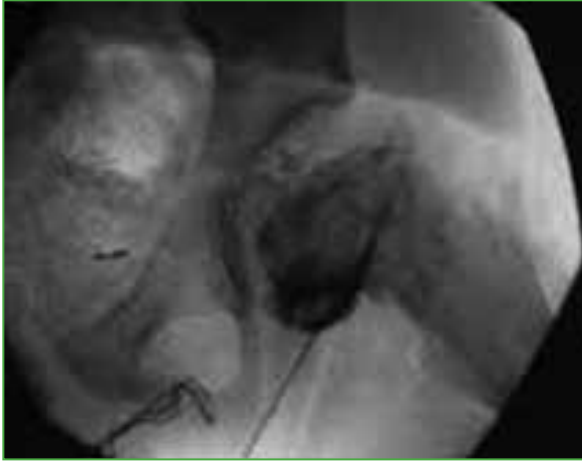


Figure 4. Diagnostic hip arthrogram.



Figure 5. Hip MRI. Grade I epiphyseal displacement is observed.



Figure 6. Positioning and application of a hip spica cast.



**Figure 7.** Patient in bed traction to achieve reduction of the displaced hemipelvis.



**Figure 8.** Hip radiograph immediately after reduction.



**Figure 9.** Anteroposterior pelvic radiograph at 6 months when osteosynthesis material was removed.



**Figure 10.** Hip radiograph 24 months after surgery.

Although the pelvis of an 18-month-old child contains a large amount of cartilage, which provides increased elasticity and resistance to torsional and shear forces, this same cartilage has high remaining growth potential. Therefore, this type of high-energy trauma can cause permanent damage to the pelvic girdle, the hip joint due to injury mainly to the triradiate cartilage, and in this case, to the proximal femur.<sup>5</sup>

For the reasons described above, stabilization of the femoral epiphysiolysis and of the iliac wing physis was chosen using minimally invasive techniques in order to avoid additional periosteal stripping or damage to the regional blood supply.

When treating a pelvic fracture in children, the instability pattern and the degree of displacement, together with the associated growth-plate injury, must be considered. The belief that anatomical deformities will not cause problems in adulthood is unacceptable.

Vertically displaced unstable type C pelvic fractures can progress to clinically significant pelvic deformity, as well as sacroiliac fusion, scoliosis, and lower-limb length discrepancy.<sup>6</sup>

We must therefore make every effort to ensure that our reduction maneuvers are precise and avoid further stress on the cartilage, especially in the region of the triradiate cartilage or, as in this case, the Risser cartilage.<sup>7</sup> Otherwise, the growth of the pelvic ring will be inhibited, and growth-plate arrest will lead to pelvic asymmetry.

In the treatment of transphyseal fracture of the proximal femur, once instability was confirmed, priority was given to achieving stability by placing a central screw, which was removed at 4 months to prevent physeal arrest *per se*.<sup>8</sup>

Conflicts of interest: The authors declare no conflicts of interest.

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# Prof. Dr. Salomón Schächter (1926-2025)



*Emeritus Professor, Université René Descartes, Paris*  
*Member, Académie Nationale de Médecine, France*  
*Member, Académie de Chirurgie, France*

Salo is gone. We never worked together in a hospital or clinic. I never saw him operate. We belonged to different disciplines. It is hard for me to go back and trace exactly how our paths first crossed. I shared with him other aspects of our medical life. I served on the AAOT Board of Directors during his presidency. Later, I worked alongside him at SLAOT and at the Faculty of Medicine. Finally, when Jorge Romanelli was unable to present his book, he asked me to do it. I will use here some paragraphs of that presentation at the Argentine Medical Association a couple of years ago, because in reading them one can glean many biographical details, his achievements, and his legacy. I remember asking ChatGPT from OpenAI for help at that time.

*“Schächter por Schächter. Una historia de vida”*: I had read it in the summer of 2022. I was in Pinamar; it was a good time for reading. I didn’t write notes in the margins, but I wrote down many definitions and reflections. I didn’t read it twice because I didn’t want to study it like a textbook: I wanted to read it as a book. Perhaps I will return to it in the future, as I do with many books. But every book leaves an impression on the reader. Perhaps, as Joseph Conrad said, *“One writes only half the book; the other half is with the reader.”*

In presenting the book, it was essential first to speak about its author. He was known by many, each from different perspectives. Schächter was a distinguished physician, with virtually every achievement, honor, position, and recognition a medical professional can aspire to. He lacked nothing, except writing that book. He had published five others, but this last one was different. It was his story.

The book was essentially his biography: his journey from distant Tarnopol, in Poland (today Ukraine), where he was born, to the pampas of Argentina. He embodied the archetype of the Argentine physician—the son of immigrants, an immigrant himself—who came from Europe and grew up, trained, and flourished here. With few demands, I imagine few rights, and many obligations, mostly personal ones. He transformed every environment in which he worked, trained physicians, and left behind disciples. His time in the different departments left indelible marks. I was told he was a demanding chief, requiring absolute attention, a devotee of punctuality and precision. His perseverance and, above all, his intellectual rigor and honesty were admirable. A master surgeon, yet always deeply respectful of the patient. A surgeon of unwavering precision, always the same number of stitches in every THA. He was never heard raising his voice, though he was not paternalistic.

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Although I had known Salo for many years, our clinical work never overlapped; our specialties were different, I worked in pediatric hospitals. But I came to know him deeply through his institutional, societal, and academic roles. He was the sponsor of my doctoral thesis. I had the pleasure and honor of accompanying him through various scientific and professional institutions. That is how I came to understand his work within the Argentine Association of Orthopedics and Traumatology. Later, in the early 1990s, during his presidency of the Latin American Society of Orthopedics, and then at the Faculty of Medicine in Buenos Aires, when he served as Dean at the end of the last century and the beginning of the current one. Later still, when he created ESCORT, a pioneering distance-learning platform for orthopedic surgery.

In SLAOT, as we used to call it, many years ago, we enjoyed giving lectures in places throughout Latin America, some of them quite remote. At the Faculty, he lived through turbulent years. We would meet at 6 a.m. at the café on Marcelo T and Azcuénaga to plan the day. It is a pity the Faculty could not be fully set on the right course during his tenure; he remained loyal to ideas and principles that politics could never bend.

What can I say about the book? The book unfolds across four main sections: *Mis comienzos* (My Beginnings), *Mi trayectoria* (My Career), *Plática con y para mis nietas y nietos* (Conversations With and For My Grandchildren), and finally *Y ahora qué* (And Now What).

In *Mis Comienzos*, he recounts his early years in a Europe shaken by tension and uncertainty, with the distant rumblings of World War II already audible. It was a troubling and increasingly hostile environment, especially for Jews. His arrival in Buenos Aires brought his family to what he describes as a safe, welcoming Argentina—an Argentina open to those willing to work hard. It was, in his words, a land of opportunity. His description of adapting to school life is particularly striking, portraying both the linguistic hurdles and the perseverance required to overcome them. A quiet sadness weaves through those pages.

In *Mi Trayectoria*, the first hundred pages reveal a man with an almost priestly relationship to medicine. He appears as a kind of medieval monk, devoted exclusively to the love and study of his discipline—living almost entirely for the practice of medicine, with scarcely any intervals of leisure. His approach feels reverential, nearly ascetic.

As Dean, his most significant ambitions were curricular reform and adjusting the Faculty's educational capacity. He believed the undergraduate curriculum should be grounded in an integrated basic-clinical model, with early exposure to real clinical settings where knowing and doing must be inseparable. Educational capacity, he argued, should be shaped by the availability of actual healthcare resources. His persistent reflections on study, work, and responsibility paint a vivid portrait of his character. His conviction that ethics and morality are learned within the family—at home, not in the Faculty—is a core principle running through his thinking.

In the newspaper *La Prensa*, over several months in 2020—likely during the height of the pandemic—Schächter published a series of anecdotes accompanied by his own reflections. The stories of Evaristo, his interviews with Escardó (Piolín de Macramé), the anecdote involving Sandro and his connection to Ferré, his mentor, are truly unmissable. The narratives are unique, and the reflections that follow them even more so, ranging from the humility that elevates character to the understanding and tolerance that must never be absent in a physician.

In *Plática con y para mis nietas y nietos*, he opens himself to a wide array of questions: What is my philosophical orientation? Do I believe in the existence of God? How do I see myself socially? What do I love most about my work? He speaks about art, life and death, what he might study if not medicine, and the “youth of my old age.” And in the final conversations with Nico, he reflects on how he positions himself politically, socially, and philosophically. I don't want to spoil the details, but it is in these pages where his personality emerges most transparently.

I must also highlight a series of phrases and passages scattered throughout the book.

When welcoming new students, he writes that one must work with love—and that is how one works when one carries within oneself the spring of an ideal. He then affirms that those who work under such conditions imprint a stamp of youth upon their actions, and that youth is found precisely in those who work with enthusiasm for an ideal.

He states that science is neither good nor bad, neither moral nor immoral in itself. It is human beings, it is the scientist who gives—or fails to give—it its ethical and human substance.

With a note of nostalgia, he reflects that overspecialization, excessive technicality, and the massification of medical care have, in some measure, contributed to the decline of the physician's traditional wisdom, artistry, and virtue.

He claims that his greatest professional merit was having worked intensely; and, in another paragraph, he summarizes a philosophy that shaped his entire career: one learns to work by working, one learns to teach by teaching, one learns to operate by operating.

He would often repeat Antonio Machado's reflection on knowledge and culture: Only what is kept is lost; only what is given is preserved.

Paraphrasing Mother Teresa, he wrote that one must never stop in life. If one cannot run, one must jog. If one cannot jog, one must walk. If one cannot walk, one must use a cane. If that is not enough, then a wheelchair—but one must never stop.

In the final section, he asks himself, "And now what?" He reflects on old age. A friend's sarcastic remark serves as illustration: human life can be divided into four stages—childhood, adolescence, adulthood, and "my, how good you look!" He reflects as well on regrets, and even asks forgiveness for believing he may have made mistakes.

I ended by telling Salo that I had truly enjoyed reading his book—his life story, both professional and intimate, all the way to Dulcinea and his family.

I wholeheartedly recommend reading this book to anyone wishing to understand the life and work of Schächter (with an umlaut on the a, as he always insisted). Its pages relieve me—or at least greatly ease—the task of presenting him and recalling him today. I sense that almost everything is already there.

Allow me to add Francis Bacon's words:

*"Some books are to be tasted, others to be swallowed, and some few to be chewed and digested."*

*Prof. Dr. Carlos Tello  
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