Journal of the Asociación Argentina de Ortopedia y Traumatología

AN ORGAN OF THE ASOCIACIÓN ARGENTINA DE ORTOPEDIA Y TRAUMATOLOGÍA

VOL. 89, N.° 6 / DECEMBER 2024 / Pp. 559-673

Full english text available. Indexada en SciELO, LILACS, Latindex, Dialnet, Doaj, Redib, AmeliCA y JournalTOCs • Incluida en el Núcleo Básico de Revistas Científicas Argentinas del CONICET.
ISSN 1852-7434 (EN LÍNEA)

First Edition of the Course "Fundamentals of Peer Review"

Dr. Guillermo A. Ricciardi
Orthopedics and Traumatology Service, Hospital General de Agudos "Dr. Teodoro Álvarez", Autonomous City of Buenos Aires

"Doubt is one of the names of intelligence."
Jorge Luis Borges

The Editorial Board is pleased to announce the successful completion of the first edition of the course "Fundamentals of Peer Review." This activity is designed for health professionals who currently serve, or are interested in serving, as manuscript reviewers for the Journal of the Argentine Association of Orthopedics and Traumatology.

Being a reviewer is a vital task in academic life, ensuring the quality and integrity of published knowledge. The "researcher-reviewer" archetype serves as the ideal guiding model for this role. A reviewer's competence is primarily supported by their expertise in a specific scientific area and their understanding of research methodology. However, the reviewer's perspective differs significantly from that of a researcher. It requires mastering distinct processes and skills to perform the task effectively. Progress in this role comes from critical inquiry, and this course was specifically designed to bridge the gap between the academic and clinical experiences of orthopedic surgeons and the critical assessment of scientific literature.

We are pleased to report the positive reception of the first edition, which was attended by 29 registered physicians. Participants successfully completed six modules, three practical sessions, three synchronous meetings, and a final evaluation. It is our hope that the course "Fundamentals of Peer Review" will remain a valuable addition to the ongoing professional development of orthopedic surgeons in future editions.

Dr. GUILLERMO A. RICCIARDI • guillermoricciardi@gmail.com https://orcid.org/0000-0002-6959-9301

How to cite this article: Ricciardi GA. First Edition of the Course "Fundamentals of Peer Review". *Rev Asoc Argent Ortop Traumatol* 2024;89(6):559. https://doi.org/10.15417/issn.1852-7434.2024.89.6.2073

Case Presentation

Reynier Ramírez Suárez,[*] Norys Tan Suárez,[**] Nidhessy Pagés Morales[#]
[*]Maxillofacial Surgery Service, Hospital Universitario "Manuel Ascunce Domenech", Universidad de Ciencias Médicas, Camagüey, Cuba
[**]School of Stomatology, Universidad de Ciencias Médicas, Camagüey, Cuba
[#]Imaging Service, Hospital Universitario "Manuel Ascunce Domenech", Universidad de Ciencias Médicas, Camagüey, Cuba

Resolution on page 657.

Pain in the Temporomandibular Region

ABSTRACT
The case of a 54-year-old female patient who presented to the clinic with pain in the left temporomandibular joint is described. Following a physical examination, imaging studies were conducted, revealing nodular calcifications in the internal region of the left mandibular ramus as a radiographic finding. Additional imaging studies were subsequently requested.
Keywords: Phleboliths; vascular anomaly; calcifications; radiopaque.
Level of Evidence: IV

Dolor en la región temporomandibular

RESUMEN
Se presenta el caso de una mujer de 54 años de edad que acudió a la consulta por dolor en la articulación temporomandibular izquierda. Luego del examen clínico, se solicitaron estudios por imágenes y, en las radiografías, se observaron calcificaciones nodulares en la región interna de la rama mandibular izquierda. Se decidió indicar otros estudios por imágenes.
Palabras clave: Flebolito; anomalía vascular; calcificaciones; radiopaco.
Nivel de Evidencia: IV

INTRODUCTION

A 54-year-old woman presented with pain in the left temporomandibular joint (TMJ). Clinical examination revealed partial edentulism in both the upper and lower arches, crepitus in the left TMJ, tenderness upon palpation, and restricted opening and closing movements. Panoramic and selective radiographs of the TMJ were obtained (Figures 1 and 2).

FINDINGS AND INTERPRETATION OF IMAGING STUDIES

The panoramic radiograph revealed partial edentulism in the upper and lower arches with bone resorption secondary to tooth extraction, further exacerbated by the absence of prosthetic rehabilitation. The remaining teeth showed restorations. In the region of the left mandibular ascending ramus, multiple nodular calcifications were observed, characterized by a radiopaque halo surrounding a central radiolucent area.

The TMJ radiograph demonstrated sclerotic areas and erosion, predominantly in the left condylar region. The calcifications identified on the panoramic radiograph were visualized with greater precision.

Received on June 11th, 2024. Accepted after evaluation on September 2nd, 2024 • Dr. REYNIER RAMÍREZ SUÁREZ • reynierramirez93@gmail.com https://orcid.org/0000-0002-3759-0249
How to cite this article: Ramírez Suárez R, Tan Suárez N, Pagés Morales N. Postgraduate Orthopedic Instruction - Imaging. Case presentation. *Rev Asoc Argent Ortop Traumatol* 2024;89(6):560-561. https://doi.org/10.15417/issn.1852-7434.2024.89.6.1978

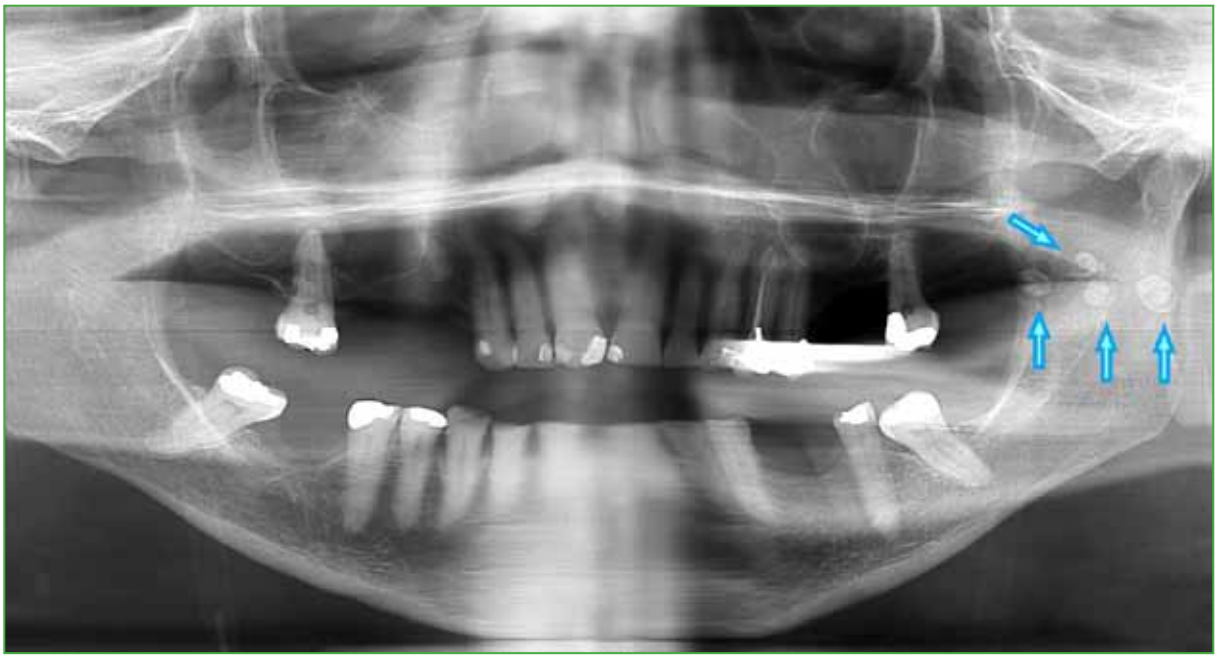


Figure 1. Panoramic radiograph of the temporomandibular joint.

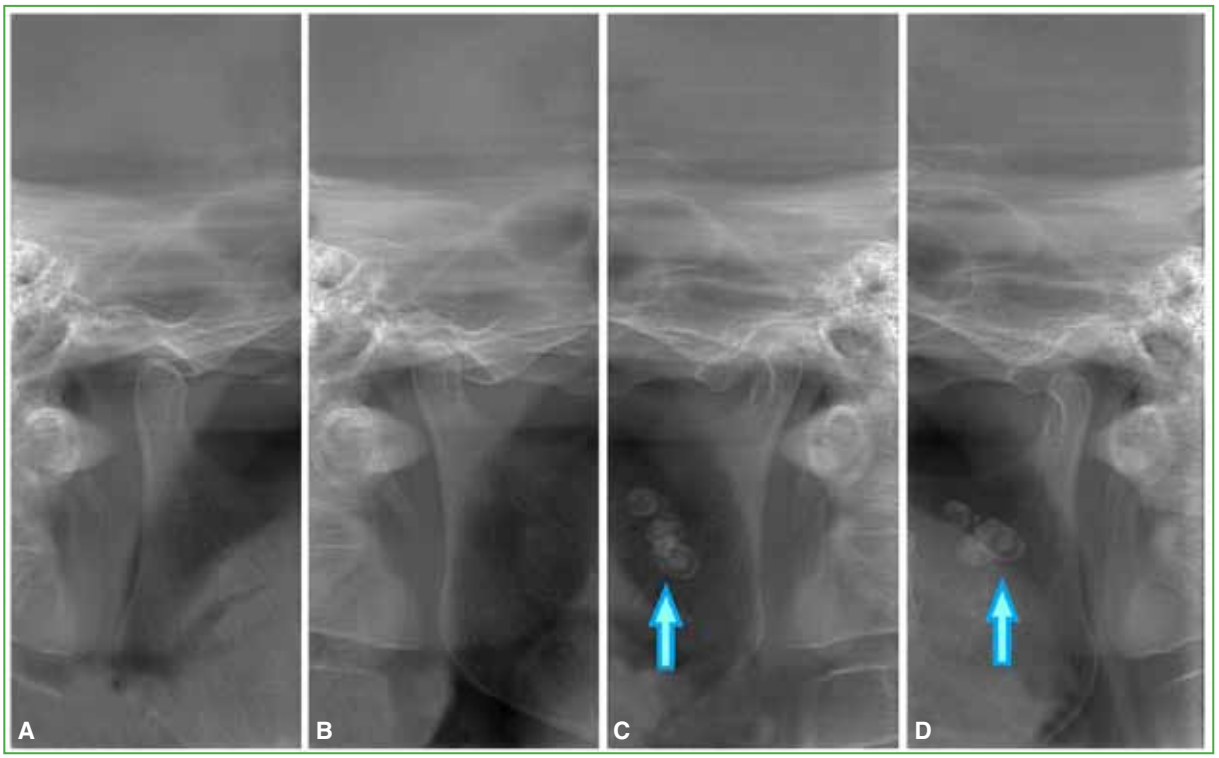


Figure 2. Radiograph of the temporomandibular joint. **A.** Right joint with open mouth. **B.** Right joint with mouth closed. **C.** Left joint with mouth closed. **D.** Left joint with open mouth.

N. Tan Suarez ORCID ID: https://orcid.org/0000-0002-6328-0631
N. Pagés Morales ORCID ID: https://orcid.org/0009-0002-4092-4577

Clavicle Fracture: MIPO Superior Fixation Technique

Facundo Fazzone, Rafael Garay, Santiago Focaraccio, Carlos E. Martínez, Ítalo A. A. Tornatore Garrido
Upper Limb Team, Instituto Dupuytren de Traumatología y Ortopedia, Autonomous City of Buenos Aires, Argentina.

ABSTRACT

Introduction: Since Neer's foundational work, the superiority of surgical treatment over conservative management for displaced clavicle fractures has been established. However, open techniques carry risks such as sensory nerve injury, stretching, and painful scarring. The MIPO (minimally invasive plate osteosynthesis) technique may mitigate these complications. This retrospective series evaluates our experience with closed, displaced, midshaft clavicle fractures, describes the surgical technique with emphasis on the approach, and presents functional outcomes. **Material and Methods:** We retrospectively analyzed 32 patients (28 men [87.5%] and 4 women [12.5%]) with closed, simple, or comminuted fractures of the middle third of the clavicle treated surgically between January 2021 and March 2023. The average follow-up was 19 months (range 14–25), and the mean patient age was 32 years. Exclusion criteria included patients under 16 years old, associated injuries, and significant comorbidities. Functional outcomes were assessed using the ASES and the visual analog scale (VAS) for pain. **Results:** Surgery was performed within 3 days of injury, and radiological consolidation occurred at an average of 15.6 weeks. The mean modified Constant-Murley score was 88.34, the mean ASES score was 83.8, and the mean VAS pain score was 0.5. No cases of subclavicular hypesthesia or painful scarring were reported. **Conclusion:** This technique achieved fracture consolidation and full range of motion while minimizing complications. The MIPO approach, with its simple and reproducible parameters, can be considered a safe option.

Keywords: Fracture; clavicle; MIPO; nerve injury.
Level of Evidence: IV

Fractura de clavícula: técnica MIPO de fijación por la cara superior

RESUMEN

Introducción: A partir de los estudios clásicos propuestos por Neer, se ha establecido que los resultados de la cirugía abierta son superiores a los del tratamiento conservador en las fracturas desplazadas de clavícula. Sin embargo, la técnica abierta no está exenta de complicaciones (lesión nerviosa sensitiva, desperiostizaciones, cicatriz dolorosa). La aplicación de la técnica MIPO permitiría disminuir estos riesgos. **Objetivos:** Comunicar nuestra experiencia en fracturas cerradas, desplazadas y mediodiafisarias de clavícula; describir la técnica quirúrgica focalizando en el abordaje y mostrar los resultados funcionales. **Materiales y Métodos:** Serie retrospectiva de 32 pacientes (28 hombres [87,5%] y 4 mujeres [12,5%] con fracturas del tercio medio de la clavícula, cerradas, con trazos simples y conminutos, operados entre enero de 2021 y marzo de 2023. La edad promedio era de 32 años y el seguimiento promedio fue de 19 meses (rango 14-25). Se realizaron controles radiográficos y se evaluó la función mediante la escala de Constant-Murley modificada, la escala ASES y la escala analógica visual para dolor. **Resultados:** El tiempo hasta la cirugía fue de 3 días, se constató la consolidación radiológica en una media de 15.6 semanas. El puntaje promedio de Constant-Murley modificado fue de 88,34; el puntaje ASES, de 83,8 y el de la escala analógica visual, de 0,5. No se reportaron hipoestesias subclaviculares ni dolor en la cicatriz. **Conclusiones:** Se logró la consolidación y la movilidad completa, evitando morbilidades y complicaciones asociadas. La MIPO, a partir de parámetros técnicos simples y reproducibles, es una opción segura.

Palabras clave: Fractura de clavícula; MIPO; lesión nerviosa.
Nivel de Evidencia: IV

INTRODUCTION

Clavicle fractures are classified into medial, middle, and lateral thirds, with fractures of the middle third accounting for 80% of all clavicle fractures.[1] Surgical treatment of fractures in the middle third has demonstrated better outcomes in terms of healing time and reduced risk of pseudoarthrosis.[2,3]

Received on April 28th, 2024. Accepted after evaluation on August 22nd, 2024 • Dr. FACUNDO FAZZONE • facundofazzone@gmail.com https://orcid.org/0009-0005-1336-0392
How to cite this article: Fazzone F, Garay R, Focaraccio S, Martínez CE, Tornatore Garrido IAA, Focaraccio S. Clavicle Fracture: MIPO Superior Fixation Technique. *Rev Asoc Argent Ortop Traumatol* 2024;89(6):562-572. https://doi.org/10.15417/issn.1852-7434.2024.89.6.1946

Open reduction and internal fixation with plates and screws for clavicle fractures is not without complications. These include pseudoarthrosis in areas with significant bone resorption, wound infections, implant intolerance, sensory loss in the infraclavicular region, cosmetic concerns, and painful scars.[4,5]

Alternative techniques, such as intramedullary nailing, cause less surgical trauma but carry risks of fragment rotation and significant challenges during reoperations for implant removal. Pin osteosynthesis alone has been associated with inadequate fixation and implant migration.[6,7]

The MIPO (minimally invasive plate osteosynthesis) technique has yielded favorable outcomes in diaphyseal fractures of the upper and lower limbs.[8,9] This method achieves relative stability while preserving the biological benefits of the fracture hematoma, as it avoids direct invasion of the fracture site and minimizes extensive soft tissue dissection.[5-9]

However, the clavicle presents unique technical challenges for reduction and implant placement, along with increased neurovascular risks.[10]

The objectives of this study are to present our experience with closed, displaced, mid-diaphyseal clavicle fractures; to describe the surgical technique with an emphasis on reducing sensory nerve injury and optimizing surgical times; and to report the functional outcomes.

MATERIALS AND METHODS

This retrospective study included a series of 32 patients (28 men [87.5%] and 4 women [12.5%]) with closed, simple, or comminuted fractures of the middle third of the clavicle, treated surgically between January 2021 and March 2023. The mean follow-up period was 19 months (range: 14–25 months). Patients were aged between 18 and 72 years (mean: 32 years); 21 fractures were on the right clavicle and 11 on the left.

Anatomically contoured locking plates specifically designed for the clavicle were used in all patients. Radiographic follow-up was performed, and functional outcomes were assessed using the modified Constant-Murley score, the ASES (American Shoulder and Elbow Surgeons) score, and a visual analog scale (VAS) for pain.

Inclusion criteria were: acute fractures, with a maximum of 72 h, fractures in the middle third, closed, displaced with more than 2 cm of shortening or overriding, without fragment contact, simple or comminuted traces; age >16 years.

Exclusion criteria were: associated neurovascular injuries, open fractures, associated fractures, clavicle fractures outside the middle third; comorbidities (diabetes, smoking, alcoholism, etc.), age <16 years.

Radiological follow-up was conducted at 1 week and 4 weeks postoperatively, and then biweekly until complete callus formation was observed.

Surgical Technique

The patient is placed in a beach chair position on a radiolucent table. An interscapular bolster is placed to facilitate fracture reduction (Figures 1 and 2). The affected upper limb is left free to allow manipulation during the operation. The C-arm is positioned at the bedside, ensuring the surgeon has unrestricted mobility. Before the surgery, the fracture line and clavicle boundaries are identified with radiological guidance, and the incision is marked using a guide implant identical to the one to be used.

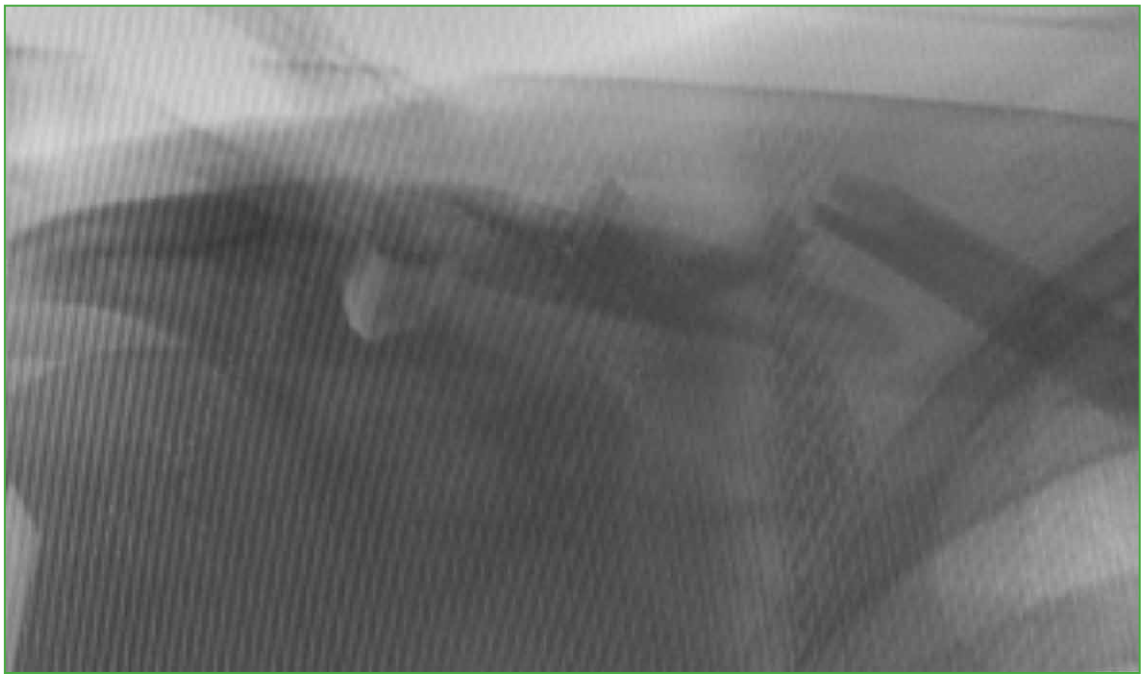


Figure 1. Image intensifier, AP view. Displaced segmental middle third fracture.

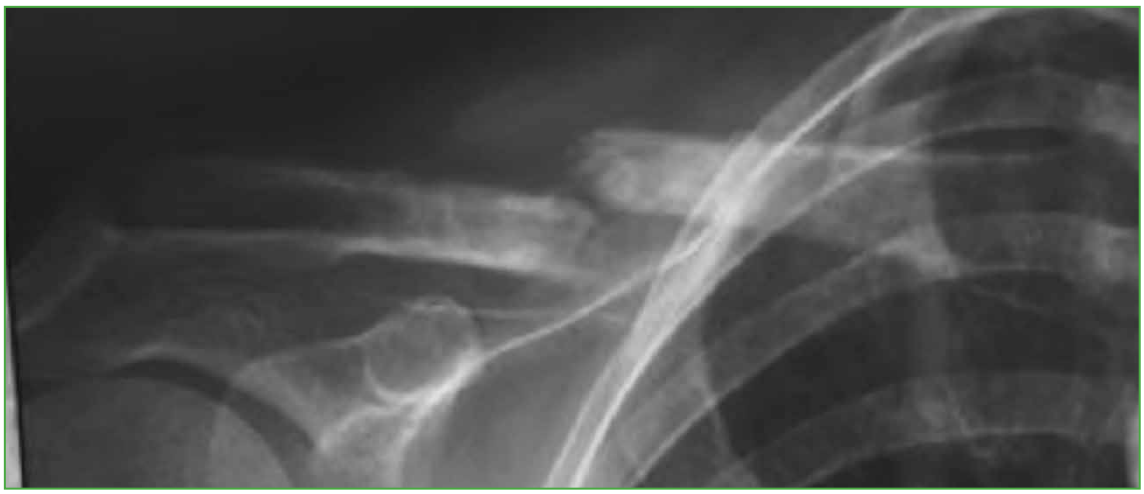


Figure 2. Preoperative oblique clavicle radiograph.

To protect the sensory branches of the supraclavicular nerve, specific anatomical landmarks are utilized. A medial point is marked 2.5–4 cm from the acromioclavicular joint, and a lateral point is marked 4–6 cm from the sternoclavicular joint. This creates a 9 cm margin where three terminal branches of the medial trunk of the supraclavicular nerve can typically be found (Figure 3). The lateral trunk, which provides sensory innervation to the shoulder above the circumflex, lies outside the surgical field.[11]

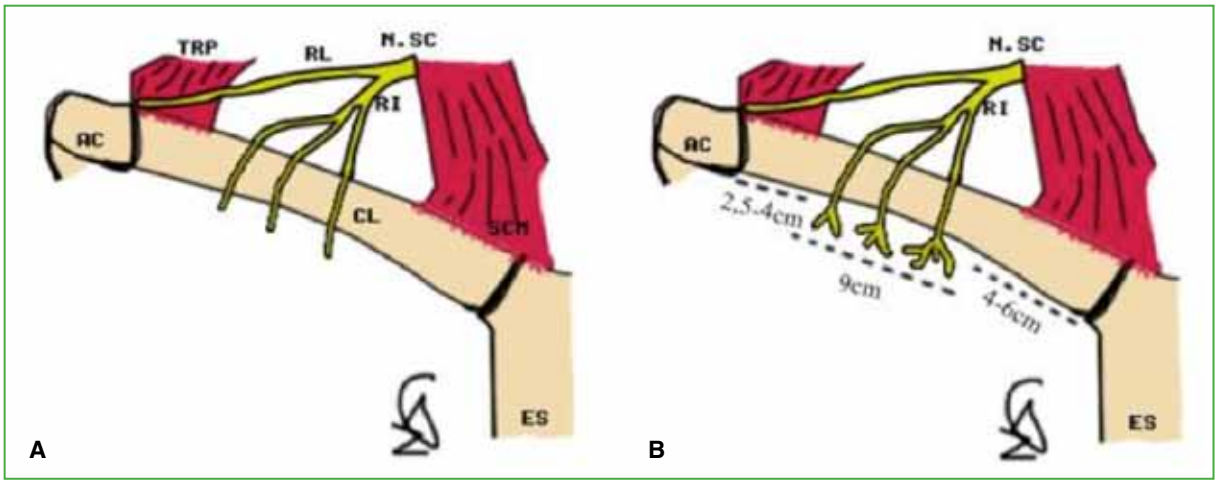


Figure 3. Representation of the innervation of the supraclavicular sensory branches.

The superior aspect of the clavicle is approached by making a skin incision 1 cm lateral and medial to the fracture (Figure 4), extending through the skin and exposing the platysma. Subcutaneous blunt dissection is performed between the periosteal plane and the platysma to avoid injury to sensory branches. If proper fracture reduction is not achieved using the beach chair position and interscapular bolster, indirect maneuvers such as shoulder mobilization (elevation and retraction) or digital compression at the fracture site can be employed. In cases where these methods are insufficient, direct maneuvers may involve placing K-wires (Figure 5) into both fragments to facilitate reduction.

Figure 4. Radiologcally demarcated approaches.

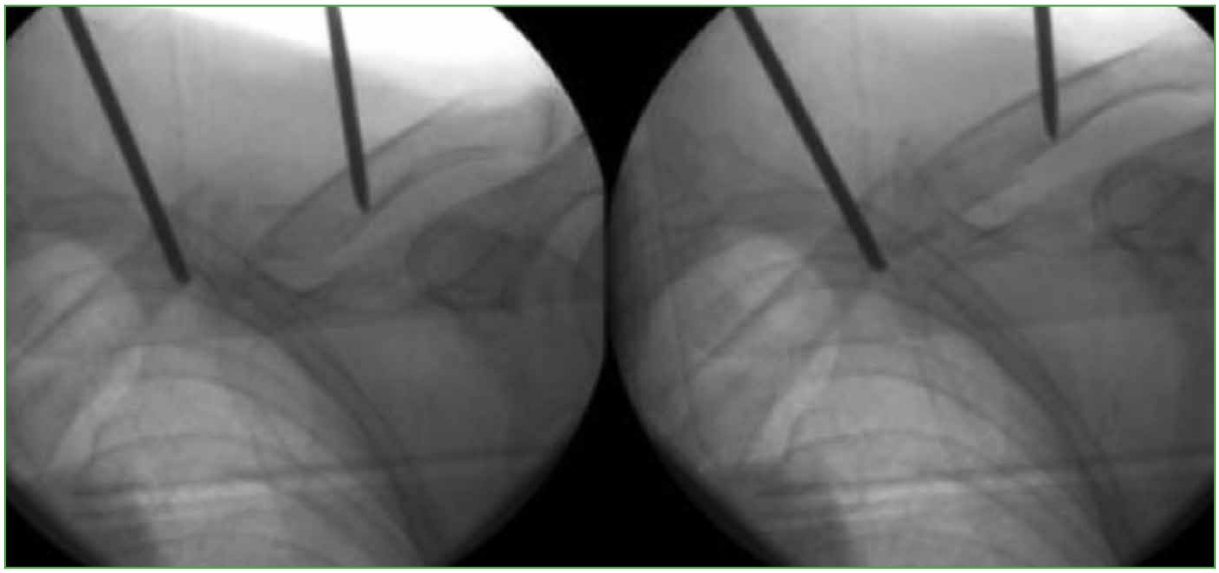


Figure 5. Fracture reduction using *joystick* pins.

Timely surgical intervention is crucial to prevent soft callus formation, which can hinder effective fracture reduction.

Once the fracture is reduced and confirmed using the C-arm, the implant (Figure 6) is slid along the superior aspect of the clavicle. It is initially fixed with one screw on each side (medially and laterally) to restore clavicular length. The remaining screws are then placed to ensure stable fixation, maintaining contact between the main fragments. Bicortical locking screws are preferred, especially medially, where care must be taken to avoid injury to neurovascular structures due to drill penetration or screw length. Alternatively, cortical screws may be used initially to minimize implant prominence, which can cause patient discomfort. Locking screws can then be added for enhanced stability. For challenging reductions, joystick-like pins (minimum diameter 2.5 mm) can be used to restore clavicular length (Figure 5). The reduction is completed by adjusting plate interference (Figure 7), pulling the displaced fragments toward the plate using cortical screws before completing fixation with locking screws.

After implant fixation, the platysma, subcutaneous tissue, and skin are sutured to provide optimal implant coverage.

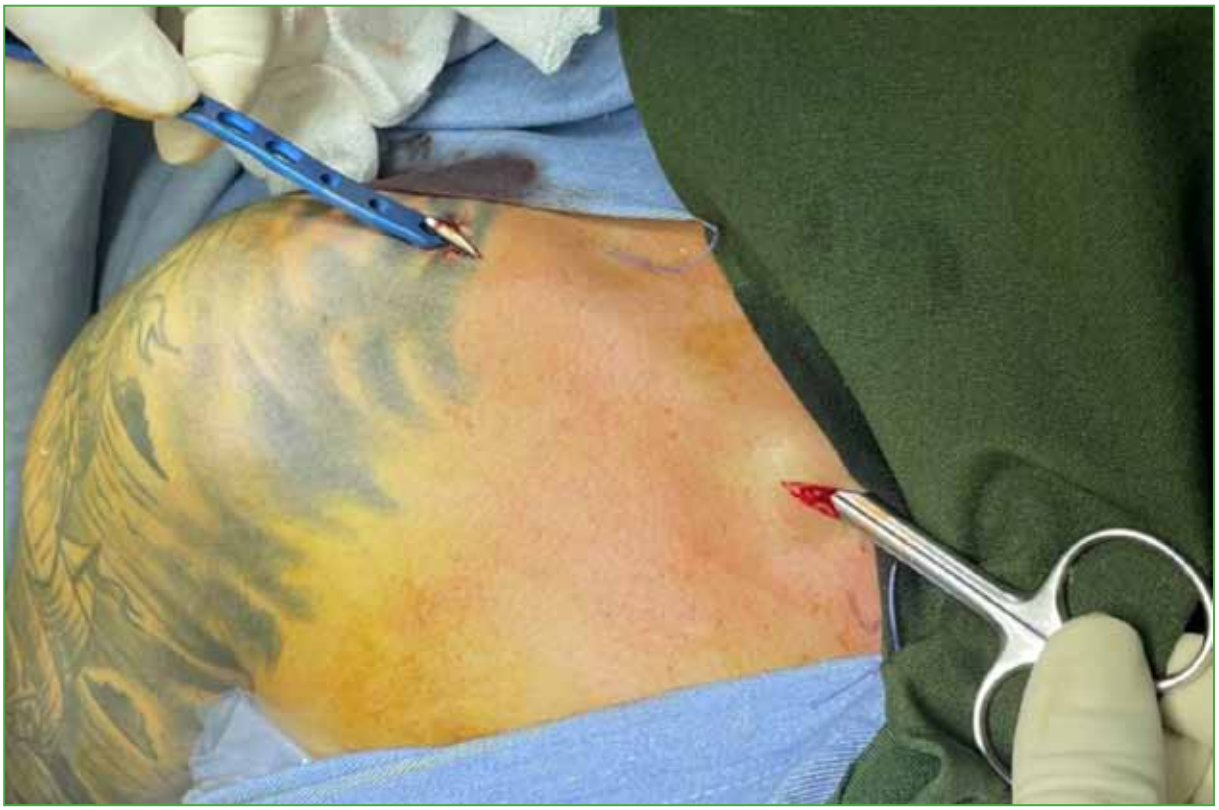


Figure 6. Blunt passage of the implant under the platysma.

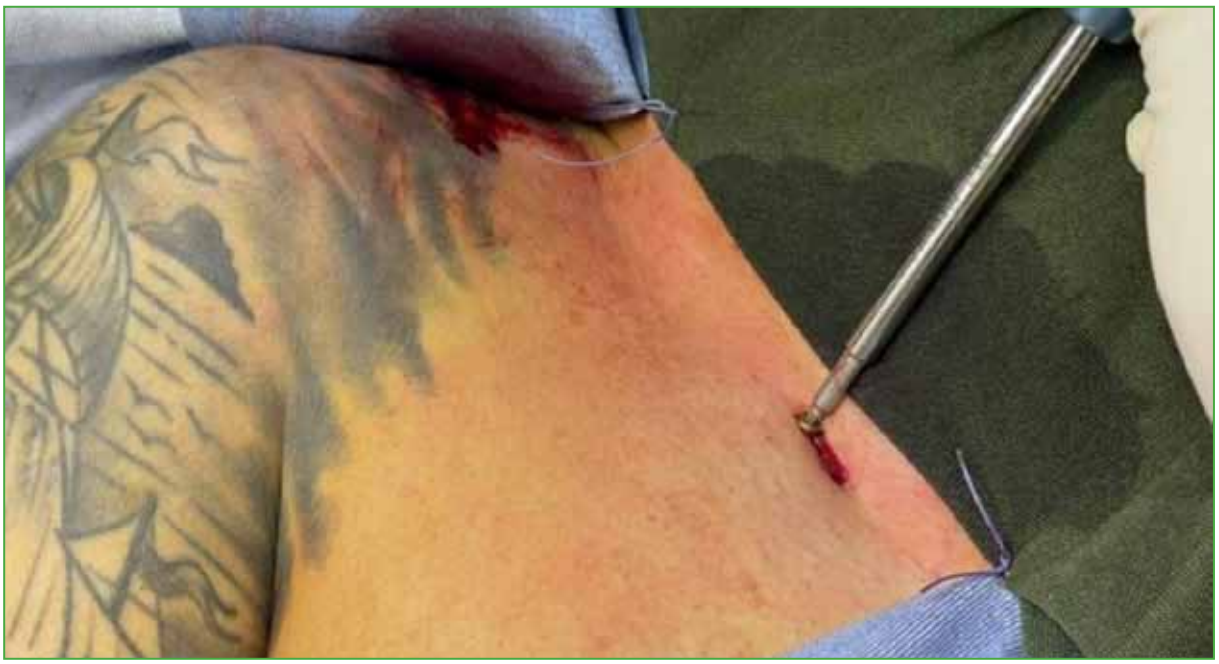


Figure 7. Approximation of the implant to the bone with cortical screw.

Intraoperative fluoroscopic control with the C-arm (Figure 8) is essential to verify fracture reduction, implant positioning, and screw length. Positioning the C-arm at the patient's head helps ensure free movement for the surgical team.

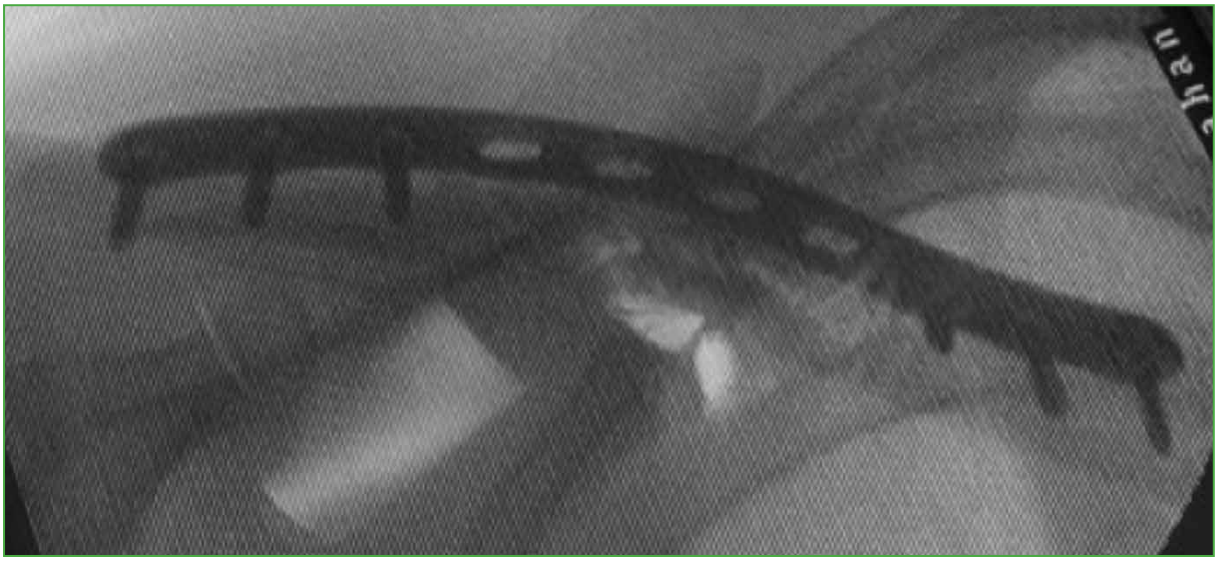


Figure 8. Postoperative radiological control. Anatomical plate acting as a bridge.

RESULTS

The duration of surgery ranged from 32 to 95 minutes (mean: 42 minutes). Consolidation was achieved in all patients within 13 to 21 weeks (mean: 15 weeks) (Figure 9).

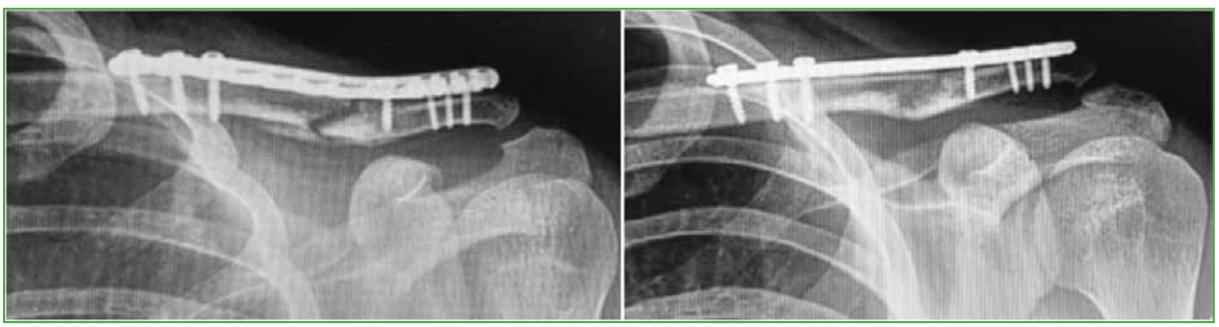


Figure 9. Postoperative radiological control. Anatomic plate acting as a bridge.

Range of motion (ROM) was assessed using a goniometer. All patients regained ROM comparable to the non-operated side. Average measurements were as follows: flexion 178°, extension 35° and abduction 85° (Figure 10).

No implants required removal. There were no cases of wound infection, vascular injury, or hypoesthesia in the infraclavicular region (Figure 11).

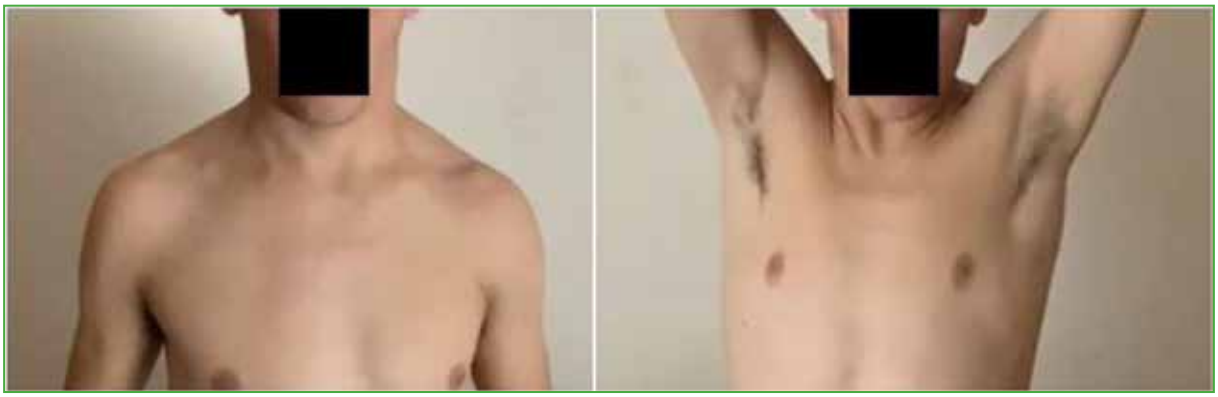


Figure 10. Mobility one month after surgery. **A.** Shoulder at rest. **B.** Shoulder in maximum abduction.

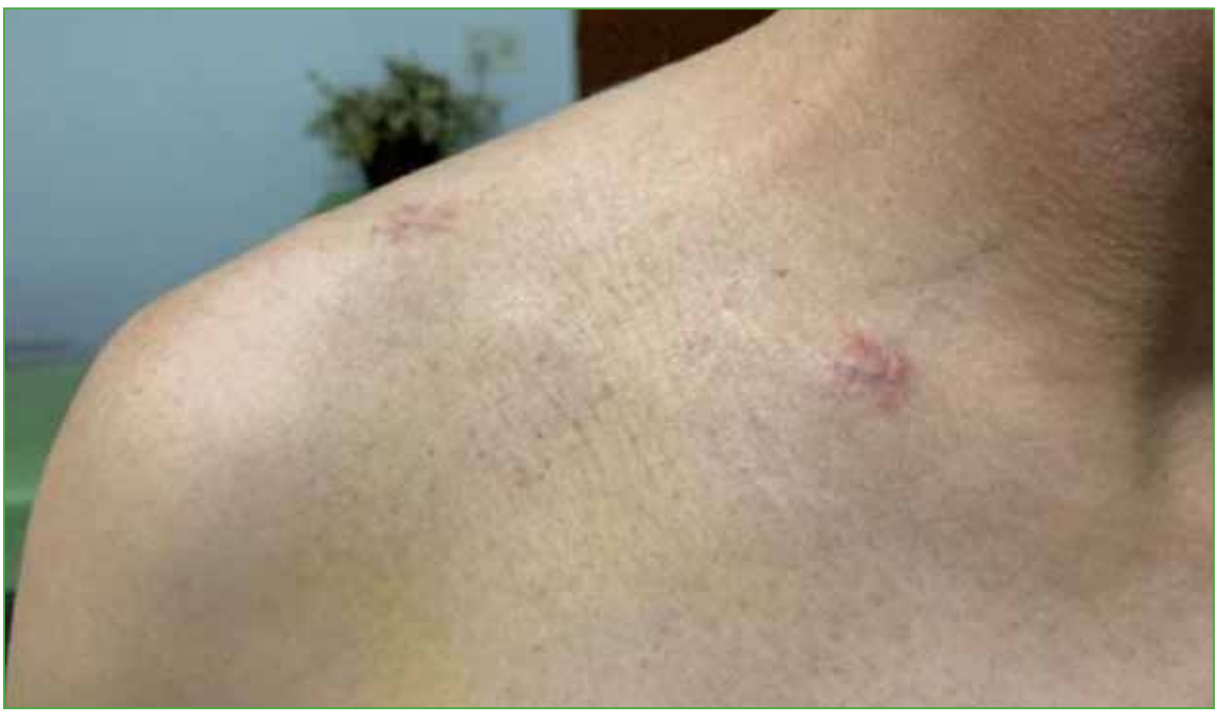


Figure 11. Remote evolution of the surgical wound.

One patient developed medial and lateral keloids. A scar revision was performed using a lozenge excision, followed by the application of Steri-Strip® tapes to reduce tension in the surgical area, resulting in satisfactory healing.

The results of the series are summarized in the Table. In the Constant-Murley scale, Spanish version for Argentina,[12] the average score was 88.34 (range 78-100). The average score of the ASES scale was 83.8 (range 76-89).[13] The pain score according to the visual analog scale was, on average, 0.5 (range 0-2).

Table. Data from the retrospective series.

Pacient	Age	Sex	ASES Score	Constant-Murley Score	Visual analog scale for pain
1	30	Male	83	80	1
2	25	Female	89	96	0
3	16	Male	85	92	0
4	69	Male	85	100	0
5	31	Male	77	60	3
6	17	Male	85	88	1
7	26	Female	76	83	2
8	27	Male	82	100	0
9	16	Male	84	100	0
10	55	Male	85	78	1
11	55	Male	85	79	1
12	50	Male	81	80	2
13	41	Male	85	84	1
14	44	Female	85	88	1
15	19	Male	82	69	2
16	31	Male	81	70	1
17	67	Male	79	86	2
18	48	Male	88	88	1
19	50	Male	78	75	2
20	72	Male	84	86	1
21	29	Female	88	89	0
22	18	Male	86	90	0
23	35	Male	80	89	1
24	40	Male	82	88	1
25	41	Male	86	100	0
26	18	Male	89	86	0
27	31	Male	86	94	0
28	30	Male	87	85	0
29	25	Male	86	98	0
30	25	Male	86	100	0
31	27	Male	87	100	0
32	44	Male	80	91	2

ASES = *American Shoulder and Elbow Surgeons*.

DISCUSSION

The application of the MIPO principle minimizes disruption to the biological processes involved in fracture healing, providing relative stability that ensures adequate mechanical support for bone consolidation. This technique has been successfully applied across various bone segments with excellent outcomes.[8,9,10,14] We were able to replicate these positive results in our series of patients.

The debate over anterior versus superior placement of the implant remains ongoing. Kang et al.,[14] Iannotti et al,.[15] and Celestre et al.[16] advocate for anterior placement due to its reduced likelihood of causing patient discomfort and its biomechanical advantages, including lower risks of implant breakage and pull-out. In our series, a superior plate placement was used, yielding comparable results without implant breakage. Additionally, superior placement avoided injury to the deltoid at its insertion on the lateral third and the anterior edge of the clavicle. Superior fixation also simplifies the procedure, as it eliminates the need for extensive plate pre-molding to fit individual anatomy. When applied to comminuted fractures, a plate on the superior aspect functions as a bridge. In transverse fractures subjected to high stress under load, it acts as a tension band, generating compression at the fracture site. These biomechanical principles underpin the favorable outcomes achieved in this study.[14,17-19]

The length of screws, particularly on the medial side, poses a potential risk of vascular injury. Sohn et al. recommend anterior implant placement to mitigate this risk.[10] In our series, we used locking screws, which can even be monocortical, to capitalize on the enhanced cortical stability. By locking the screw to the plate, the risk of contralateral injury is eliminated. To further reduce risk during drilling, we used short drill bits with guides serving as depth stops. This approach provided sufficient fixation without any cases of screw pull-out or implant breakage.

Subclavicular nerve injury, a frequent complication reported by various authors,[11,20] often results in subcutaneous implant discomfort and scar pain. However, this complication was avoided in our patients by identifying the locations of the sensory branches and carefully preserving them during the surgical approach. The implant was also carefully slid under the platysma to further reduce the risk of nerve injury.

Six of our patients had tattoos in the surgical area; however, these did not interfere with the use of the anatomical landmarks essential for the MIPO technique.

The limitations of this study include the short follow-up period and the absence of a control group treated with open reduction, which would allow for more meaningful comparisons.

CONCLUSIONS

This study demonstrated successful fracture consolidation and full recovery of range of motion while avoiding morbidities and complications such as neurovascular injury, implant rupture, and implant removal. Based on straightforward and reproducible technical parameters, the MIPO technique represents a safe and effective surgical option.

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

R. Garay ORCID ID: https://orcid.org/0009-0003-1090-1670
S. Focaraccio ORCID ID: https://orcid.org/0000-0001-7199-9841
C. E. Martínez ORCID ID: https://orcid.org/0000-0002-6031-0532
I. A. A. Tornatore Garrido ORCID ID: https://orcid.org/0009-0001-1710-3247

REFERENCES

1. Postachhini F, Gumina S, De Santis P, Albo F. Epidemiology of clavicle fratures. *J Shoulder Elbow Surg* 2002;11(5):452-6. https://doi.org/10.1067/mse.2002.126613
2. Hill JM, McGuire MH, Crosby LA. Closed treatment of displaced middle-third fractures of the clavicle gives poor results. *J Bone Joint Surg Br* 1997;79(4):537-9. https://doi.org/10.1302/0301-620x.79b4.7529
3. Zlowodzki M, Zelle BA, Cole PA, Jeray K, McKee MD. Treatment of acute midshaft fractures: systemic review of 2,144 fractures. *J Orthop Trauma* 2005;19(7):504-7. https://doi.org/10.1097/01.bot.0000172287.44278.ef

4. Bostman O, Manninen M, Pihlajamaki H. Complications of plate fixation in fresh displaced midclavicular fractures. *J Trauma* 1997;43(5):778-83. https://doi.org/10.1097/00005373-199711000-00008
5. Liu PC, Hsieh CH, Chen JC, Lu CC, Chuo CY, Chien SH. Infection after surgical reconstruction of a clavicle fracture using a reconstruction plate: a report of seven cases. *Kaohsiung J Med Sci* 2008;24(1):45-9. https://doi.org/10.1016/s1607-551x(08)70073-1
6. Frigg A, Rillmann P, Perren T, Gerber M, Ryf C. Intramedullary nailing of clavicular midshaft fractures with the titanium elastic nail problems and complications. *Am J Sports Med* 2009;37(2):352-9. https://doi.org/10.1177/0363546508328103
7. Smekal V, Irenberger A, Struve P, Wambacher M, Krappinger D, Kralinger FS. Elastic stable intramedullary nailing versus nonoperative treatment of displaced midshaft clavicular fractures—a randomized, controlled, clinical trial. *J Orthop Trauma* 2009;23(2):106-12. https://doi.org/10.1097/bot.0b013e318190cf88
8. Apivatthakakul T, Arpornchayanon O, Bavornratanavech S. Minimally invasive plate osteosynthesis of the humeral shaft fracture. Is it possible? A cadaveric study and preliminary report. *Injury* 2005;36(4):530-8. https://doi.org/10.1016/j.injury.2004.05.036
9. Krettek C, Schandelmaier P, Miclau T, Tscherne H. Minimally invasive percutaneous plate osteosynthesis (MIPPO) using the DCS in proximal and distal femoral fractures. *Injury* 1997;28(Suppl 1):20-30. https://doi.org/10.1016/s0020-1383(97)90112-1
10. Sohn HS, Shin SJ, Kim BY. Minimally invasive plate osteosynthesis using anterior–inferior plating of clavicular midshaft fractures. *Arch Orthop Trauma Surg* 2012;132:239-44. https://doi.org/10.1007/s00402-011-1410-6
11. Havet E, Duparc F, Tobenas-Dujardin AC, Muller JM, Fréger P. Morphometric study of the shoulder and subclavicular innervation by the intermediate and lateral branches of supraclavicular nerves. *Surg Radiol Anat* 2007;29:605-10. https://doi.org/10.1007/s00276-007-0258-5
12. Gómez D, Dainotto T, Moya D, Patiño JM. Traducción y adaptación transcultural del Constant-Murley Score al español de la Argentina. *Rev Asoc Argent Ortop Traumatol* 2022;87(4):579-92. https://doi.org/10.15417/issn.1852-7434.2022.87.4.1491
13. Martínez-Cano JP, Llinás PJ, Escobar SS, López R, Caicedo Álvaro, Herrera G. Validación de la versión en español para Colombia de la escala ASES. *Artroscopia* [Internet] 2022;29(1): Available at: https://revistaartroscopia.com.ar/index.php/revista/article/view/221
14. Kang H, Song JK, Rho JY, Lee J, Choi J, Choi S. Minimally invasive plate osteosynthesis (MIPO) for mid-shaft fracture of the tibia (AO/OTA classification 42): A retrospective study. *Ann Med Surg (Lond)* 2020;60:408-12. https://doi.org/10.1016/j.amsu.2020.11.033
15. Iannotti MR, Crosby LA, Stafford P, Grayson G, Goulet R. Effect of plate location and selection on the stability of midshaft clavicle osteotomies: a biomechanical study. *J Shoulder Elbow Surg* 2002;11(5):452-67. https://doi.org/10.1067/mse.2002.125805
16. Celestre P, Roberston C, Mahar A, Oka R, Meunier M, Schwartz A. Biomechanical evaluation of clavicle fracture plating technique: does a locking plate provide improved stability? *J Orthop Trauma* 2008;22(4):241-7. https://doi.org/10.1097/bot.0b013e31816c7bac
17. Basamania CJ, Rockwood CA. Fractures of the clavicle. En: Rockwood CA (ed.) *The shoulder*, 4th ed. Philadelphia: WB Saunders; 2008, p. 423-8.
18. Bleeker NJ, van Veelen NM, van de Wall BJM, Sierevelt IN, Link BC, Babst R, et al. MIPO vs. intra-medullary nailing for extra-articular distal tibia fractures and the efficacy of intra-operative alignment control: a retrospective cohort of 135 patients. *Eur J Trauma Emerg Surg* 2022;48(5):3683-91. https://doi.org/10.1007/s00068-021-01836-4
19. Apivatthakakul T, Chiewcharntanakit S. Minimally invasive plate osteosynthesis (MIPO) in the treatment of the femoral shaft fracture where intramedullary nailing is not indicated. *Int Orthop* 2009;33(4):1119-26. https://doi.org/10.1007/s00264-008-0603-2
20. You JM, Wu YS, Wang Y. Comparison of post-operative numbness and patient satisfaction using minimally invasive plate osteosynthesis or open plating for acute displaced clavicular shaft fractures. *Int J Surg* 2018;56:21-5. https://doi.org/10.1016/j.ijsu.2018.06.007

Results of Arthroscopic Ligamentoplasty of the Triangular Fibrocartilage Complex Using the Carratalá Technique

Juan Matías Sala,[*] Aldo D. Ledesma,[*] Luis E. Galván,[#] Josué Silva Martínez[##]
[*]*Servicio de Cirugía de Mano Patagónica (CIMAP), OTI, Clínica del Valle S.R.L. Comodoro Rivadavia, Chubut, Argentina.*
[#]*Hand and Upper Limb Service, Hospital Puerta de Hierro, Jalisco, Mexico.*
[##]*Hand and Upper Limb Service, Hospital Real San José, Guadalajara, Mexico.*

ABSTRACT

Objective: To present the outcomes of reconstructing the triangular fibrocartilage complex (TFCC) in Atzei Type 4 chronic lesions through arthroscopic reconstruction using the Carratalá technique and a palmaris longus graft. **Materials and Methods:** We retrospectively evaluated nine patients with Atzei Type 4 TFCC lesions, including six male and three female patients. All lesions were reconstructed arthroscopically with a free graft of the palmaris longus tendon, secured with radial and ulnar fixation using the Carratalá technique. We assessed range of motion (ROM), grip strength, the Mayo wrist score, and the Disabilities of the Arm, Shoulder, and Hand (DASH) score. **Results:** Pain and strength tests results improved in the 9 patients, in an average follow-up of 14 months. All of the patients worked. The average ROM was 80° for both extension and flexion, with a pronation-supination range of 160°. The Mayo wrist score was excellent in 78% of cases, good in 11%, and poor in 11%. The DASH score improved from an average of 61 points preoperatively to 9 points at 14 months postoperatively. The average comparative contralateral grip strength was 85%. **Conclusions:** Arthroscopic reconstruction of the TFCC in Atzei Type 4 chronic lesions using the Carratalá ligamentoplasty for distal radioulnar stability is a minimally invasive and replicable technique that yields favorable functional outcomes.
Keywords: Wrist arthroscopy; Atzei 4; triangular fibrocartilage complex; chronic lesion.
Level of Evidence: IV

Resultados del tratamiento artroscópico de lesiones Atzei 4 del complejo del fibrocartílago triangular mediante ligamentoplastia de Carratalá

RESUMEN

Objetivo: Comunicar los resultados de la reconstrucción del complejo del fibrocartílago triangular en las lesiones crónicas Atzei 4, mediante la ligamentoplastia de Carratalá con injerto de palmar menor. **Materiales y Métodos:** Se evaluó, en forma retrospectiva, a 9 pacientes (6 hombres y 3 mujeres) con lesión del complejo del fibrocartílago triangular Atzei 4. Todas las lesiones se reconstruyeron con artroscopia mediante un injerto libre del palmar menor con fijación radial y cubital usando la técnica de Carratalá. Se analizaron los rangos de movilidad, la fuerza de agarre y la escala MWS y el cuestionario DASH. **Resultados:** Las pruebas de dolor y la fuerza mejoraron en los 9 pacientes, en un seguimiento promedio de 14 meses. Todos trabajaban. El rango de movilidad promedio fue de 80° de extensión, 80° de flexión y 160° de pronosupinación. El puntaje de la escala MWS fue excelente en el 78%, bueno en el 11% y malo en el 11%. El puntaje DASH promedio antes de la cirugía era de 61 y fue de 9 a los 14 meses de la intervención. El promedio de la fuerza comparativa contralateral fue del 85%. **Conclusiones:** La reconstrucción artroscópica del complejo del fibrocartílago triangular en lesiones crónicas Atzei 4, mediante la ligamentoplastia de Carratalá para la estabilización radiocubital distal, es una variante artroscópica mínimamente invasiva, replicable con buenos resultados funcionales.
Palabras clave: Artroscopia de muñeca; Atzei 4; complejo del fibrocartílago triangular; lesión crónica.
Nivel de Evidencia: IV

Received on June 5th, 2024. Accepted after evaluation on October 2nd, 2024 • Dr. JUAN MATÍAS SALA • salajuanmatias@icloud.com https://orcid.org/0000-0001-5542-5004

How to cite this article: Sala JM, Ledesma AD, Galván LE, Silva Martínez J. Results of Arthroscopic Ligamentoplasty of the Triangular Fibrocartilage Complex Using the Carratalá Technique. *Rev Asoc Asoc Argent Ortop Traumatol* 2024;89(6):573-585. https://doi.org/10.15417/issn.1852-7434.2024.89.6.1984

INTRODUCTION

The triangular fibrocartilage complex (TFCC) is the primary stabilizer of the distal radioulnar joint (DRUJ). It consists of the articular disc, the proximal and distal dorsal and palmar ligaments, the ulnocarpal ligaments, and the ligamentum subcruentum.[1-4] DRUJ stability depends on the TFCC, the joint capsule, the posterior ulnar ligament, the pronator quadratus, and the distal oblique band. The TFCC is a fibrocartilaginous disc that has rich vascularization in its ulnar region, limited vascularization on the radial side, and no vascularization in the center.[2]

TFCC injury is one of the most common causes of ulnar wrist pain and can significantly limit activities of daily living.[3,4]

In 1989, Palmer categorized TFCC injuries into two groups (Table 1): type 1 (acute or traumatic) and type 2 (chronic or degenerative).[5] Based on anatomical and histological insights into the TFCC, Atzei proposed a classification (Table 2) for Palmer's 1B lesions, dividing them into five types.[4]

Table 1. Palmer's classification for triangular fibrocartilage complex (TFCC) lesions.

Class 1	A. Central perforation B. Ulnar avulsion C. Avulsion of the ulnocarpal ligaments D. Radial avulsion
Class 2	TFCC central wear Central wear of the TFCC and chondromalacia of the lunate or ulnar head. Perforation of the TFCC and chondromalacia of the lunate or ulnar head. C plus perforation of the lunotriquetral ligament D plus ulnocarpal osteoarthritis

Table 2. Atzei classification for ulnar injuries of the triangular fibrocartilage complex based on their stability, ligamentous structures, potential for repair, and suggested treatment.

Type	DRU Inestability	Appearance of the distal TFCC	Appearance of the proximal TFCC	TFCC repair potential	Appearance of the DRU cartilage	Suggested treatment
1	Mild/No	Broken	Intact	Good	Good	Capsule repair
2	Moderate/ Severe	Broken	Broken	Good	Good	Foveal repair
3	Moderate/ Severe	Intacto	Broken	Good	Good	Foveal repair
4	Severe	Broken	Broken	Poor	Good	Graft reconstruction
5	Moderate/ Severe	Variable	Variable	Variable	Poor	Artroplasty or salvage

DRUJ = distal radioulnar joint; TFCC = triangular fibrocartilage complex.
Taken from: Sala M, Daroda S. Results of the Knotless Arthroscopic Foveal Anchorage of the Triangular Fibrocartilage Complex in Atzei 2/3 Lesions. *Rev Asoc Argent Ortop Traumatol* 2021;86(5):581-594. https://doi.org/10.15417/issn.1852-7434.2021.86.5.1374

Various histological changes have been observed in TFCC injuries. Rein et al. developed a scale based on cellular changes due to age and prior trauma. Their research demonstrated a reduction in the cellular matrix of the articular disc, altering its histological composition and resulting in irreparable degenerative lesions.[6,7]

According to Atzei and Luchetti, Atzei 4 lesions are considered irreparable and they lead to chronic DRUJ instability. In such cases, reconstruction with a graft is recommended.[4]

For irreparable TFCC injuries, multiple ligament reconstruction techniques are available, including both open and arthroscopic approaches, with varying outcomes.[8-10]

Advances in wrist arthroscopy have facilitated the evaluation of both the DRUJ and TFCC, enabling minimally invasive anatomic repairs and reconstructions.[11-13]

The Carratalá TFCC arthroscopic ligament reconstruction technique incorporates concepts from Adams and Berger's open reconstruction method and Atzei's arthroscopically assisted approach.[14] This arthroscopic technique reconstructs the radioulnar ligaments anatomically at their radial and ulnar insertions using a tendon graft, thereby restoring DRUJ stability.

The aim of this study was to evaluate the outcomes of treating Atzei 4 lesions using the Carratalá ligament reconstruction technique.

MATERIALS AND METHODS

A retrospective study was conducted to evaluate the arthroscopic surgical reconstruction of Atzei 4 TFCC lesions using the Carratalá ligament reconstruction technique. Preliminary outcomes are presented for the first nine patients treated (Table 3).

Table 3. Demographic characteristics of patients

Patient	Age (years)	Sex	Atzei Injury	Evolution of pain (months)	Nakamura Test	Berger's test	Dominant hand
1	34	Female	4	8	Positive	Positive	Yes
2	42	Male	4	9	Positive	Positive	No
3	38	Female	4	14	Positive	Positive	Yes
4	45	Male	4	18	Positive	Positive	Yes
5	33	Male	4	6	Positive	Positive	Yes
6	40	Male	4	12	Positive	Positive	Yes
7	37	Male	4	10	Positive	Positive	Yes
8	44	Male	4	8	Positive	Positive	Yes
9	39	Female	4	11	Positive	Positive	Yes

The reconstruction technique was applied to nine patients (six men and three women) with chronic unstable TFCC lesions. Eight dominant and one non-dominant hands were operated on. All lesions were reconstructed arthroscopically with a free graft of the palmaris longus tendon, secured with radial and ulnar fixation using the Carratalá technique.

Outcomes were assessed through wrist range of motion, grip strength, the Mayo Clinic Wrist Score (MWS), and the Disabilities of Arm, Shoulder, and Hand (DASH) score.

Inclusion criteria included: Age >30 years, DRUJ instability and TFCC tear confirmed by clinical tests and MRI, symptoms persisting for more than six months, and history of prior surgery for TFCC injury. In all cases, the diagnosis and presence of Atzei 4 lesions were confirmed via arthroscopy before initiating the proposed treatment.

Exclusion criteria included: Age <30 years; histological changes in the central disc and ligamentous retraction of the TFCC, confirmed by arthroscopy; and presence of distal radioulnar osteoarthritis.

Wrist range of motion (flexion, extension, ulnar and radial deviations) was measured using a standard PVS hand goniometer, while grip strength was assessed with a standard hydraulic joint dynamometer (Baseline-Orthowell®).

The treatment protocol used was as follows: During the initial consultation, if instability without a stop was identified using the Nakamura test, an MRI was ordered. If a foveal lesion of the TFCC was detected (sometimes with signs of foveal retraction), surgical treatment was recommended.

Surgical Technique

The procedure is performed under ultrasound-guided brachial plexus block anesthesia with a pneumatic cuff inflated to 250 mmHg to prevent ischemia. 3-4, 6R, and 6U portals are used. The radiocarpal joint is explored, and the TFCC is inspected (Figure 1). At this stage, chronic injury with irreparable ligamentous debris is confirmed in both previously untreated injuries and those with failed suture repairs.

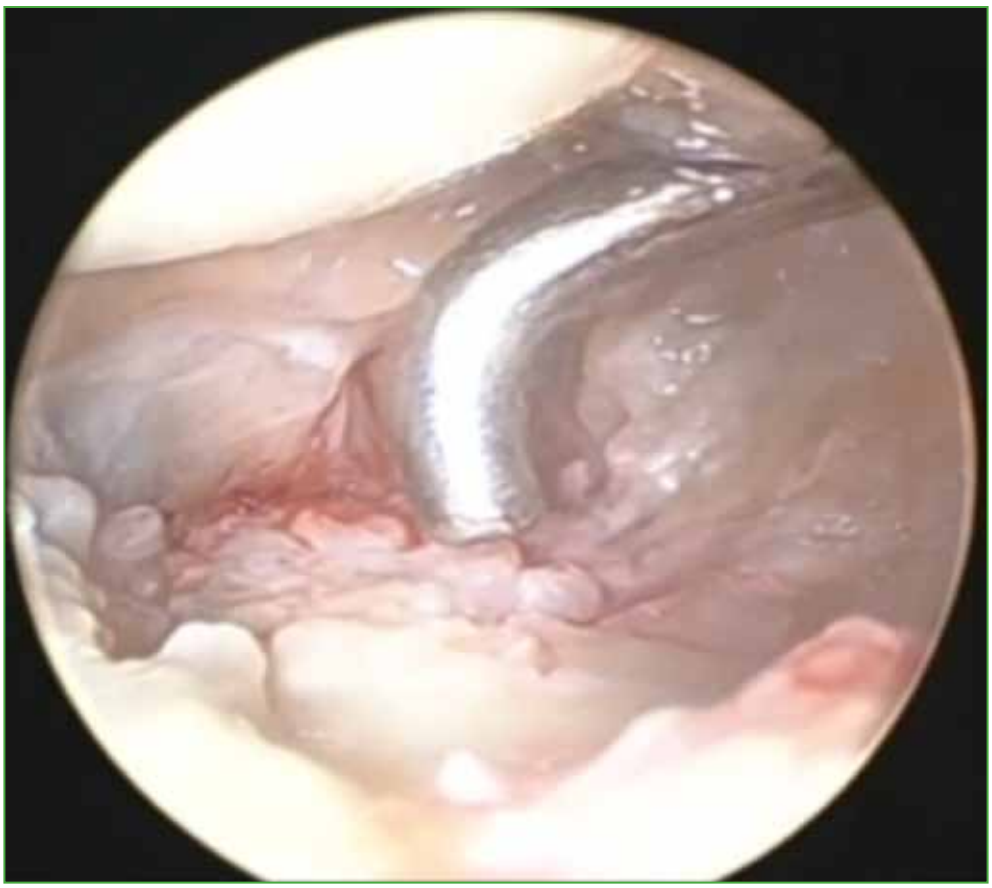


Figure 1. Radiocarpal and triangular fibrocartilage complex examination.

The radioulnar joint surface is evaluated through portal 3-4. Once good condition is confirmed, a tendon graft is harvested from the palmaris longus (Figure 2). The graft is prepared using a 2-0 Vicryl suture with Krackow stitches at both ends to minimize handling damage. A lateral incision of approximately 2 cm is made, located 3 cm from the tip of the ulnar styloid.

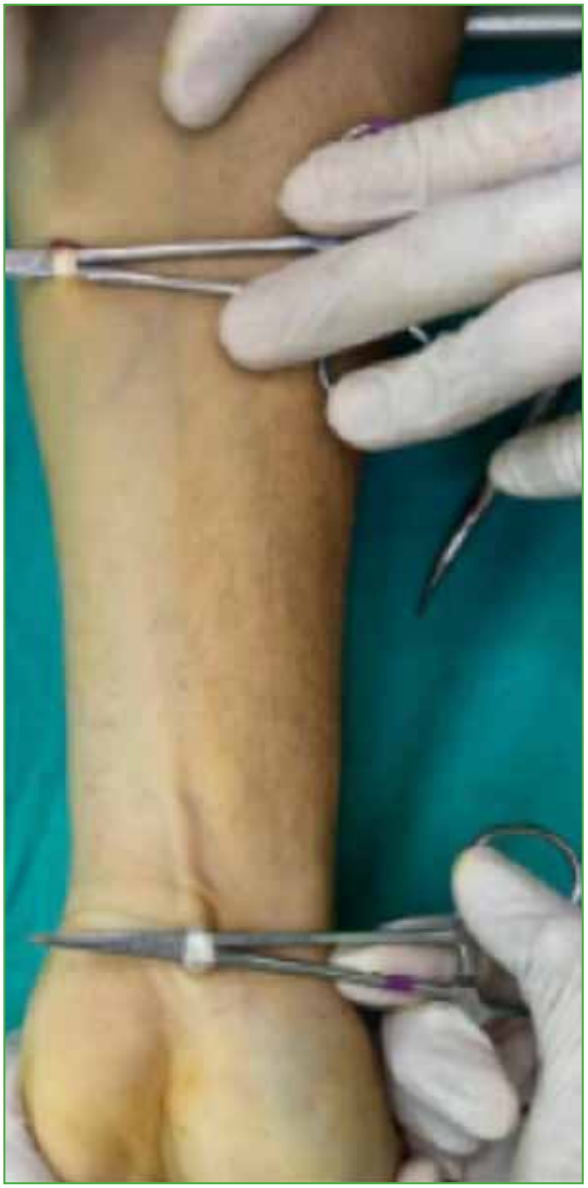


Figure 2. Graft harvesting of the palmaris longus.

Through this incision, under direct visualization via portal 3-4, a 4-mm bone tunnel is drilled at the fovea (Figure 3). Using portal 3-4 for direct visualization, two guides—one volar and one dorsal—are placed at the radial notch, diverging at a 30° angle relative to the radial metaphysis axis. A 3-mm drill is used to create the radial tunnels, ensuring the radial cortex is spared (Figure 4).

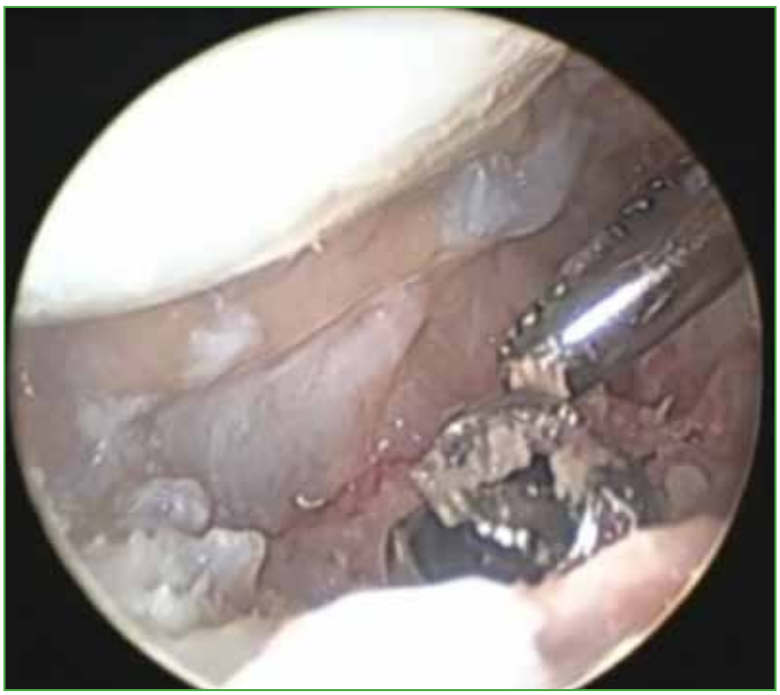


Figure 3. Foveal tunnel perforation with view through portal 3-4.

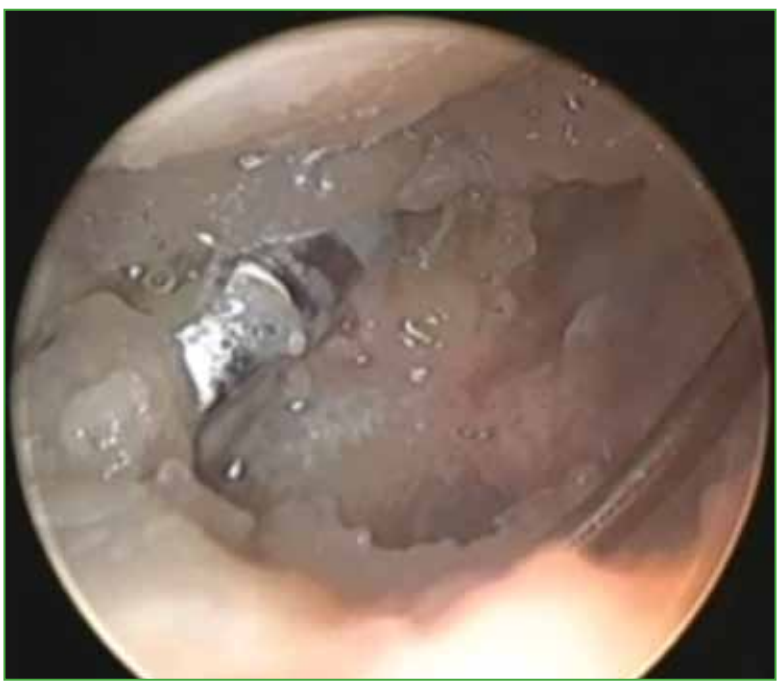


Figure 4. Placement of guides over the radius and drilling over the radial notch.

A SutureLasso® (Arthrex, Naples, FL, USA) with a nitinol loop is introduced through the bone tunnel (Figure 5). The tendon graft is passed from portal 6U to 6R using the nitinol loop (Figure 6), which is then retrieved through the bone tunnel (Figure 7).

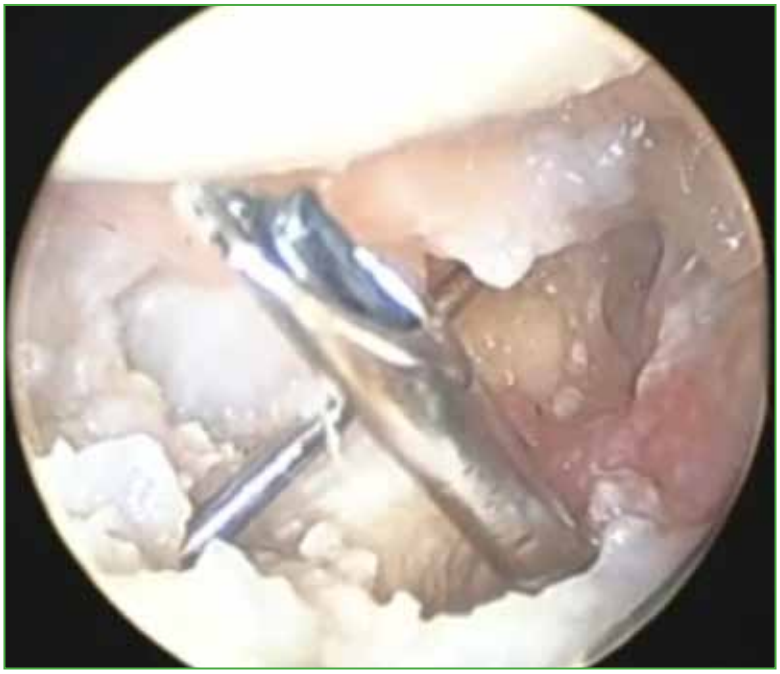


Figure 5. Introduction of nitinol through the foveal bone tunnel.

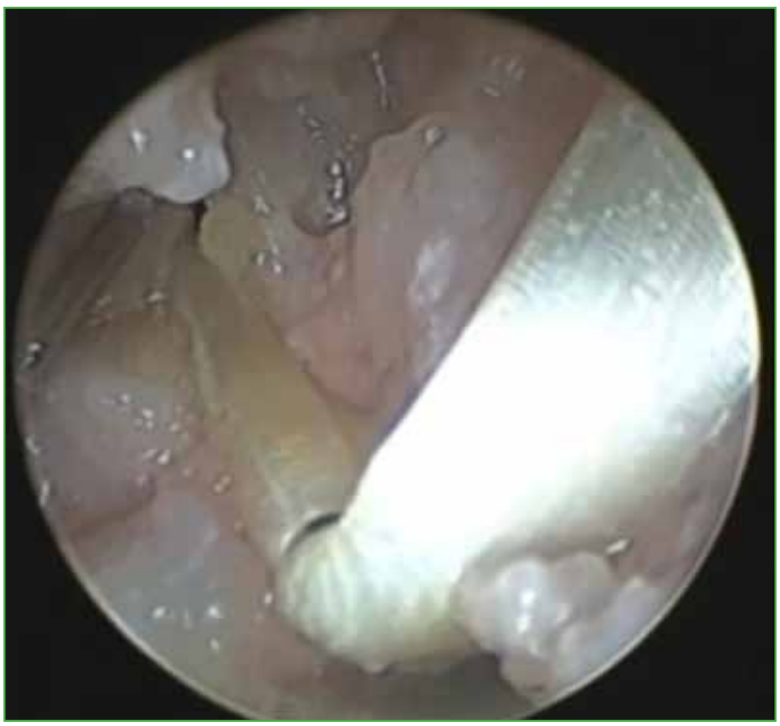


Figure 6. Passage of the palmaris longus graft from portal 6U to portal 6R and retrieval with nitinol through the bone tunnel.

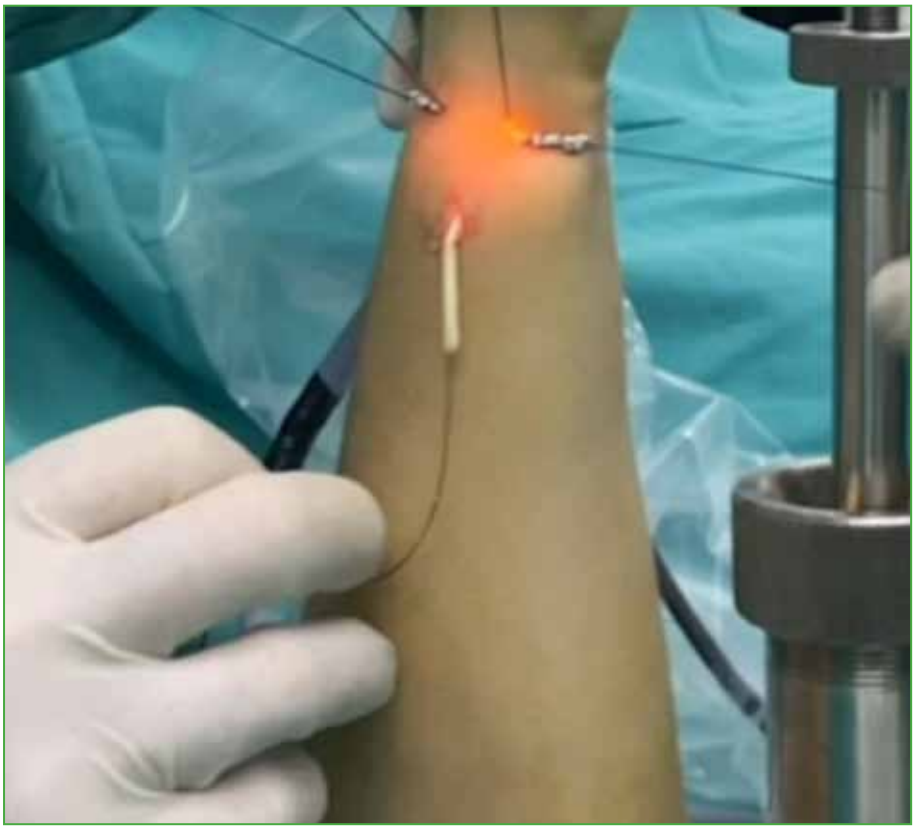


Figure 7. Graft retrieval through the bone tunnel.

Both ends of the tendon are anchored within the radial tunnels using two 3.5-mm biotenodesis screws (Figure 8). The portion of the tendon retrieved through the ulnar bone tunnel is secured to the ulnar diaphysis, 2.5 cm from the styloid, using a 4-mm biotenodesis screw (Figure 9) (Video).

The joint, fixation points, and graft tension are inspected, and DRUJ stability is confirmed. The surgical procedure is then concluded (Figure 10).

RESULTS

The reconstruction technique was performed on nine patients of working age (mean age: 44 years) who had chronic unstable TFCC lesions. The average follow-up period was 14 months, and the outcomes showed significant improvements.

The average range of motion was 80° of extension, 80° of flexion, and 160° of pronation. Regarding the Mayo Wrist Score (MWS), 78% of cases were rated as excellent, 11% as good, and 11% as poor. The average DASH score improved from 61 before surgery to 9 at 14 months postoperatively. Finally, the average contralateral comparative grip strength was 85%.

One poor outcome was observed in a patient who experienced distal radioulnar subluxation immediately after surgery. This progressed to distal radioulnar osteoarthritis, necessitating a second procedure with the arthroscopic Sauvé-Kapandji technique.[15]

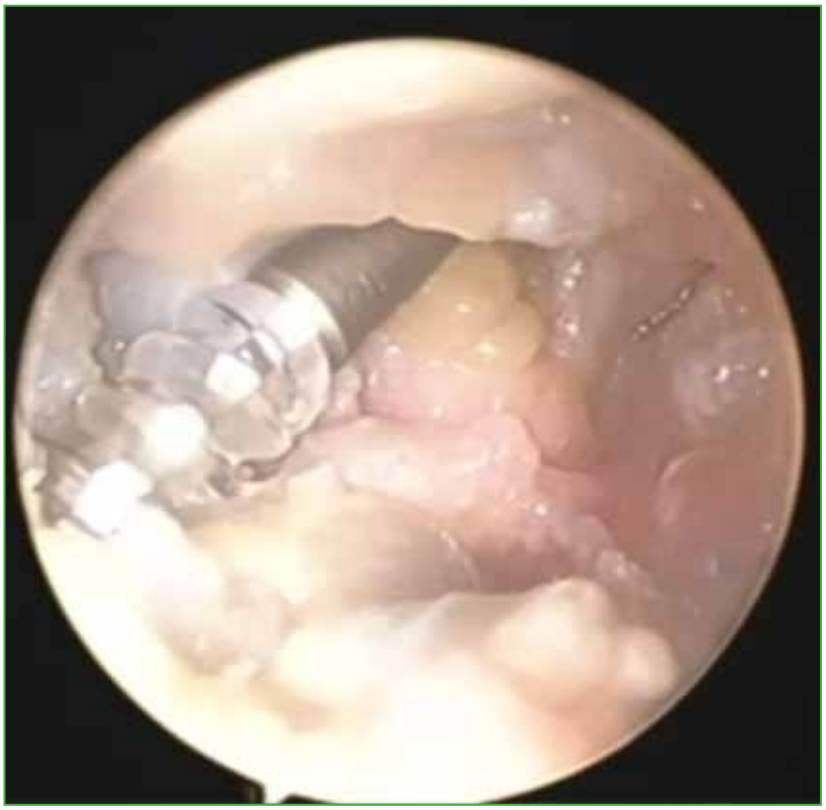


Figure 8. Anchoring of the palmaris longus graft to the radial tunnels with a 3.5 mm biotenodesis screw.

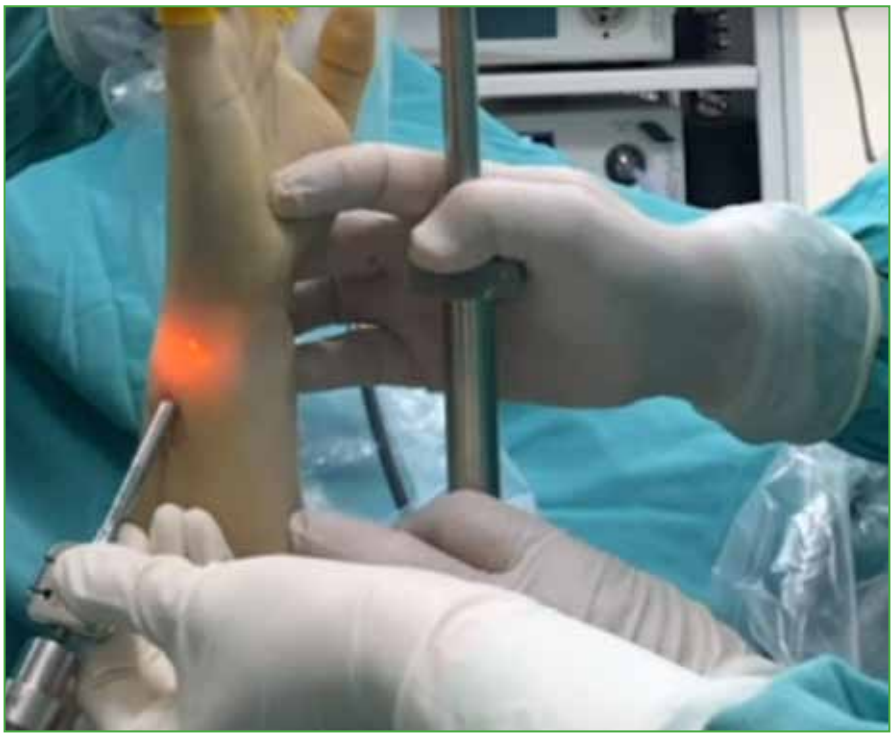


Figure 9. Anchorage of the tendon retrieved through the bone tunnel to the ulnar diaphysis.

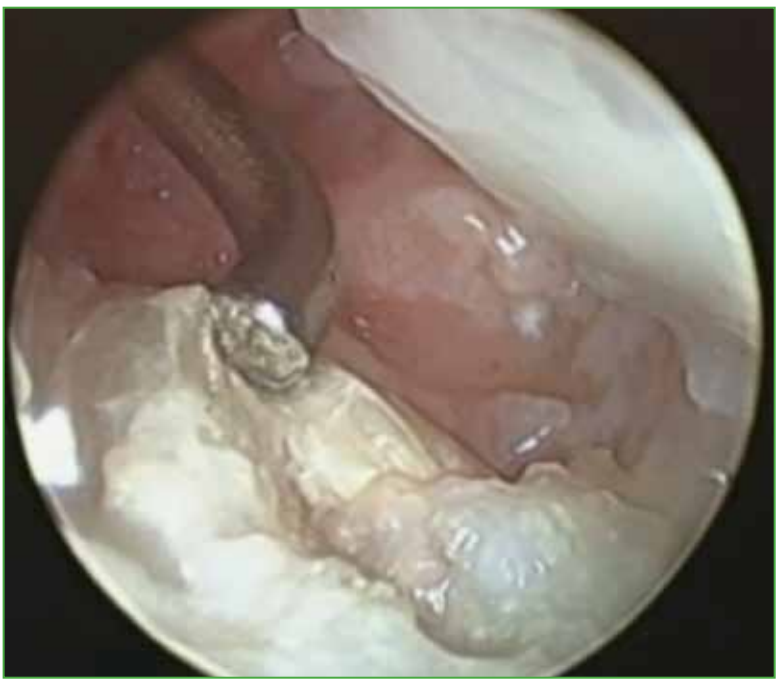


Figure 10. Inspection of the joint and tendon graft tension.

We highlight patient 3 from our series, who had an additional scapholunate ligament injury requiring surgical intervention. With the patient's consent, a revision ligamentoplasty was performed seven months postoperatively. Upon revision, a fibrotic mantle was observed integrating the tendon grafts, showing ligamentization (Figure 11). This process resembled neofibrocartilage formation and maintained DRUJ stability (Figure 12). These findings align with those described in Lindsay's study on ligamentization in the wrist.[16]

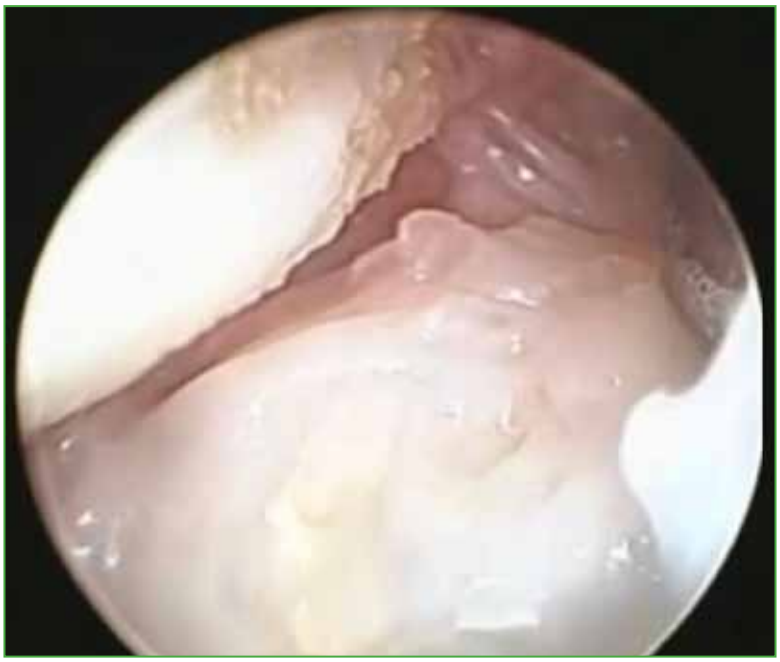


Figure 11. View of the fibrotic mantle integrating tendons.

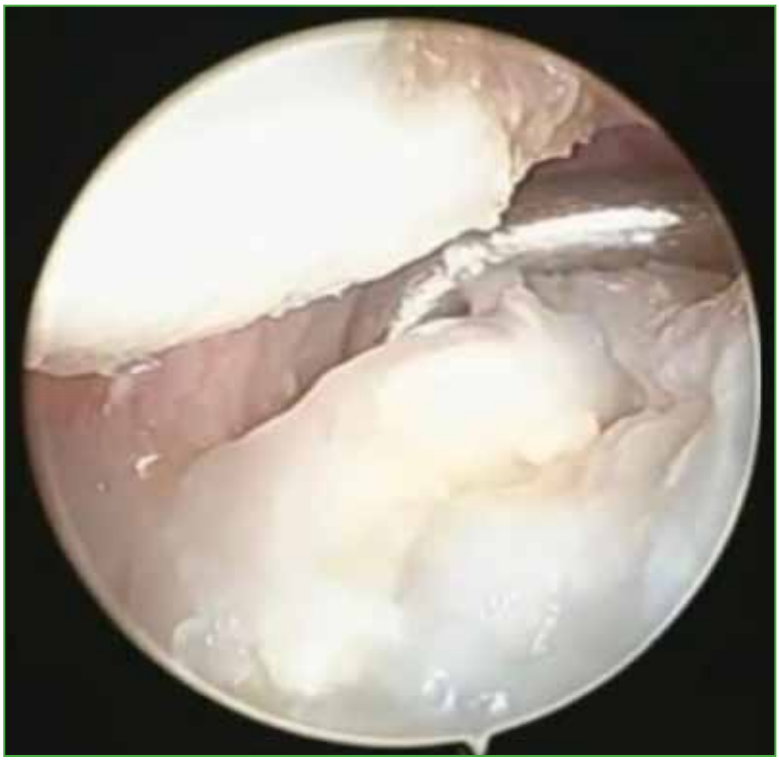


Figure 12. Fibrosis covered graft, with adequate tension and stability.

DISCUSSION

Various treatment options have been published for chronic TFCC injuries, often based on the original Adams and Berger technique. These authors proposed an open, non-anatomic radial and ulnar ligament reconstruction technique, with variable outcomes.[13]

Luchetti et al., along with Chu-Kay Mak and Ho in 2017, developed an arthroscopically assisted technique derived from the non-anatomic reconstruction described by Adams, also reporting variable outcomes.[15]

In 2021, Liu and Fok, as well as Zhang et al., published a technique for chronic foveal lesions with preserved radial insertion. However, this approach could not be applied in our study due to the presence of irreparable radial injuries in our patient cohort.[17,18]

Carratalá et al. introduced the TFCC ligamentoplasty technique for addressing chronic instability in Atzei 4 lesions. Their limited series included four patients (mean age: 41 years) with a follow-up period of 24 months. The outcomes were categorized as excellent (1 case), good (2 cases), and poor (1 case) based on the Mayo Wrist Score (MWS). The pre-surgical DASH score averaged 44, improving to 11 post-surgery.[14]

In our series, the Carratalá ligament reconstruction technique was performed on nine consecutive patients with a follow-up period of 14 months. Our results showed excellent or good outcomes, comparable to those reported by other authors, despite the shorter follow-up period. A comparative summary of our series alongside other major studies is presented in Table 4.

Table 4. Comparative outcomes with reference series

Results	Technique	Patients (n)	Follow-up (months)	Grip (%)	DASH score	MWS (excellent or good)	Sensory neuropathy	Residual instability
Luchetti et al.	Atzei reconstruction	11	68	-	48 preop. 25 postop.	82	1	1
Chu-Kay Mak and Ho	Author's	28	62	71	-	79	3	-
Carratalá et al.	Author's	4	24	-	44 preop. 11 postop.	85	-	-
Liu and Fok	Author's	12	29	90	31 preop. 9 postop.	95	-	-
Zhang et al.	Reconstruction with bone monotunnel with grafting	12	21	89	-	89	-	-
Sala et al.	Carratalá ligamentoplasty	9	14	85	61 preop. 9 postop.	90	-	1

DASH = *Disabilities of Arm, Shoulder and Hand score*; MWS = *Mayo Wrist Score*; preop. = preoperative; postop. = postoperative.

All the aforementioned studies, including ours, demonstrated similar outcomes—ranging from excellent to good—with minimal complications. Patients regained a comparable percentage of strength, and our DASH and MWS scores were equal to or better than the previously reported outcomes.

Based on the existing literature and the results of our case series, we consider the Carratalá ligamentoplasty technique to offer the best biomechanical solution for repairing Atzei 4 lesions.

The strengths of our study include the evaluation of a homogeneous group of patients, consistent application of the treatment by a single surgeon, and a revision ligamentoplasty in which a structure resembling neofibrocartilage was observed. However, the study's retrospective design, small sample size, and lack of long-term follow-up are notable limitations.

CONCLUSIONS

Arthroscopic reconstruction of the TFCC in chronic Atzei 4 injuries using the Carratalá ligamentoplasty technique for distal radioulnar stabilization is a minimally invasive, reproducible approach that achieves good functional outcomes.

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

A. D. Ledesma ORCID ID: https://orcid.org/0009-0000-2519-7127
L. E. Galván ORCID ID: https://orcid.org/0000-0002-5989-557X
J. Silva Martínez ORCID ID: https://orcid.org/0009-0007-1787-8978

REFERENCES

1. Okuda M, Sato K, Mimata Y, Murakami K, Takahashi G, Doita M. Morphology of the ulnar insertion of the triangular fibrocartilage complex and related osseous landmarks. *J Hand Surg Am* 2021;46(7):625.e1-625.e7. https://doi.org/10.1016/j.jhsa.2020.12.006
2. Chu-Kay Mak M, Ho PC. Arthroscopic-assisted triangular fibrocartilage complex reconstruction. *Hand Clin* 2017;33(4):625-37. https://doi.org/10.1016/j.hcl.2017.07.014
3. Jung HS, Song KS, Jung HS, Yoon BI, Lee JS, Park MJ. Clinical outcomes and factors influencing these outcome measures resulting in success after arthroscopic transosseous triangular fibrocartilage complex foveal repair. *Arthroscopy* 2019;35(8):2322-30. https://doi.org/10.1016/j.arthro.2019.03.060
4. Atzei A, Luchetti R. Foveal TFCC tear classification and treatment. *Hand Clin* 2011;27(3):263-72. https://doi.org/10.1016/j.hcl.2011.05.014
5. Fischer J, Thompson NW, Harrison JWK. Triangular fibrocartilage complex lesions-A classification. In: Banaszkiewicz P, Kader D. *Classic papers in orthopaedics.* London: Springer; 2014, pp. 371-2. https://doi.org/10.1007/978-1-4471-5451-8_93
6. Zook EG. Age changes in the triangular fibrocartilage of the wrist joint. *Plast Reconstr Surg* 1979;64(1):128. https://doi.org/10.1097/00006534-197907000-00095
7. Rein S, Krenn V, Hagert E, García-Elias M, Lluch A, Kremer T, et al. Degeneration of the articular disc in the human triangular fibrocartilage complex. *Arch Orthop Trauma Surg* 2021;141(4):699-708. https://doi.org/10.1007/s00402-021-03795-2
8. Ma CH, Lin TS, Wu CH, Li DY, Yang SC, Tu YK. Biomechanical comparison of open and arthroscopic transosseous repair of triangular fibrocartilage complex foveal tears: A cadaveric study. *Arthroscopy* 2017;33(2):297-304. https://doi.org/10.1016/j.arthro.2016.10.027
9. Ruch DS, Anderson SR, Ritter MR. Biomechanical comparison of transosseous and capsular repair of peripheral triangular fibrocartilage tears. *Arthroscopy* 2003;19(4):391-6. https://doi.org/10.1053/jars.2003.50137
10. Andersson JK, Åhlén M, Andernord D. Open versus arthroscopic repair of the triangular fibrocartilage complex: a systematic review. *J Exp Orthop* 2018;5(1):1-10. https://doi.org/10.1186/s40634-018-0120-1
11. Mathoulin CL. Indications, techniques, and outcomes of arthroscopic repair of scapholunate ligament and triangular fibrocartilage complex. *J Hand Surg Eur Vol* 2017;42(6):551-66. https://doi.org/10.1177/1753193417708980
12. Atzei A, Luchetti R, Braidotti F. Arthroscopic foveal repair of the triangular fibrocartilage complex. *J Wrist Surg* 2015;4(1):22-30. https://doi.org/10.1055/s-0035-1544226
13. Adams BD, Berger RA. An anatomic reconstruction of the distal radioulnar ligaments for posttraumatic distal radioulnar joint instability. *J Hand Surg Am* 2002;27(2):243-51. https://doi.org/10.1053/jhsu.2002.31731
14. Carratalá V, Lucas FJ, Miranda I, Martínez C, Guisasola E. All-arthroscopic triangular fibrocartilage complex ligamentoplasty: technique and results. *J Wrist Surg* 2022;12(2):104-12. https://doi.org/10.1055/s-0042-1757765
15. Luchetti R, Khanchandani P, Da Rin F, Borelli PP, Mathoulin C, Atzei A. Arthroscopically assisted Sauvé-Kapandji procedure: An advanced technique for distal radioulnar joint arthritis. *Tech Hand Up Extrem Surg* 2008;12(4):216-20. https://doi.org/10.1097/BTH.0b013e31818ee28a
16. Lindsay TAJ. Ligamentization and remnant integration: review and analysis of current evidence and implications for scapholunate reconstruction. *J Wrist Surg* 2020;10(6):476-83. https://doi.org/10.1055/s-0040-1716863
17. Liu B, Fok MWM. The medium term outcomes of an all-arthroscopic triangular fibrocartilage complex foveal reconstruction using tendon graft. *Int Orthop* 2021;45(5):1273-9. https://doi.org/10.1007/s00264-021-04976-9
18. Zhang W, Hou P, Wang C, Wu T, Ho PC, Sun L. Arthroscopic one-tunnel transosseous reconstruction of chronic triangular fibrocartilage complex foveal tears: outcomes in 12 patients. *J Hand Surg Eur Vol* 2022;47(3):296-301. https://doi.org/10.1177/17531934211056854

Arthroscopic Repair of the TFCC by Knotless Double-row Suture Anchoring and Early Mobilization: Preliminary Outcomes

Juan Matías Sala, Aldo D. Ledesma
Servicio de Cirugía de Mano Patagónica (CIMAP), OTI, Clínica del Valle S.R.L. Comodoro Rivadavia, Chubut, Argentina.

ABSTRACT

Objective: This study retrospectively evaluates the functional outcomes of patients with triangular fibrocartilage complex (TFCC) foveal injuries treated arthroscopically with knotless double-row suture anchor repair. **Materials and Methods:** Fourteen consecutive patients with Atzei type 2/3 TFCC foveal lesions were retrospectively analyzed. All were of working age and had an average follow-up of 15 months. Arthroscopic repair was performed using a knotless double-row suture anchor repair with monotunnel foveal anchorage. One suture fixed the volar radioulnar ligament, while the other secured the dorsal radioulnar ligament to the fovea. Outcomes assessed included range of motion (ROM), grip strength, the Mayo Wrist Score, and the Disabilities of the Arm, Shoulder, and Hand (DASH) score. **Results:** Improvements in pain and strength were observed. The Mayo Wrist Score results were rated as excellent or good. The average DASH score improved from 62 preoperatively to 8 postoperatively. Comparative grip strength was 80% of the contralateral side. **Conclusions:** Arthroscopic repair of Atzei type 2/3 lesions using a double-row suture anchor repair with monotunnel ligament anchorage yields good outcomes, improving ROM, restoring stability, and achieving partial or total recovery of strength. Careful attention should be given to suture passage through the TFCC and screw fixation in the metaphysis to minimize complications.

Keywords: Wrist arthroscopy; triangular fibrocartilage complex; TFCC isometric anchorage; radioulnar instability.
Level of Evidence: IV

Resultados del tratamiento artroscópico de lesiones foveales del complejo del fibrocartílago triangular mediante doble sutura isométrica sin nudo

RESUMEN

Objetivo: Evaluar, en forma retrospectiva, la función y los resultados de los pacientes con una lesión foveal del complejo del fibrocartílago triangular tratados con un anclaje óseo isométrico con doble sutura ligamentaria, monotúnel, por vía artroscópica. **Materiales y Métodos:** Se evaluó a 14 pacientes consecutivos, en edad laboral, que tenían una lesión foveal del complejo del fibrocartílago triangular Atzei 2/3 y un seguimiento promedio de 15 meses. Todas las lesiones se repararon mediante artroscopia con una doble sutura ligamentaria, isométrica, sin nudo con anclaje foveal monotúnel. Se utilizó una sutura para fijar el ligamento radiocubital volar y otra para fijar el ligamento radiocubital dorsal a la fóvea. Se evaluaron el rango de movilidad, la fuerza de agarre, y se utilizaron el *Mayo Wrist Score* y el puntaje DASH. **Resultados:** Los puntajes de dolor y fuerza mejoraron. El *Mayo Wrist Score* fue excelente y bueno. El puntaje DASH preoperatorio era de 62 y de 8 en el posoperatorio. El promedio de la fuerza comparativa contralateral fue del 80%. **Conclusiones:** La reparación artroscópica de las lesiones Atzei 2/3 mediante doble sutura isométrica con anclaje ligamentario monotúnel, sin nudo logra buenos resultados: mejora el rango de movilidad, recupera la estabilidad y la fuerza en forma total o parcial. Se debe tener cuidado en el pasaje de las suturas por el complejo del fibrocartílago triangular y la fijación mediante el tornillo en la metáfisis para evitar las complicaciones comunicadas en esta serie.

Palabras clave: Artroscopia de muñeca; complejo del fibrocartílago triangular; anclaje isométrico; inestabilidad radiocubital distal.
Nivel de Evidencia: IV

Received on June 4th, 2024. Accepted after evaluation on October 2nd, 2024 • Dr. JUAN MATÍAS SALA • salajuanmatias@icloud.com https://orcid.org/0000-0001-5542-5004

How to cite this article: Sala JM, Ledesma AD. Arthroscopic Repair of the TFCC by Knotless Double-row Suture Anchoring and Early Mobilization: Preliminary Outcomes. *Rev Asoc Argent Ortop Traumatol* 2024;89(6):584-605. https://doi.org/10.15417/issn.1852-7434.2024.89.6.1980

INTRODUCTION

The triangular fibrocartilage complex (TFCC) primarily functions to stabilize the distal radioulnar joint (DRUJ) and to transmit and cushion the load of the hand to the wrist.

This complex is composed of the articular disc, the proximal and distal dorsal and palmar radioulnar ligaments, the ulnocarpal ligaments, and the extensor carpi ulnaris (ECU) subsheath. The articular disc is specifically responsible for load transmission and cushioning.[1]

The stability of the DRUJ relies on the compression between articular surfaces and the tension generated during movement by the dorsal and volar radioulnar ligaments. These ligaments attach radially at the distal radius and deeply at the ulnar fovea. They originate from the ulnodorsal and ulnovolar angles of the distal radius, converging at the distal ulnar fovea, with some fibers extending to the ulnar styloid.[1]

The DRUJ can be conceptualized as a "tensegrity" structure, where tension and compression work together to ensure proper joint function.[1]

Secondary stabilizers of the DRUJ include the joint capsule, the posterior ulnar sheath, the deep head of the pronator quadratus, and the distal oblique band of the interosseous membrane.[2]

The TFCC has a rich vascular supply in its ulnar area, poor vascularity on its radial side, and no vascularization at the center of the disc.[1,2] This complex is surrounded by fibrous structures that play a crucial role in rotational stability, load transmission, and force translation from the wrist to the forearm.[2]

TFCC injury is one of the most common causes of ulnar wrist pain, often limiting daily activities.[1,3]

Palmer classified TFCC injuries into two types: traumatic (acute) and degenerative (chronic) (Table 1).[1-6]

Table 1. Palmer's classification for triangular fibrocartilage complex (TFCC) lesions.

Class 1	A. Central perforation B. Ulnar avulsion C. Avulsion of the ulnocarpal ligaments D. Radial avulsion
Class 2	TFCC central wear Central wear of the TFCC and chondromalacia of the lunate or ulnar head. Perforation of the TFCC and chondromalacia of the lunate or ulnar head. C plus perforation of the lunotriquetral ligament D plus ulnocarpal osteoarthritis

Acute injuries result from wrist trauma involving hyperextension, ulnar deviation, direct impact, or weight-bearing activities.[1,3] Degenerative injuries are associated with repetitive axial loading and ulnar deviation, as well as poor healing of distal radius fractures.[5,6]

Atzei and Luchetti modified the traditional "hammock" concept of the TFCC to an "iceberg" model. In this model, the superficial fibers represent the visible portion that tolerates and absorbs impact, while the deep fibers, responsible for stability, remain hidden. They expanded Palmer's classification for 1B lesions, distinguishing between injuries to superficial and deep fibers and differentiating acute from chronic lesions (Table 2). [1,3]

Wrist arthroscopy is the gold standard for diagnosing and treating TFCC injuries. The two most commonly used arthroscopic tests are the hook test for foveal lesions and the trampoline test for superficial lesions, both with sensitivity and specificity close to 90%.[2,5]

Table 2. Atzei classification for Palmer's 1B lesions.

Class	DRUJ instability	TFCC Involvement Distal	Proximal	Healing potential of the TFCC	DRUJ cartilage condition	Treatment
1 Distal repairable	Mild or negative	Torn	Healthy	Good	Good	Suture
2 Repairable foveal	Moderate or severe	Torn	Torn	Good	Good	Foveal repair
3 Distal and foveal repairable	Moderate or severe	Healthy	Torn	Good	Good	Foveal repair
4 Not repairable	Severe	Torn	Torn	Poor	Good	Reconstruction
5 DRUJ osteoarthritis	Moderate or severe	-	-	-	Poor	Salvage procedure

DRUJ = distal radio ulnar joint; TFCC = triangular fibrocartilage complex.

The preferred technique for treating unstable TFCC lesions involves reinsertion of the foveal fibers.

The aim of this study was to demonstrate that isometric, anatomic repair using the arthroscopically assisted monotunnel anchor technique yields favorable outcomes for TFCC Atzei 2/3 lesions.

MATERIALS AND METHODS

A retrospective study was conducted to evaluate outcomes in 14 adult patients with deep TFCC Atzei 2/3 lesions who underwent surgery between February 1, 2021, and December 31, 2022. Atzei 2 and 3 lesions are foveal TFCC injuries causing DRUJ instability.

Inclusion criteria were: age >18 years, no history of TFCC surgery or wrist arthroscopy, who had ulnar wrist border pain compatible with a TFCC injury limiting work, sport or daily activities; positive Berger, Ruby and Nakamura tests, Atzei 2/3 lesions confirmed by arthroscopy and a minimum postoperative follow-up of 6 months. In this study, the association or not of ulnar styloid fracture was not considered.

Exclusion criteria were: previous TFCC surgery, previous wrist arthroscopy, Palmer 2 degenerative TFCC lesions, and DRUJ osteoarthritis.

Fourteen patients (10 males and 4 females) with unstable foveal TFCC lesions were included. Twelve surgeries involved dominant wrists, while two involved non-dominant wrists.

Wrist range of motion in flexion, extension, and ulnar/radial deviation was measured using a standard PVS hand goniometer. Grip strength was evaluated with a Baseline-Orthowell® hydraulic joint dynamometer.

Pain was assessed using the visual analog scale (VAS) and functional outcomes were measured with the Mayo Clinic Wrist Score (MWS) and the Disabilities of Arm, Shoulder, and Hand (DASH) score.

The mean time from injury to surgery was 4 months (range: 6 weeks to 14 months). Postoperative follow-up ranged from 11 to 22 months (mean: 15 months).

The treatment protocol was as follows: During the first consultation for ulnar wrist pain, a detailed history of the trauma mechanism was obtained, followed by a clinical examination. Tests including Nakamura's, Waiter's, Ruby's, Berger's, and axial ulnocarpal compression in three wrist positions (compared to the contralateral side) were performed. Radiographs (anteroposterior and weight-bearing anteroposterior views) and MRI were requested.

For injuries confirmed by imaging within 6 weeks of occurrence, immobilization with a sugar-tong splint for 3 weeks was prescribed. Following immobilization, physiotherapy was initiated. If positive clinical signs persisted after rehabilitation, diagnostic and therapeutic wrist arthroscopy was performed. For injuries presenting more than 6 weeks after the trauma, surgical repair was directly indicated.

Surgical Technique

The procedure is performed under plexus block anesthesia with an ischemia-preventive cuff inflated to 250 mmHg. Standard portals 3-4 and 6R, along with an ulnar incision approximately 3 cm long and located 1.5 cm distal to the ulnar styloid tip, are routinely utilized.

First, the entire radiocarpal joint is explored. Subsequently, the trampoline and hook tests are conducted to assess TFCC lesions and classify them (Figures 1 and 2).

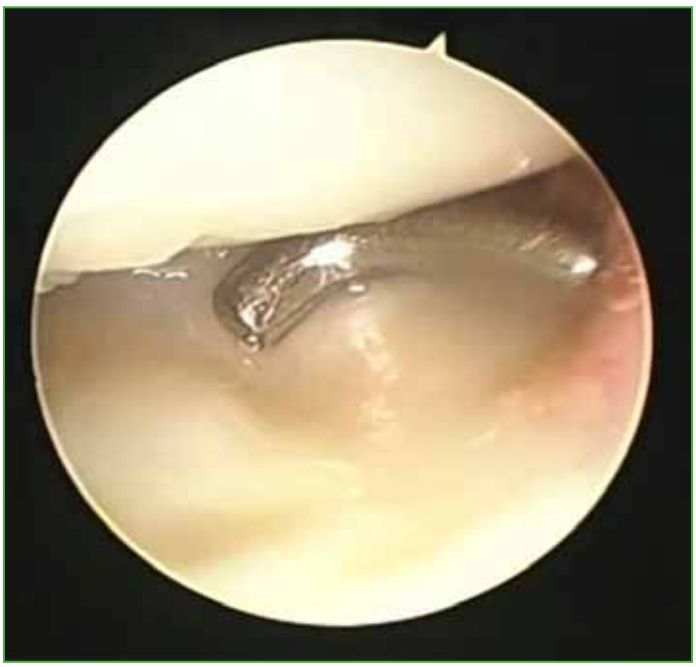


Figure 1. Trampoline test.

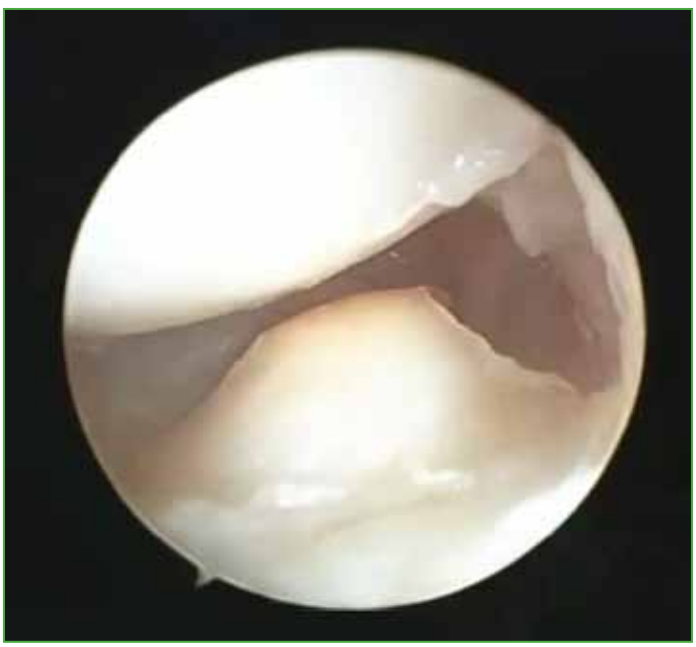


Figure 2. Hook test.

During the hook test, the probe is inserted through the 6R portal into the prestyloid recess. An attempt is made to elevate the articular disc. A negative test indicates failure to elevate the disc, while a positive test confirms successful elevation and indicates a foveal lesion of the deep radioulnar ligaments.

During the trampoline test, the probe is inserted through the 6R portal and pressed onto the articular disc to assess its tension. If the disc resists depression, the test is negative. Conversely, a positive test demonstrates depression of the disc, confirming a lesion of the superficial radioulnar ligaments.

Once a lesion is confirmed, synovectomy and debridement are performed. A TFCC guide is positioned externally at the ulnar site, entering through portal 6R, to create the ulnar tunnel in Matsumoto zone 2/2 (Figure 3).

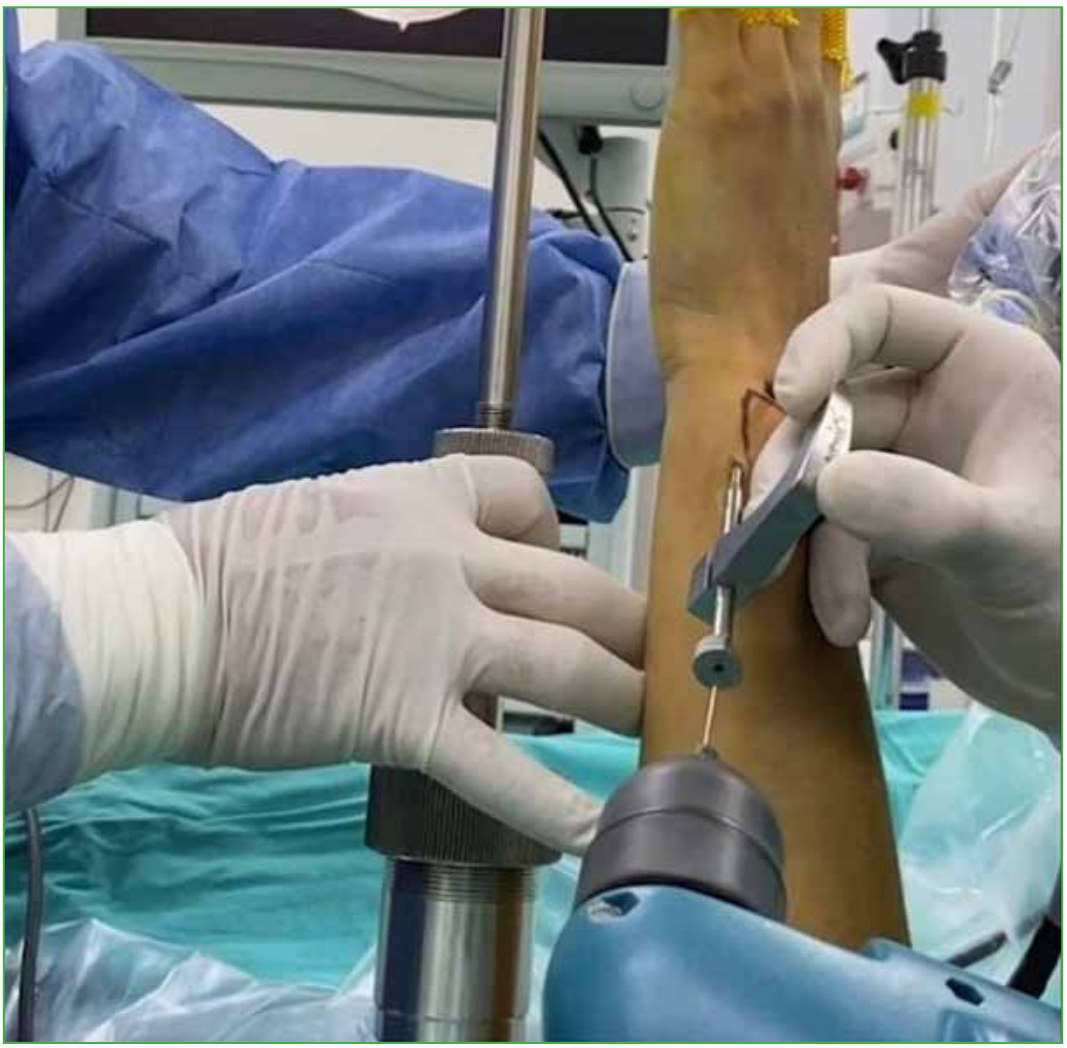


Figure 3. Placement of the triangular fibrocartilage complex guide through the 6R portal.

An ulnar incision, approximately 3 cm long, is made starting 1.5 cm distal to the ulnar styloid. This approach allows placement of the guide wire through portal 6R. Careful dissection is crucial to prevent injury to the ulnar sensory branch.

The guide is set at a 45° angle, 1.5 cm from the ulnar styloid, with an aperture for pin placement. Maintaining this angle and distance is essential to ensure the pin exits in the correct area of the ulna.

After proper alignment, a pin is inserted using a motor to create the ulnar tunnel. The pin penetrates the articular disc, confirming the tunnel's accurate positioning in Matsumoto zone 2.

Reaming of the bone tunnel is performed using a 3.5 mm guide with a reamer protector to prevent damage to the sensory branch of the ulnar nerve. Reaming is limited to the ulna and must avoid drilling through the articular disc to preserve its integrity for subsequent anchorage. After reaming, the guide, reamer, and initial pin are removed.

A suture passer with a 2.0 unbreakable suture (FiberWire®) is introduced through the ulnar tunnel, penetrating the volar radioulnar ligament in zone 1. The needle is inserted 2 mm dorsal to the ulnocarpal ligaments. One end of the suture is retrieved through portal 6R, while the other remains outside the ulnar tunnel (Figures 4-6).

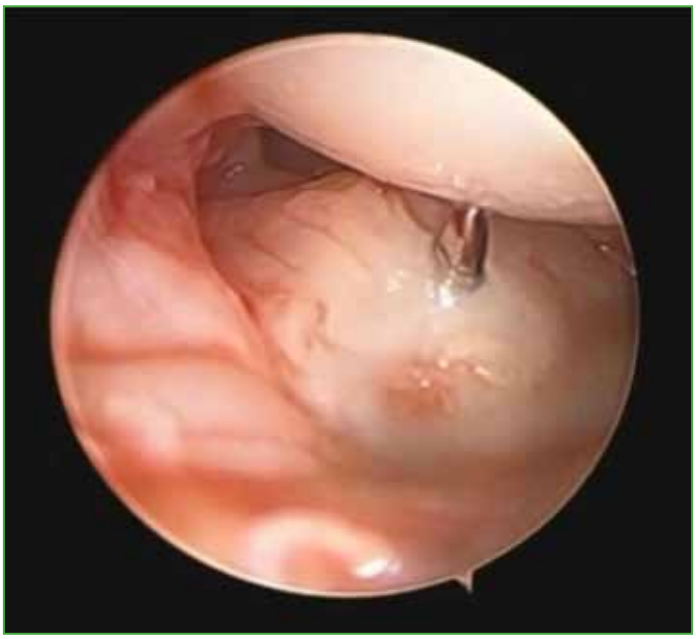


Figure 4. View of the pin in zone 2.

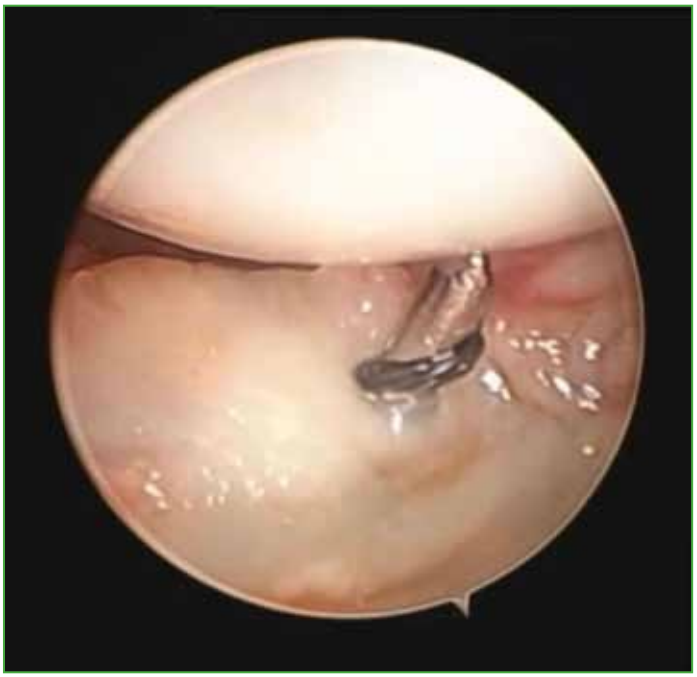


Figure 5. Suture pin insertion in Matsumoto zone 2.

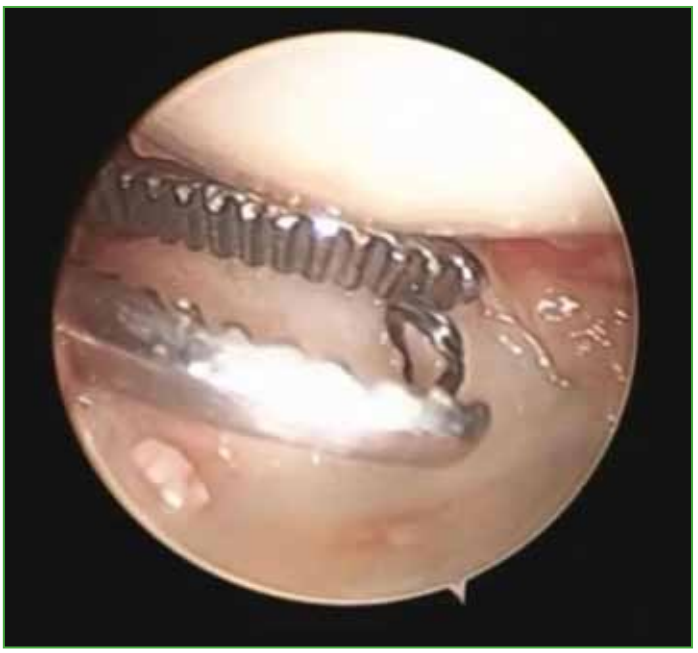


Figure 6. Retrieval of the thread through portal 6R.

A suture puller is then introduced through the ulnar tunnel, penetrating the volar radioulnar ligament in zone 3, with an insertion 2 mm dorsal to the ulnocarpal ligaments. The suture puller exits through portal 6R, creating a loop. The free end of the first suture is passed through this loop and gently pulled, securing it in the ulnar tunnel. This process tightens the fibrocartilage at the volar ligament margin (Figures 7-9).

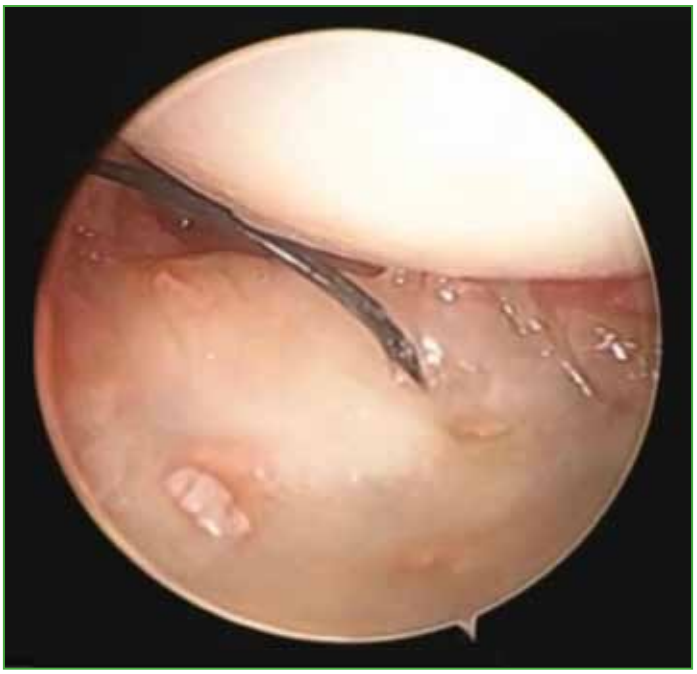


Figure 7. View from portal 3-4 of the suture passer thread retrieved through portal 6R.

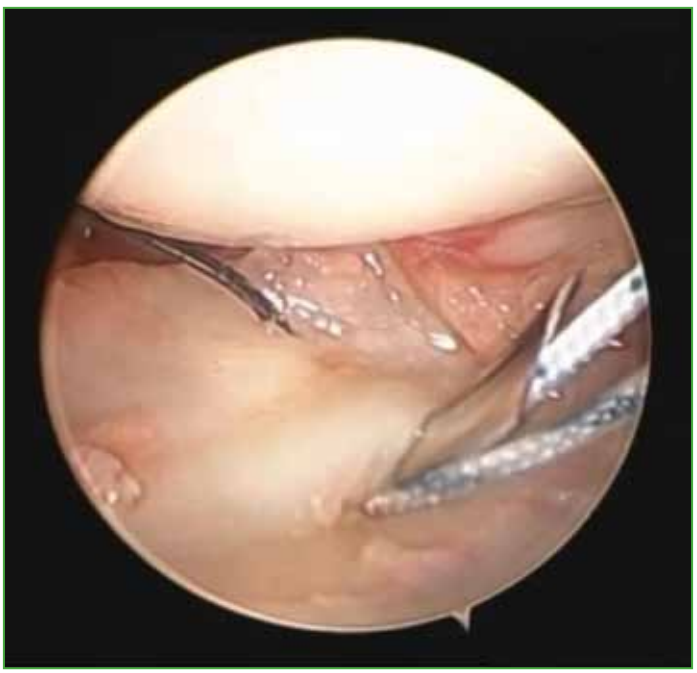


Figure 8. Needle with FiberWire® suture perforating the volar radioulnar ligament.

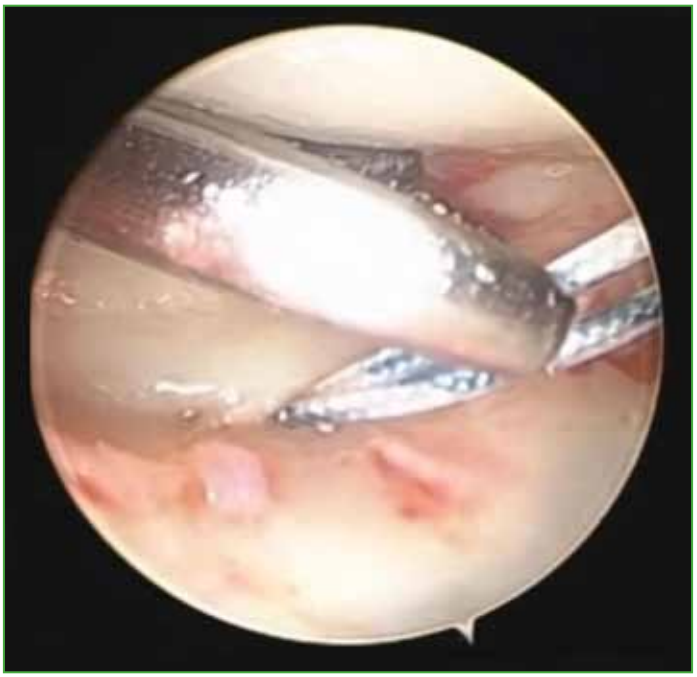


Figure 9. Retrieval of the FiberWire® suture through the 6R portal.

The approximate distance between the two perforations of the volar radioulnar ligament is 2 to 3 mm. The end of the suture that was retrieved through portal 6R is placed inside the loop of the suture retriever and gently pulled from the end of the suture retriever that was held outside the ulnar tunnel by visualization through portal 3-4. The free end that was through portal 6R is seen to descend through the traction of the suture retriever and is introduced into the ulnar hole by tightening the fibrocartilage at its volar ligamentous margin (Figures 10-13). In this way, a suture is obtained by tightening the volar radioulnar ligament with its two limbs through the ulnar tunnel and its ends outside it.

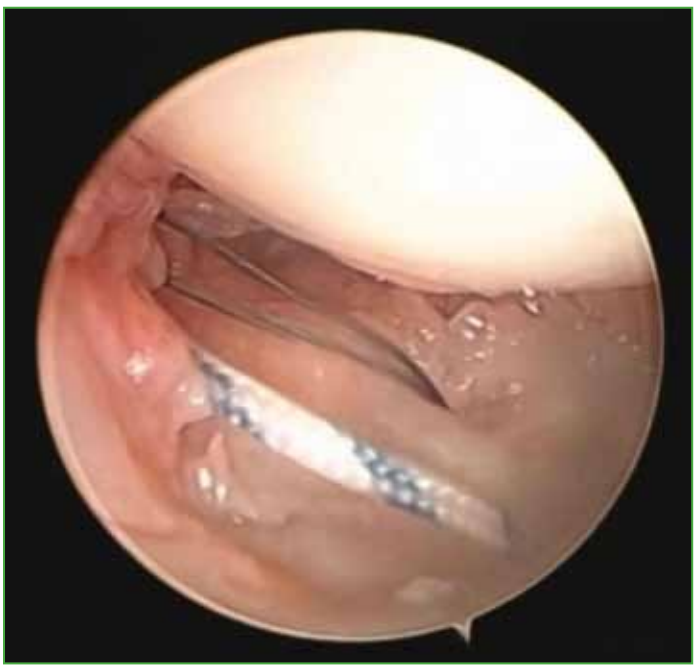


Figure 10. FiberWire® suture retrieved through the 6R portal.

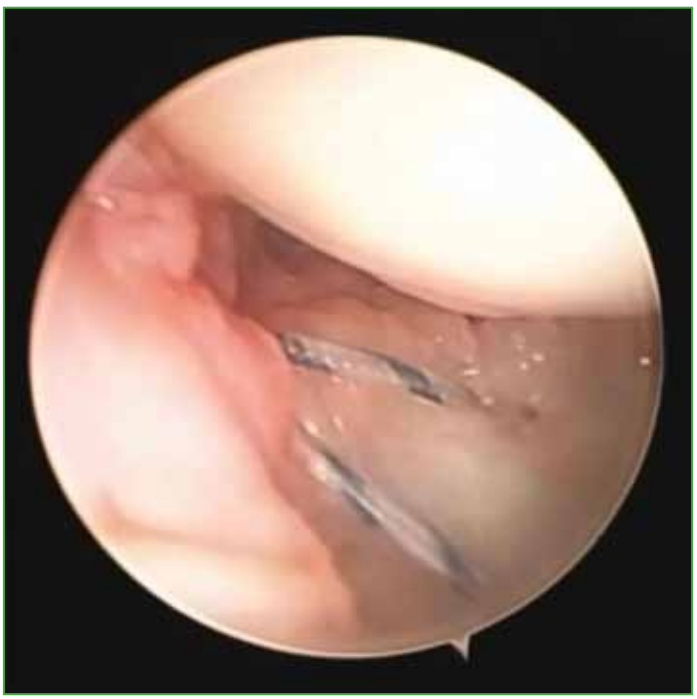


Figure 11. Passage of the FiberWire® suture through the ulnar tunnel using the suture retriever.

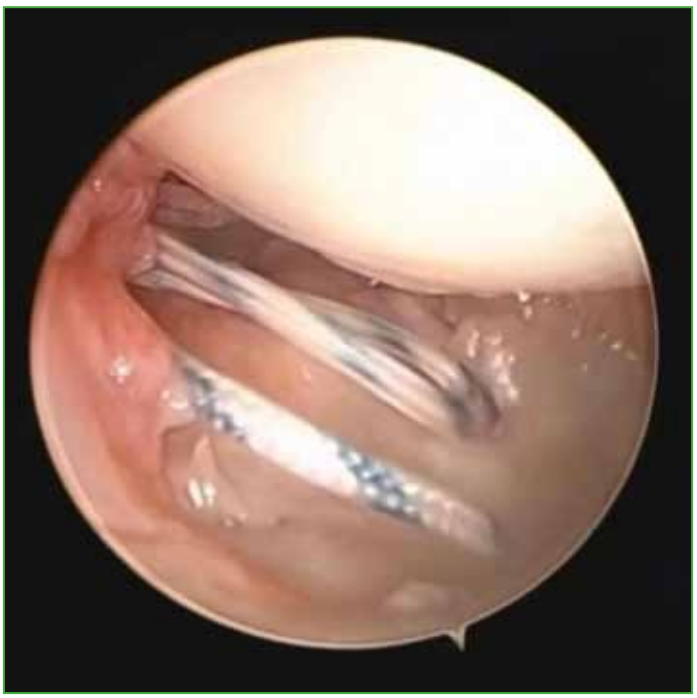


Figure 12. Suture retrieval through the ulnar tunnel, as seen through the 6R portal.

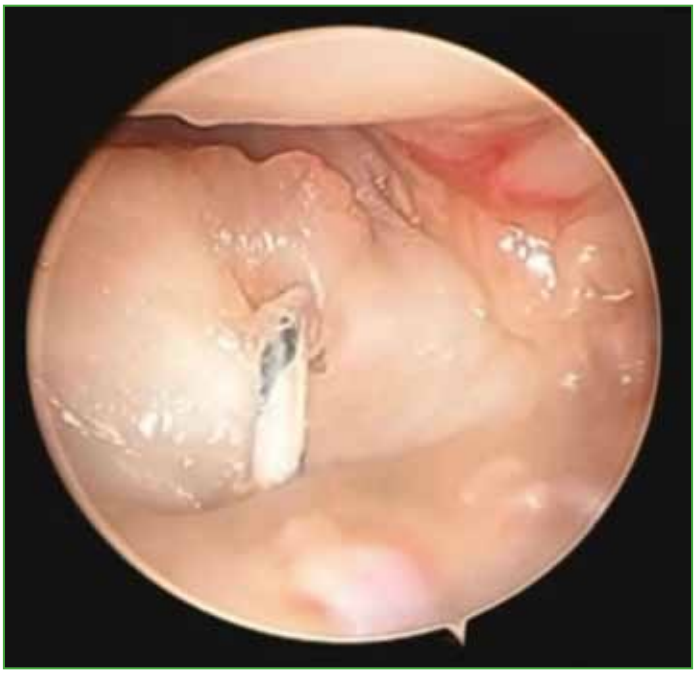


Figure 13. Tensioning of the volar radioulnar ligament, first suture, seen from portal 3-4.

Then, a suture passer with FiberWire® is used to penetrate the dorsal radioulnar ligament in zone 4, with insertion 2 mm volar to the dorsal capsule. The suture is retrieved through portal 6R and tightened through the ulnar tunnel (Figures 14-16).

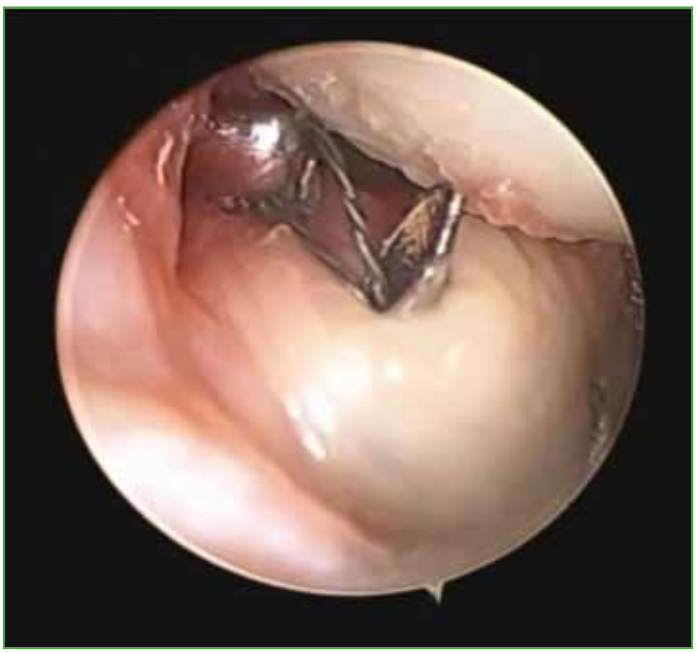


Figure 14. Second threaded pin through the ulnar tunnel. The dorsal radioulnar ligament is perforated, as seen from portal 3-4.

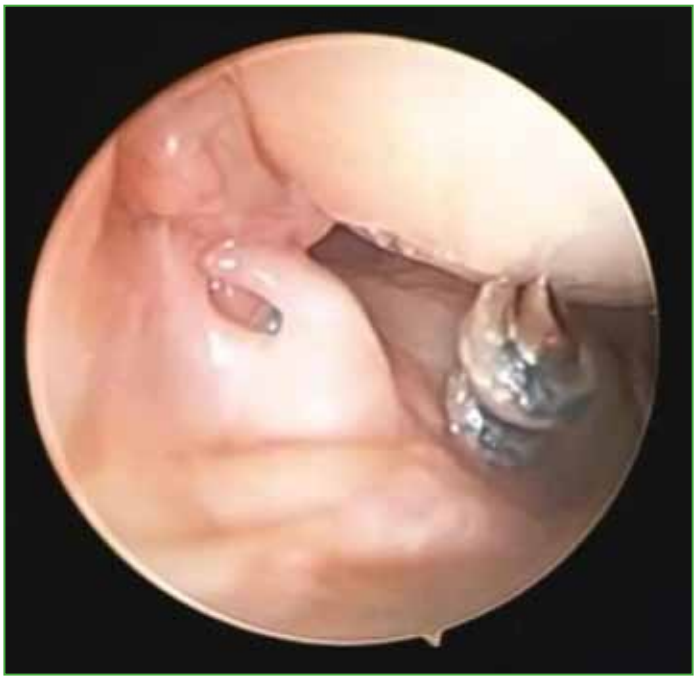


Figure 15. Second FiberWire® suture through the ulnar tunnel, 2 mm radial to the dorsal radioulnar ligament.

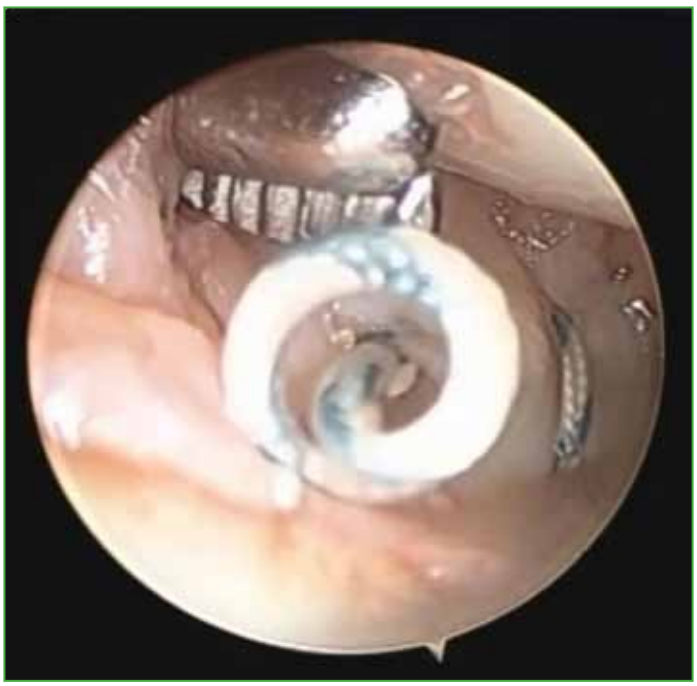


Figure 16. FiberWire® suture retrieved through the 6R portal.

Another suture puller is introduced to secure the dorsal ligament in zone 6, again 2 mm volar to the dorsal capsule. The suture is passed through the loop, tightened, and secured in the ulnar tunnel (Figures 7-9).

The approximate distance between the two dorsal radioulnar ligament perforations is 2 to 3 mm. The end of the suture that was retrieved through portal 6R is placed inside the loop of the suture retriever and gently pulled from the end of the suture retriever that was held outside the ulnar tunnel by visualization through portal 3-4. It is observed how the free end that was through portal 6R descends thanks to the traction of the suture retriever and is introduced into the ulnar hole by tightening the fibrocartilage at its dorsal ligamentous margin (Figures 17 and 18).

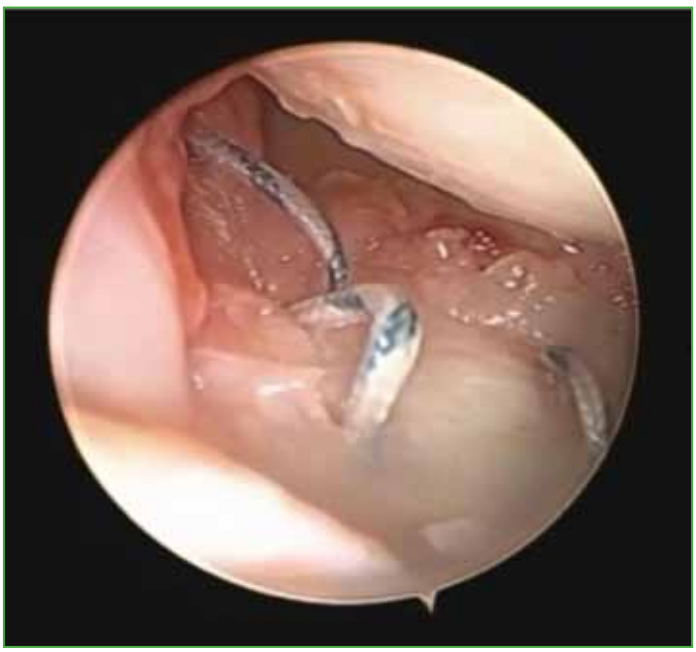


Figure 17. Second FiberWire® suture retrieved through the 6R portal.

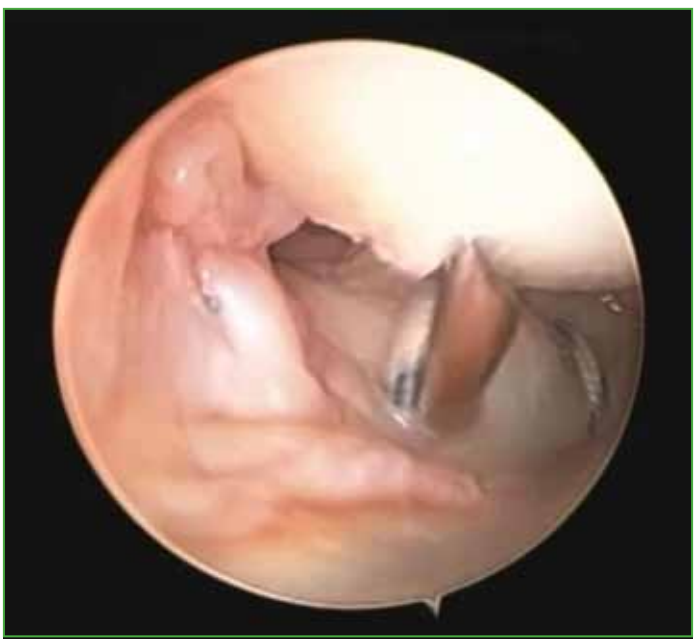


Figure 18. Passage and retrieval of the FiberWire® suture through the ulnar tunnel, view from portal 3-4.

In this way, a suture is obtained by tightening the dorsal radioulnar ligament with its two limbs through the ulnar tunnel and its ends outside the ulnar tunnel (Figure 19).

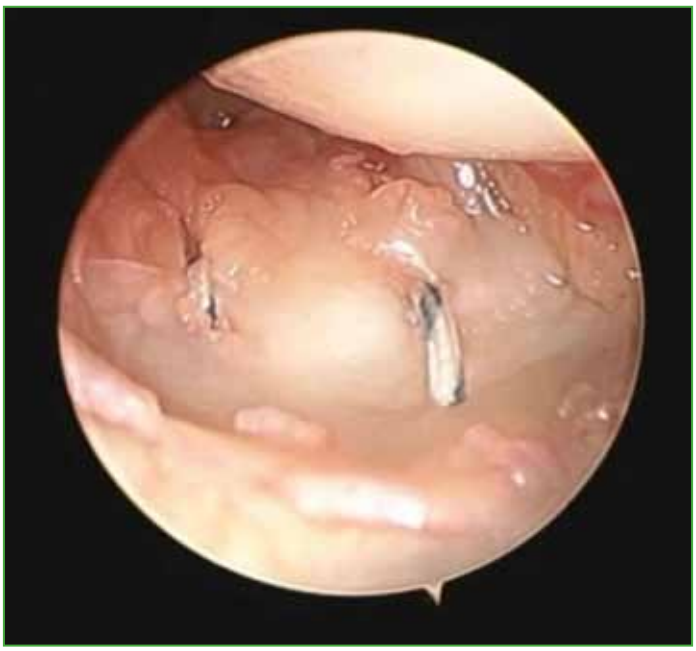


Figure 19. Tensioning of the dorsal radioulnar ligament of the triangular fibrocartilage complex, view from portal 3-4.

The two sutures tightening the TFCC are observed through portal 3-4, one in zones 1 and 3 corresponding to the volar radioulnar ligament and the other tightening the TFCC in zones 4 and 6 tightening the dorsal radioulnar ligament.

To finalize the repair, a 2.5 mm knotless anchorage device is employed. This device consists of a biodegradable screw with an eyelet for suture placement. A 2.2 mm bone tunnel is drilled horizontally into the ulnar metaphysis, 1 cm distal to the previously created ulnar tunnel, taking care to avoid damage to the dorsal sensory branch of the ulnar nerve. The sutures are threaded through the eyelet of the device, and the fixation system is inserted into the tunnel. After ensuring proper positioning, the device is impacted with a hammer, and the free suture ends are pulled to confirm secure anchorage.

The wrist is then placed in the traction tower, and the trampoline and hook tests are repeated to confirm stability (Figure 20). Full pronation and supination movements are performed under visualization to ensure the sutures remain secure. Finally, the wrist is removed from the traction tower, and the DRUJ is tested using the Nakamura test. Once stability is confirmed, the portals and ulnar incision are closed, and a Münster-type splint (sugar-tong splint) is applied. Figures 21 and 22 illustrate the bone and suture placements (Video).

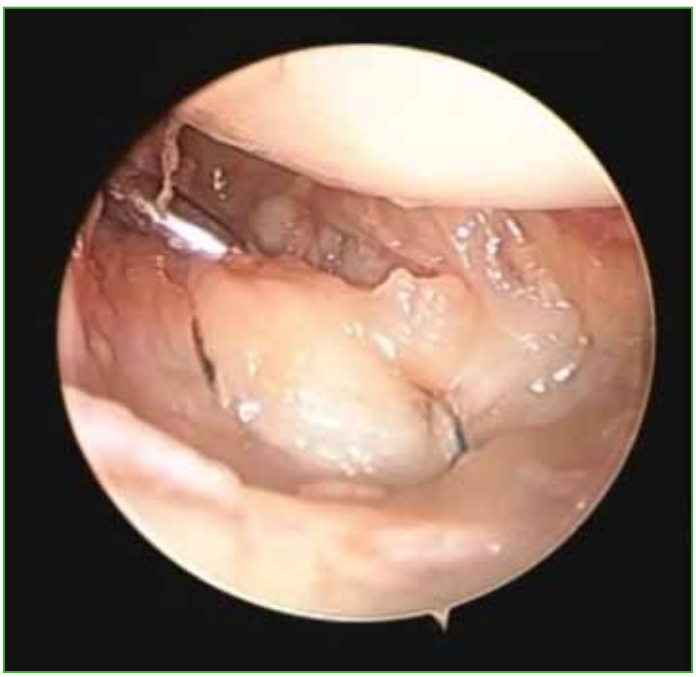


Figure 20. Reinsertion of the dorsal and volar ligaments of the triangular fibrocartilage complex. Negative hook test. View from portal 3-4.

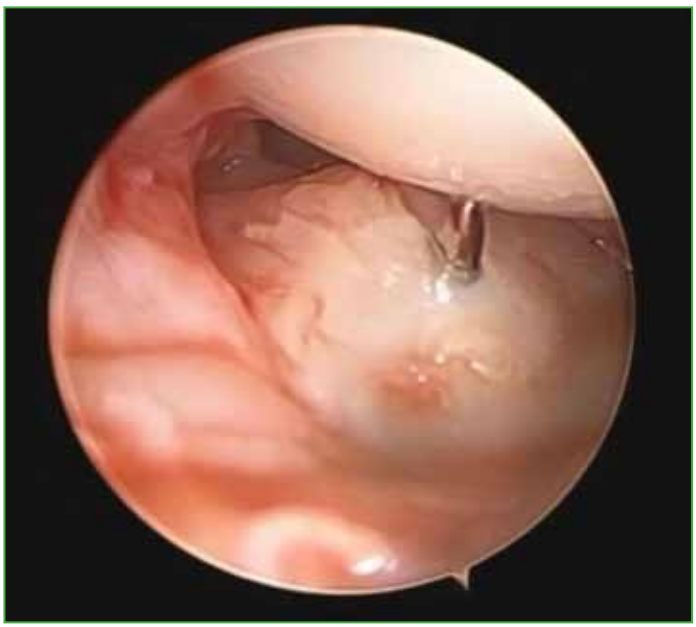


Figure 21. Verifying the pin in bone zone 2.

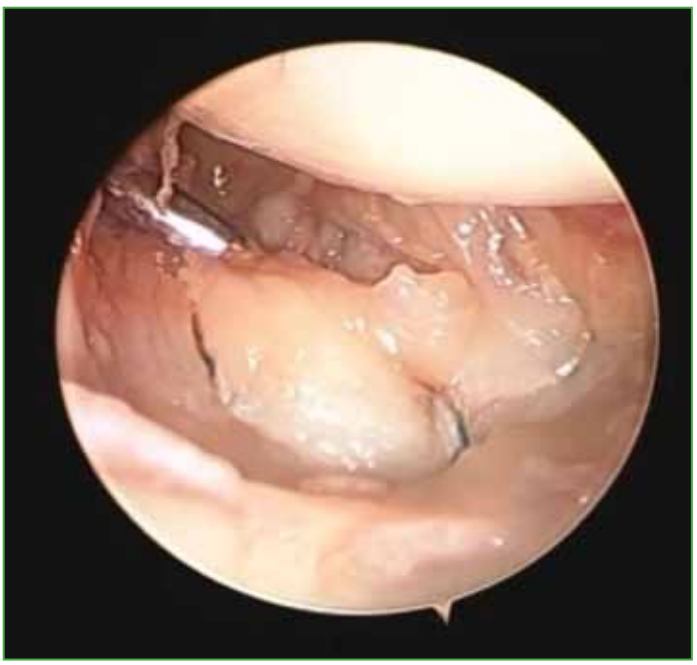


Figure 22. Verifying the suture areas in positions 1 and 3 (volar suture), and 4 and 6 (dorsal suture).

Postoperative Protocol

Seventy-two hours after surgery, the first dressing change is performed. The Münster-type splint is removed, a whale wrist brace is applied, and early mobility exercises are initiated under the guidance of a kinesiologist or occupational therapist.

The early mobility protocol includes: use of a nocturnal wrist brace for the first 3 weeks only; immediate initiation of 70% pronation, with progressive increase to 100% by the third week; immediate initiation of full flexion-extension (100%).

At the third week, the nocturnal wrist brace is discontinued, and strengthening exercises for the stabilizing tendons of the distal radioulnar joint (DRUJ) are introduced. Progressive strengthening begins at 6 weeks, and sports activities, including paddle and racquet sports, are authorized after 2 months.

RESULTS

Fourteen consecutive patients were retrospectively evaluated with a follow-up ranging from 11 to 22 months (mean: 15 months). None of the patients dropped out of follow-up.

Range of motion was measured using a standard PVS handheld goniometer, yielding the following results: extension: 85°; flexion: 80°; radial deviation: 20°; ulnar deviation: 30°; pronation: 80°; supination: 75°

Grip strength was assessed at the third month of follow-up using a standard hydraulic joint dynamometer (Baseline-Orthowell®). Comparative grip strength with the contralateral hand was 80% for both dominant and non-dominant operated hands.

The mean DASH (Disabilities of the Arm, Shoulder, and Hand) score improved significantly, from 62 (range: 41–90) preoperatively to 8 (range: 2–16) postoperatively. The Mayo Wrist Score (MWS) was excellent in 85% of cases and good in 15%.

All patients resumed their sports activities. The mean visual analog scale (VAS) score for pain decreased from 7 preoperatively to 2 at the final follow-up.

Recovery was confirmed when the Nakamura, Ruby, and Derby tests were negative.

Postoperative MRI was performed in four patients (required by work insurance companies), and imaging specialists confirmed healed foveal insertions in all cases (Figure 23).

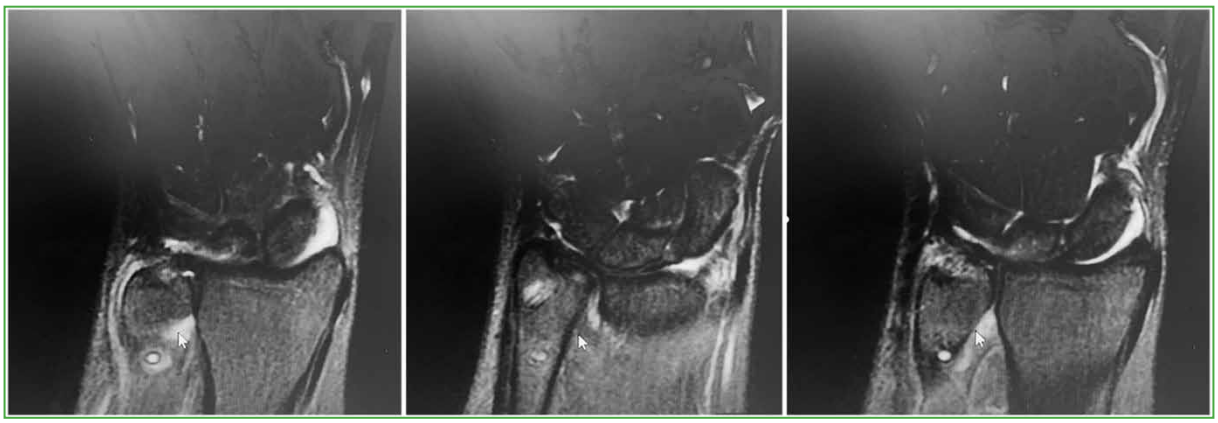


Figure 23. Foveal healing of the triangular fibrocartilage complex with vertical bone tunnel and metaphyseal anchorage at the ulna is seen.

One complication occurred: breakage of the biodegradable screw during placement due to a 2 mm ulnar metaphyseal tunnel. This issue was resolved intraoperatively by widening the tunnel with a 2.2 mm drill and successfully placing a new screw in the correct position.

DISCUSSION

A retrospective study analyzed the surgical outcomes of 14 consecutive adult patients with deep foveal lesions of the Atzei 2/3 TFCC, treated using arthroscopic knotless anchorage. The results were rated good to excellent based on the Mayo Wrist Score (MWS), and significant improvements were observed in the postoperative DASH score compared to preoperative values.

The fibers of the radioulnar ligaments exhibit a spiral rotation as they insert into the fovea. This unique configuration allows different portions of the ligaments to remain taut and functional across the full range of wrist motion, engaging specific bundles at varying joint angles. When the superficial fibers of the volar or dorsal radioulnar ligament are tightened, the deep fibers relax, and vice versa.[1]

Numerous techniques for ligament reinsertion have been described, including harpoon placement in the fovea, reinsertion with monotunnels or bitunnels, and soft tissue anchorage with sutures.[1,2,4-6]

Reinsertion of the dorsal and volar radioulnar ligaments must be both anatomical—over the correct ulnar insertion area—and isometric. Isometry, in this context, refers to the biomechanical principle of maintaining equal ligament length and tension across the widest possible range of motion.

Several alternatives have been published to solve this problematic situation. Although open surgery achieves good long-term outcomes, arthroscopic techniques offer several advantages, including complete evaluation of the lesion, reduced postoperative stiffness, minimal capsular damage, and the ability to address associated injuries.

Nakamura et al. introduced the outside-in technique using two separate tunnels for foveal lesions. In their study of 24 wrists with a mean follow-up of 3.5 years, MWS outcomes were excellent (54%), good (12%), satisfactory (16%), and poor (16%).[7] Shinohara et al. reported on foveal repair using two tunnels and needles in 11 patients with a 30-month follow-up. They found grip strength recovery at 84%, with MWS outcomes being excellent (63%), good (27%), and poor (10%). However, 27% of patients experienced neuropraxia in the territory of the sensory branch of the ulnar nerve.[4]

Ma et al. compared the biomechanical outcomes between open and arthroscopic repair in cadaveric models. They obtained better strength outcomes and lower ulnar translation in arthroscopic than in open repairs.[3] Atzei and Luchetti treated 48 patients arthroscopically, using a foveal harpoon. They reported excellent to good MWS outcomes in 83% of cases, with 85% of patients returning to sports at their pre-injury level. Despite these positive results, the Nakamura test remained positive in 8% of cases. Patients achieved 95% of flexion-extension, 98% of pronation-supination, and 92% of grip strength, though 10% experienced ulnar sensory neuropathy.[1]

Jung et al. evaluated arthroscopic foveal repair using knotless anchorage in 42 patients with a mean follow-up of 26 months. Their MWS outcomes were excellent (12 cases), good (18 cases), fair (11 cases), and poor (1 case). Grip strength reached 69% of the contralateral side.[5] Park et al. conducted a study on arthroscopic foveal repair of the TFCC using a single bone tunnel in 17 patients, with a follow-up of 30 months. Grip strength reached 57% of the unaffected side, and 83% of patients achieved excellent or good outcomes according to the MWS. The DASH score improved from 35.5 preoperatively to 9 postoperatively.[6]

In their cadaveric study, Matsumoto et al. identified the optimal positioning for transosseous tunneling and suture placement in the TFCC based on their impact on joint mobility. They divided the fovea into six zones and the TFCC into another six zones. Their findings showed that tunneling in zone 2 and suturing in any TFCC zone minimized suture mobility. Matsumoto emphasized the importance of creating a precise bone tunnel (Figures 24-26).[7]

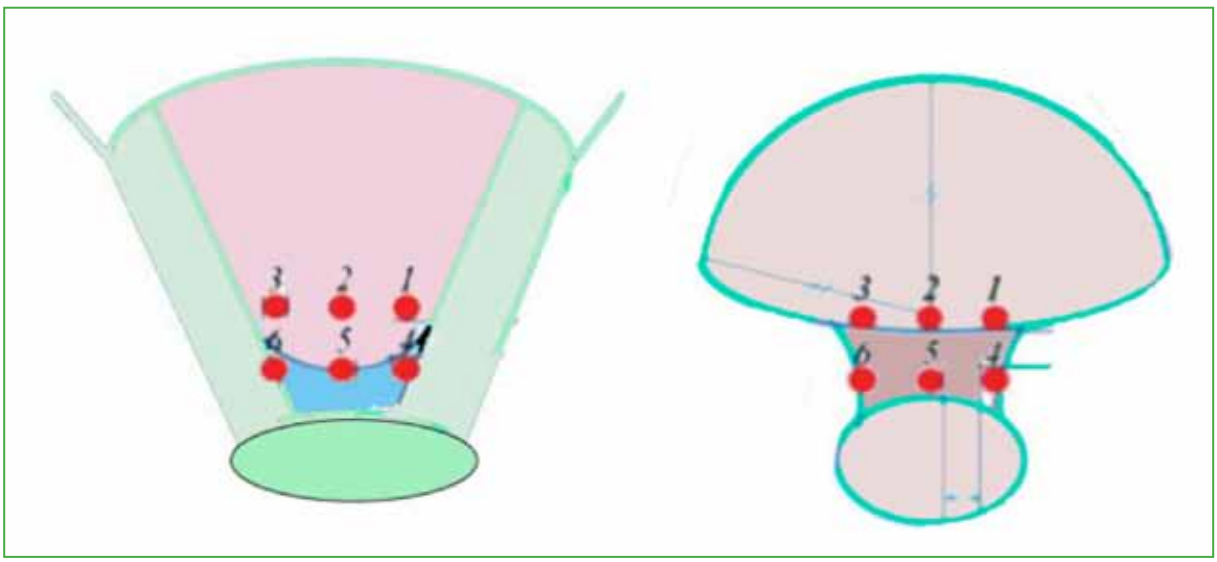


Figure 24. Images of the Matsumoto zones. Foveal areas and areas of the triangular fibrocartilage complex.

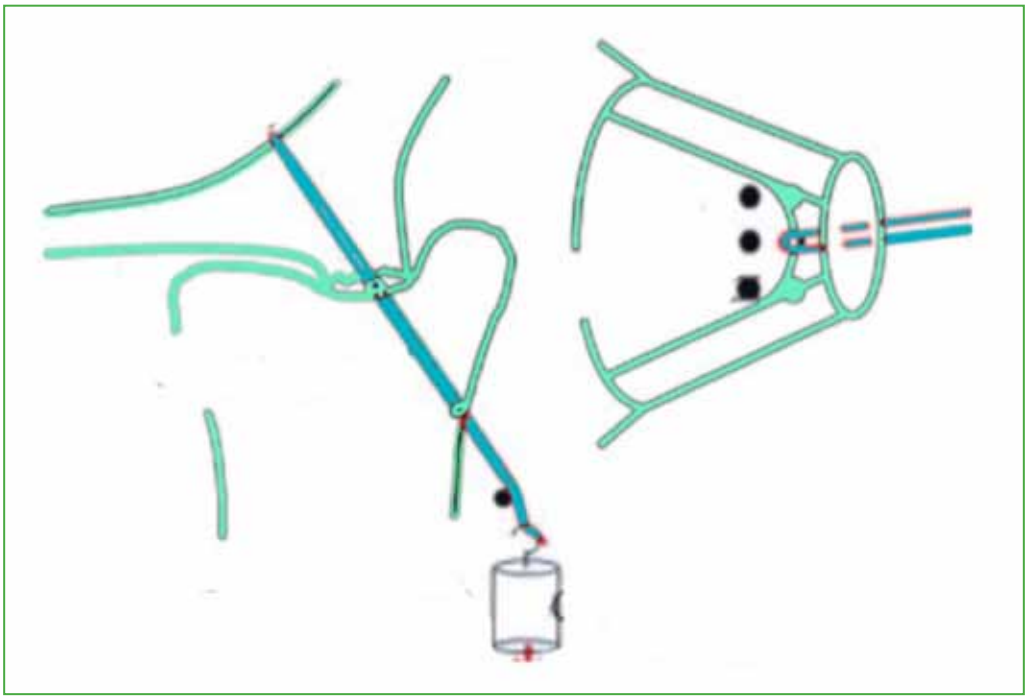


Figure 25. Coronal and axial images of the bone tunnel in zone 2.

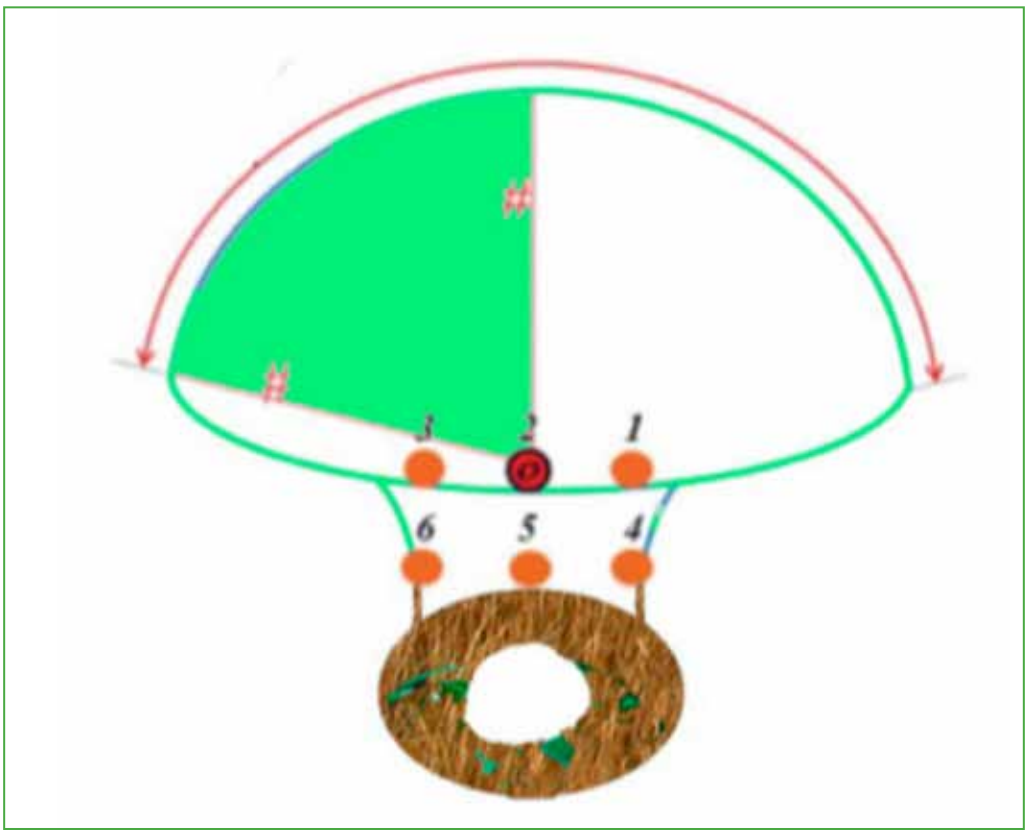


Figure 26. Image of foveal zone 2.

Table 3 presents the comparative outcomes of monotunnel fixation.

Table 3. Comparative outcomes of monotunnel fixation

Authors	Technique	Patients (n)	Follow-up (months)	Grip strength (%)	DASH	MWS (good or excellent) (%)	Sensory neuropathy	Residual instability (n)
Jung et al.	Knotless anchor, 1 tunnel	42	26	70	-	71	-	2
Shinohara et al.	Anchoring 2 tunnels with needle	11	30	-	-	93	27	-
Atzei and Luchetti	Anchoring with harpoon	48	30	92	42 preop. 20 postop.	83	-	2
Nakamura et al.	2 needle tunnels	24	42	-	-	66	-	-
Park et al.	Knotless anchor, 1 tunnel	17	30	57%	35 preop.7 postop.	83	-	-
Our series	Knotless bone anchor, 1 tunnel	14	15	70	56 preop. 8 postop.	100	16	0

MWS = *Mayo Wrist Score*; DASH = *Disabilities of Arm, Shoulder and Hand score.*

Okuda, in a study of 26 cadaveric specimens, analyzed the ligament insertion site within the fovea and its area of attachment. He described the foveal fibers as being widely and intricately interwoven at their insertion on the ulna. The TFCC insertion occupied an area of 34 mm with a diameter of 9 mm over the ulnar fovea. His findings highlighted a broad insertion area encompassing the bases of the dorsal and volar radioulnar ligaments of the TFCC. [8]

This study aligns with the concept of a broad fixation of both ligament components to achieve isometric anchorage (Figure 27).[8]

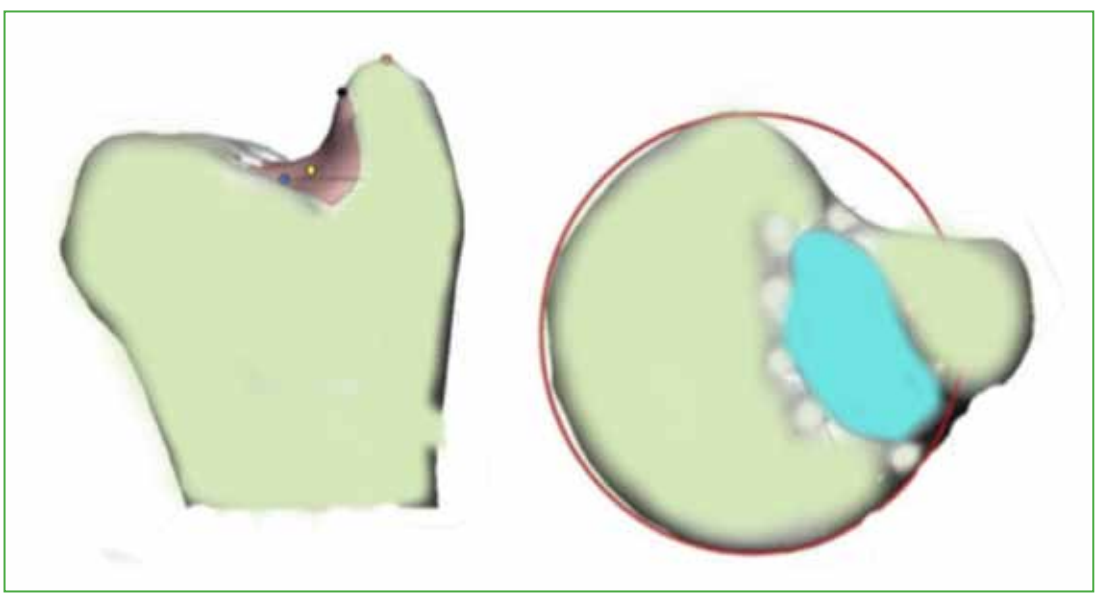


Figure 27. Insertion zone of the triangular fibrocartilage complex in the fovea.

Building upon Matsumoto and Okuda's findings, the present research evaluated the functional outcomes of arthroscopic knotless foveal anchorage for Atzei 2/3 TFCC lesions. The technique used a monotunnel in zone 2, combined with TFCC sutures in zones 1 and 3 to anchor the volar radioulnar ligament, and zones 4 and 6 to anchor the dorsal radioulnar ligament. This approach optimizes tunnel positioning to minimize suture motion and ensures comprehensive TFCC anchorage across its insertion area while preserving the isometry of the dorsal and volar radioulnar ligament fibers. Anchoring ligament fibers distant from the ulna risks increasing ligament tension, potentially causing fiber damage or restricted joint mobility.

Biomechanical studies suggest that tunnel-based anchorage is superior to foveal harpoon anchorage. Placing the ulnar tunnel in zone 2, alongside sutures in the distal radioulnar ligament zones 1 and 3 (volar) and 4 and 6 (dorsal), minimizes TFCC movement during healing and achieves comprehensive anchorage. This method recreates the original ligament insertion on the ulnar fovea, maintaining ligament length and tension. This isometric anchorage supports proper anatomical and biological healing, enabling early rehabilitation with minimal suture movement during recovery phases, fostering the anatomical repair of the foveal ligaments.

This study achieved outcomes comparable to those of previous authors, despite a shorter follow-up period. Additionally, the patients exhibited greater grip strength than reported in most prior studies, and all returned to sports.

Advances in technology and biomechanical studies confirm that the stability of the TFCC and the distal radioulnar joint (DRUJ) primarily depends on its foveal fibers. The key objective is to restore a stable, pain-free, and functional DRUJ.[1-3,5]

Other authors have reported complications such as ulnar paresthesia and reinterventions due to pain or instability. In this series, no such complications were observed. One biodegradable screw fractured during placement in a 2-mm ulnar metaphyseal tunnel, which was resolved intraoperatively by enlarging the tunnel to 2.2 mm and placing a new screw. Another case involved creating a dorsal cortical ulnar metaphyseal tunnel, which failed to ensure linear suture traction. A new tunnel, located 1 cm distal to the original, was created centrally in the metaphysis, achieving proper screw placement. This required extending the ulnar incision by 2 cm.

Other than these, no additional complications occurred. However, it is crucial to acknowledge the need for a learning curve to perform this or similar techniques. In other arthroscopic series, complications such as ulnar nerve neuropraxia, central articular disc rupture, ulnar fractures, malposition of cubital tunnels, and suture tension loss have been reported.

The strengths of this study include the homogeneous patient population, the consistent follow-up, and the use of a single surgeon employing a standardized method. Limitations include its retrospective nature and the absence of arthroscopic reevaluation to confirm long-term repair quality.

CONCLUSIONS

Arthroscopic repair of Atzei 2/3 lesions using isometric, monotunnel, knotless bone anchorage yields favorable functional outcomes. It enables foveal ligament anchorage at its anatomical insertion, improving range of motion, reducing pain, and restoring stability to the DRUJ.

Based on our results, it is possible to conclude that isometric repair using the monotunnel anchor technique with arthroscopic assistance offers good functional outcomes in the repair of TFCC Atzei 2/3 lesions.

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

A. D. Ledesma ORCID ID: https://orcid.org/0009-0000-2519-7127

REFERENCES

1. Hagert E, Hagert C-G. Understanding stability of the distal radioulnar joint through an understanding of its anatomy. *Hand Clin* 2010;26:459-66. https://doi.org/10.1016/j.hcl.2010.05.002
2. Trehan SK, Wall LB, Calfee RP, Shen TS, Dy CJ, Yannascoli SM, et al. Arthroscopic diagnosis of the triangular fibrocartilage complex foveal tear: a cadaver assessment. *J Hand Surg Am* 2018;43(7):680.e1-680.e5. https://doi.org/10.1016/j.jhsa.2017.12.017
3. Ma CH, Lin TS, Wu CH, Li DY, Yang SC, Tu YK. Biomechanical comparison of open and arthroscopic transosseous repair of triangular fibrocartilage complex foveal tears: a cadaveric study. *Arthroscopy* 2017;33(2):297-304. https://doi.org/10.1016/j.arthro.2016.10.027
4. Shinohara T, Tatebe M, Okui N, Yamamoto M, Kurimoto S, Hirata H. Arthroscopically assisted repair of triangular fibrocartilage complex foveal tears. *J Hand Surg Am* 2013;38(2):271-7. https://doi.org/10.1016/j.hsa.2012.11.008
5. Jung HS, Song KS, Jung HS, Yoon BI, Lee JS, Park MJ. Clinical outcomes and factors influencing these outcome measures resulting in success after arthroscopic transosseous triangular fibrocartilage complex foveal repair. *Arthroscopy* 2019;35(8):2322-30. https://doi.org/10.1016/j.arthro.2019.03.060
6. Park JH, Kim D, Park JW. Arthroscopic one-tunnel transosseous foveal repair for triangular fibrocartilage complex (TFCC) peripheral tear. *Arch Orthop Trauma Surg* 2018;138(1):131-8. https://doi.org/10.1007/s00402-017-2835-3
7. Matsumoto T, Tang P, Fujio K, Strauch RJ, Rosenwasser MP. The optimal suture placement and bone tunnels for TFCC repair: a cadaveric study. *J Wrist Surg* 2018;7(5):375-81. https://doi.org/10.1055/s-0038-1661361
8. Okuda M. Morphology of the ulnar insertion of the triangular fibrocartilage complex and related osseous landmarks. *J Hand Surg Am* 2021;46(7):625.e1-625.e7. https://doi.org/10.1016/j.jhsa.2020.12.006

Arthroscopic "Glider" Interposition with Associated Stabilization in Distal Radioulnar Joint Osteoarthritis: Preliminary Results

Juan Matías Sala, Aldo D. Ledesma
Servicio de Cirugía de Mano Patagónica (CIMAP), OTI, Clínica del Valle S.R.L., Comodoro Rivadavia, Chubut, Argentina.

ABSTRACT

Objectives: To describe an arthroscopic technique for treating distal radioulnar joint (DRUJ) osteoarthritis involving the interposition of a woven polyester cylinder and the palmaris longus, and to present preliminary results. **Materials and Methods:** A retrospective analysis was conducted on five patients with DRUJ osteoarthritis, classified clinically and confirmed by arthroscopy. The patients underwent treatment using the author's "glider" interposition technique. The average follow-up period was 11 months. Outcomes were evaluated using range of motion (ROM), grip strength, the Mayo Wrist Score, and the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire. **Results:** The study included five patients (four with secondary osteoarthritis and one with primary osteoarthritis). Pain and grip strength showed improvement. The average ROM post-surgery was: 75° pronation, 70° supination, 80° extension, and 70° flexion. According to the Mayo Wrist Score, results were excellent in 83% of cases and good in 17%, with no poor outcomes. The average DASH score improved from 56 preoperatively to 20 postoperatively. Grip strength compared to the contralateral side averaged 70%. **Conclusions:** The arthroscopic glider interposition technique shows promise as a minimally invasive alternative to current joint salvage procedures. This approach preserves soft tissue structures, is reproducible, stabilizes the DRUJ, and prevents proximal radioulnar impingement.

Keywords: osteoarthritis; arthroscopy; interposition; distal radioulnar joint.
Level of Evidence: IV

Interposición ósea en parapente para la artrosis radiocubital distal: resultados preliminares

RESUMEN

Objetivos: Presentar una técnica artroscópica para el tratamiento de la artrosis radiocubital distal que consiste en la interposición de un cilindro de poliéster tejido y de palmar menor, y los resultados preliminares. **Materiales y Métodos:** Se analizaron, en forma retrospectiva, los resultados de esta técnica en 5 pacientes con artrosis radiocubital distal clasificada clínicamente y por vía artroscópica, en un seguimiento promedio de 11 meses. Todas las lesiones se repararon por vía artroscópica mediante una técnica de autor denominada técnica de interposición en parapente. Se evaluaron los rangos de movilidad, la fuerza de agarre con el *Mayo Wrist Score* y el cuestionario DASH. **Resultados:** Se incluyó a 5 pacientes (4 artrosis secundarias y 1 artrosis primaria). Los resultados de las pruebas de dolor y fuerza mejoraron. El rango de movilidad promedio fue: 75° de pronación, 70° de supinación, 80° de extensión y 70° de flexión. Los resultados, según el *Mayo Wrist Score*, fueron excelentes (83%) y buenos (17%), no hubo resultados malos. El puntaje promedio del cuestionario DASH era 56 antes de la cirugía y 20 en el posoperatorio. El promedio de la fuerza comparativa contralateral fue del 70%. **Conclusiones:** La técnica de interposición artroscópica en parapente propone ser una alternativa a las técnicas de salvataje articular utilizadas hoy, ya que es mínimamente invasiva, conserva estructuras de las partes blandas, es reproducible, permite la estabilización de la articulación radiocubital distal y evita el pinzamiento radiocubital proximal.

Palabras clave: Artrosis; artroscopia; interposición; articulación radiocubital distal.
Nivel de Evidencia: IV

Received on June 5th, 2024. Accepted after evaluation on October 9th, 2024 • Dr. JUAN MATÍAS SALA • salajuanmatias@icloud.com https://orcid.org/0000-0001-5542-5004
How to cite this article: Sala JM, Ledesma AD. Arthroscopic "Glider" Interposition with Associated Stabilization in Distal Radioulnar Joint Osteoarthritis: Preliminary Results. *Rev Asoc Asoc Argent Ortop Traumatol* 2024;89(6):606-625. https://doi.org/10.15417/issn.1852-7434.2024.89.6.1983

INTRODUCTION

The distal radioulnar joint (DRUJ) is a trochlear joint involved in forearm pronation and is essential for daily activities requiring elbow flexion with the forearm in intermediate pronation. In this position, the ulnar head acts as a fulcrum against the radial sigmoid notch, absorbing loads from the hand, carpus, and forearm.[1-8] The DRUJ exhibits four anatomical variants of the radial sigmoid notch in the transverse plane: flat, C-shaped, S-shaped, and ski slope. Additionally, it presents three anatomical variants in the horizontal plane: parallel, oblique, and reverse oblique.[1,2,9]

The ulnar head has two distinct angulations contributing to the DRUJ: the distal articular angle and the radial angle.[9] The oblique surface of the radius and the increased inclination of the radial angle are associated with the DRUJ, providing a larger contact area with higher pressure.[9-11]

Osteoarthritis of the DRUJ can be primary or secondary to poorly consolidated radius fractures, tumors, Madelung's deformity, rheumatoid arthritis, infections, or fracture-dislocations. Atzei developed an arthroscopic classification of triangular fibrocartilage complex (TFCC) lesions, which includes DRUJ osteoarthritis as the most severe stage (Table).

Table. Atzei classification for ulnar injuries of the triangular fibrocartilage complex based on their stability, ligamentous structures, potential for repair, and suggested treatment.

Type	DRU Inestability	Appearance of the distal TFCC	Appearance of the proximal TFCC	TFCC repair potential	Appearance of the DRU cartilage	Suggested treatment
1	Mild/No	Broken	Intact	Good	Good	Capsule repair
2	Moderate/ Severe	Broken	Broken	Good	Good	Foveal repair
3	Moderate/ Severe	Intacto	Broken	Good	Good	Foveal repair
4	Severe	Broken	Broken	Poor	Good	Graft reconstruction
5	Moderate/ Severe	Variable	Variable	Variable	Poor	Artroplasty or salvage

DRUJ = distal radioulnar joint; TFCC = triangular fibrocartilage complex.
Taken from: Sala M, Daroda S. Results of the Knotless Arthroscopic Foveal Anchorage of the Triangular Fibrocartilage Complex in Atzei 2/3 Lesions. *Rev Asoc Argent Ortop Traumatol* 2021;86(5):581-594. https://doi.org/10.15417/issn.1852-7434.2021.86.5.1374

Osteoarthritis of the DRUJ leads to pain, loss of strength, and functional limitations that affect quality of life by restricting painful pronation. This condition may also coexist with ulnar impaction syndrome.[1-5,12]

Historically, DRUJ osteoarthritis has been treated with resection or fusion of the distal ulna. These are ablative procedures that do not restore biomechanics but are widely accepted, albeit with variable outcomes. They relieve pain and improve mobility; however, radioulnar impingement is a common complication.[1-7] These procedures include the Darrach, Bowers, and Sauvé-Kapandji techniques, among others. While the Darrach and Sauvé-Kapandji procedures are effective in managing this condition, they often result in a proximal ulnar stump with dynamic instability.[1-4]

Partial and total arthroplasties of the DRUJ are not available in Argentina and thus are not a viable option in our country.

The advancement of arthroscopy has enabled many open procedures to be performed arthroscopically, minimizing soft tissue damage. Building on the concepts of Bowers' open technique, we developed an arthroscopic DRUJ interposition technique combined with ulnar osteotomy and joint stabilization. This involves an oblique subtraction osteotomy of the ulna and anchoring a woven polyester cylinder in the radial sigmoid notch, with a palmaris longus tendon graft inside. The woven polyester cylinder, an inert prosthetic material commonly used in vascular surgery, generates minimal fibrosis, allowing adequate joint mobility without adhesions or excessive fibrosis.

We termed this technique "glider interposition" because the insertion of the graft into the joint, along with the sutures, resembles a paragliding wing with its harness. This technique facilitates DRUJ interposition with joint stabilization through the tendon graft.

The objective of this study was to evaluate the preliminary outcomes of the glider arthroscopic interposition technique for managing DRUJ osteoarthritis, focusing on achieving pain-free mobility and joint stability.

MATERIALS AND METHODS

A retrospective study was conducted to analyze surgical outcomes in five consecutive adult patients with DRUJ osteoarthritis who underwent surgery between June 1, 2021, and June 1, 2023.

Inclusion criteria were: Age >18 years, no history of prior osteoarthritis surgery or wrist arthroscopy, pain consistent with DRUJ osteoarthritis that limited daily activities, sports, or work, positive Nakamura and screwdriver tests, Atzei stage 5 lesions confirmed by radiography, MRI, and arthroscopy, and a minimum postoperative follow-up of 6 months.

The exclusion criterion was history of DRUJ surgery or wrist arthroscopy.

The study included five patients (three women and two men; four dominant hands and one non-dominant hand) with DRUJ osteoarthritis.

Wrist range of motion in flexion, extension, ulnar deviation, and radial deviation was measured using a standard PVS hand goniometer, while grip strength was assessed with a standard hydraulic dynamometer (Baseline-Orthowell®).[2]

Subjective evaluation included the Visual Analog Scale (VAS) for pain, the Mayo Clinic Wrist Score (MWS), and the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire.[1,2]

The treatment protocol was as follows: During the first consultation for wrist pain attributed to DRUJ osteoarthritis, anamnesis was performed to identify the initial trauma or degenerative mechanism, followed by a clinical examination. The Nakamura test and screwdriver test were performed, and an AP wrist radiograph was obtained (Figure 1).

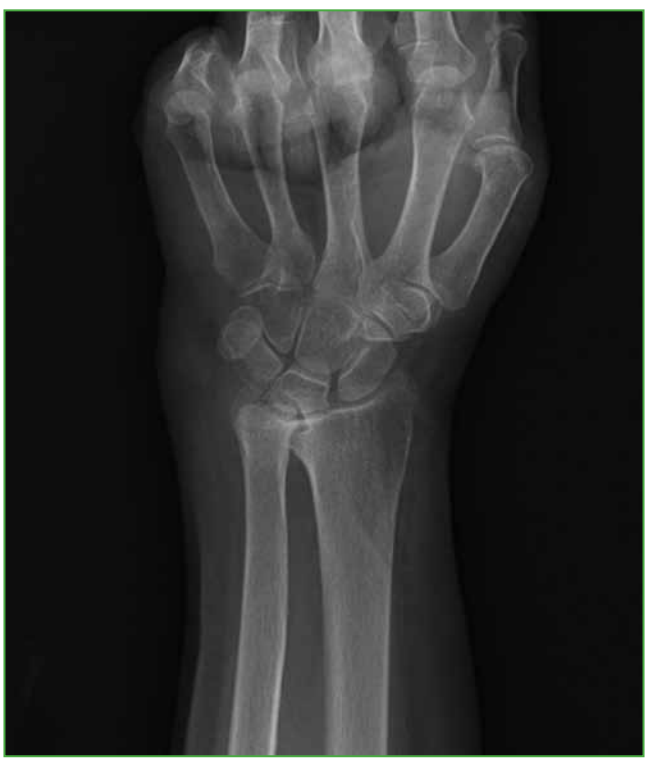


Figure 1. Wrist radiograph, AP view, showing distal radioulnar osteoarthritis.

The Nakamura test involves the patient resting their elbow on a desk while the examiner stabilizes the radius with one hand and performs volar and dorsal translations in pronation, supination, and neutral positions (Figure 2).[10]

Figure 2. Nakamura maneuver.

The screwdriver test simulates a handshake, during which the examiner passively moves the forearm into full pronation and supination. A positive test elicits pain or a mechanical block that halts the movement (Figure 3).[10] If these tests were positive, an MRI was performed to assess TFCC soft tissue integrity.

Figure 3. Screwdriver test in pronation and supination.

Patients with confirmed diagnoses underwent glider interposition arthroplasty via arthroscopy.

Surgical Technique

The glider interposition technique with DRUJ stabilization involves performing an oblique subtraction osteotomy of the ulnar head in its articular segment and reaming the sigmoid cavity of the radius. This is combined with the radial anchoring of a woven polyester cylinder containing a palmaris longus graft. The palmaris longus graft is intended to extend into the distal ulna to enhance DRUJ stability (Figure 4).

Figure 4. Woven polyester cylinder with the palmaris longus sutured at its ends, inside the cylinder.

The goal of this technique is to alleviate DRUJ friction pain associated with increased joint mobility by promoting interpositional fibrosis between the radius and ulna while stabilizing the DRUJ.

Step-by-Step Surgical Technique

Plexus block anesthesia is administered, and an ischemia-preventive cuff is placed at 250 mmHg. Portals 3-4, 6R, and the distal dorsal portal distal to the DRUJ joint (dd-DRUJ) are used. For this technique, routine midcarpal portals are not utilized.

The radiocarpal joint is accessed via portal 3-4, with instrumentation through portal 6R. The TFCC is examined, revealing chronic lesions with ligament retractions. These remnants are excised.

Optics are positioned through the dd-DRUJ portal, and work is performed through portal 6R. The DRUJ joint is inspected, and pronosupination is performed to evaluate the congruency of the radius over the ulnar head. DRUJ osteoarthritis is confirmed at this stage (Figure 5, Scheme 1).

A 3 cm incision is made on the ulna, beginning 1.5 cm distal to the ulnar styloid for guidewire placement. The ulnar approach is carefully dissected to avoid injury to the ulnar sensory branch.

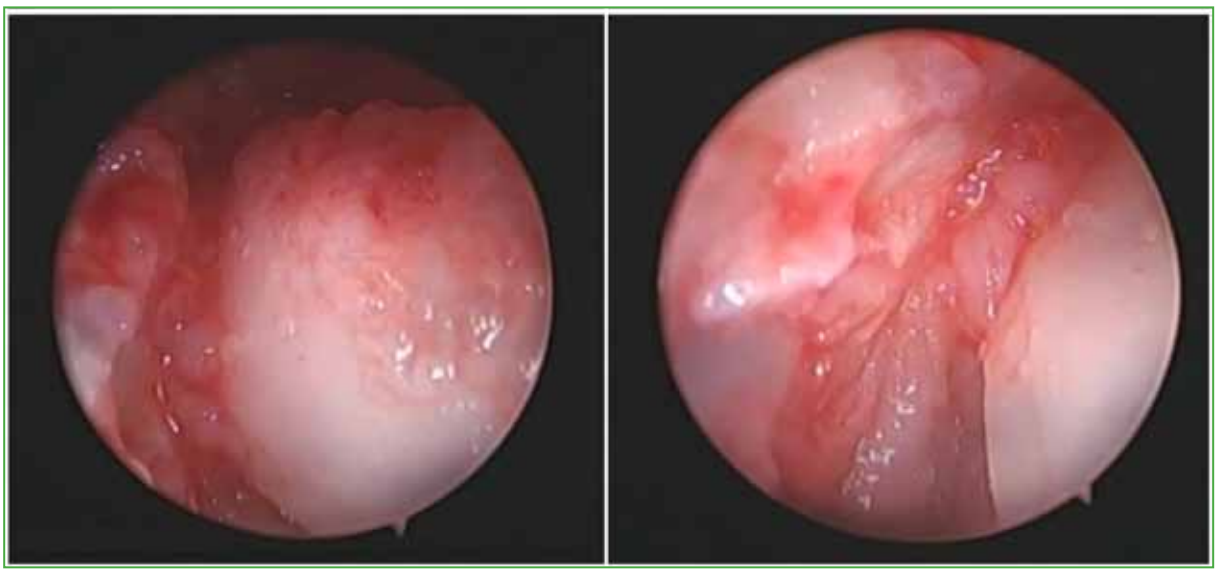


Figure 5. Radio-ulnar osteoarthritis is seen through the distal dorsal portal of the distal radioulnar joint.

Scheme 1. Debridement of ligamentous debris and the distal radioulnar joint.

The guide, which is located 1.5 cm from the ulnar styloid, has a 45° inclination with a hole to place the pin. It is necessary to respect the inclination and the distance to exit in the right area, in the ulna.

After proper positioning of the guide, a pin is inserted through it and the ulnar tunnel is created. The pin penetrates the ulna and exits through the metaphysis of the osteotomy performed.

The next step is the reaming of the bone tunnel with a 3.5 mm guide, which is performed using a drill stop so as not to damage the sensory branch of the ulnar nerve. It is reamed from the ulnar cortex toward the DRUJ joint. This ulnar hole is created for the passage of the ends of the palmaris longus (Figure 6).

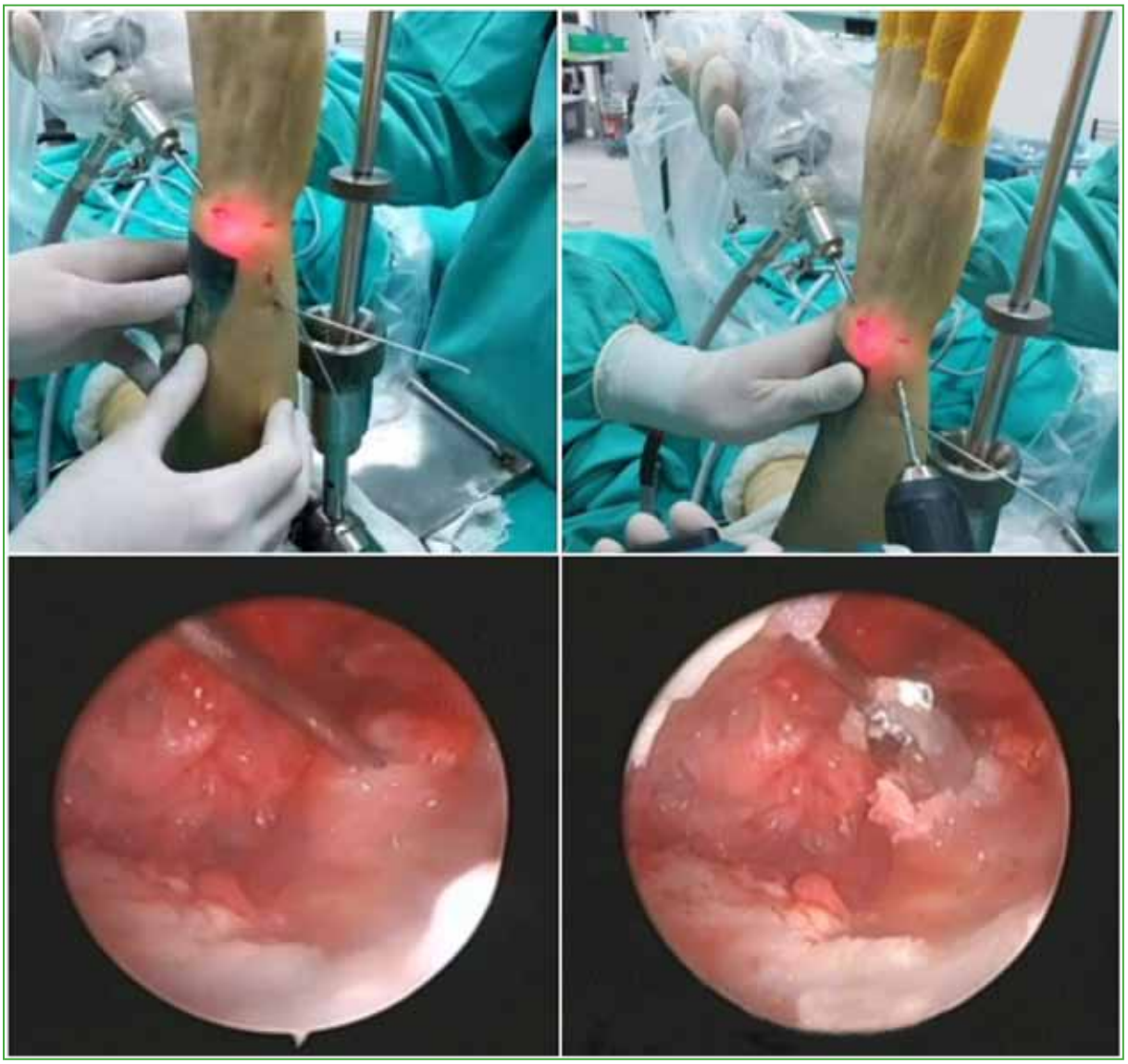


Figure 6. Placement of the pin and wick through the ulna.

The glider technique begins with a wide resection of the TFCC articular disc and an oblique subtraction osteotomy from ulnar to radial, and dorsal and volar of the ulnar head. It is performed with visualization through portal 3-4 and working through portal 6R.

The osteotomy will be approximately 4 to 6 mm according to demand, until an adequate space of the lesser sigmoid cavity is obtained (Figure 7, Scheme 2).

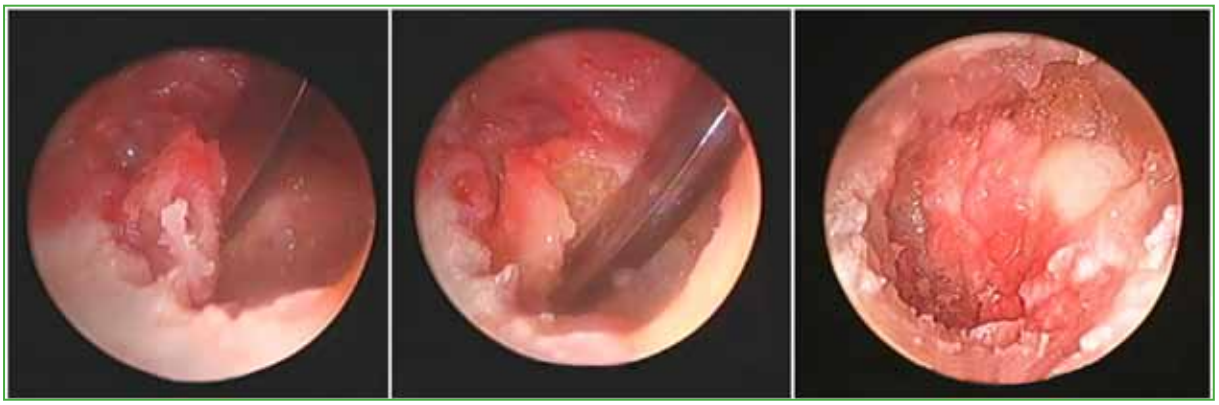


Figure 7. Images of ulnar osteotomy.

Scheme 2. Oblique osteotomy of the ulna.

It is important to verify that the ulna is not dislocated in chronic injuries; if there is a dislocation, before osteotomy, the ulna must be reduced over the sigmoid cavity of the radius and fixed to the reduced radius by means of a metaphyseal pin from ulna to radius.

After the osteotomy, the probe is placed through the dd-DRUJ portal and, through the 6R portal, a reamer is placed oriented to the lesser sigmoid cavity to regularize it with excision of the cartilage remnants leaving a C-shaped cavity to achieve greater containment (Figure 8). At this point, pronosupination is performed to evaluate the joint with the probe through the dd-DRUJ portal and confirm that the ulnar osteotomy is adequate. If bony debris remains, the ulna is reamed to regularize the surface. Intraoperative fluoroscopy confirms that osteotomy is correct (Scheme 3).

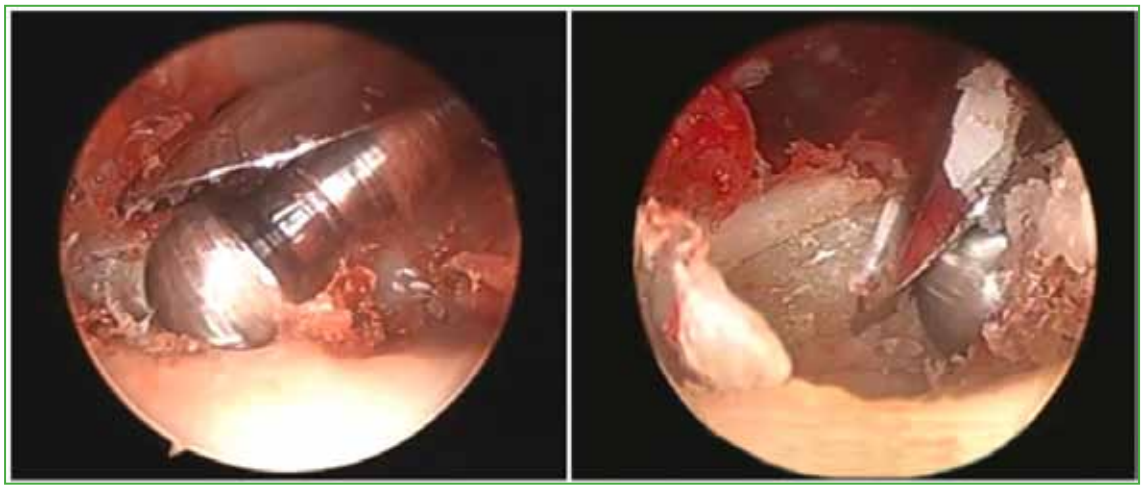


Figure 8. Ulnar reaming.

Scheme 3. Reaming of the lesser sigmoid cavity through the 6R portal.

Next, the width and length of the space created in the joint (Figure 9) are measured using the probe through portal 3-4 and through portal 6R. Having the measurements of the space created, the custom woven polyester cylinder is designed. In general, it is 4 mm long.

A 6U portal is created. Two suture retrievers are passed through the ulnar incision into the ulnar tunnel and out through the DRUJ joint. One suture is retrieved via portal 6R and the other via the 6U portal (Scheme 4).

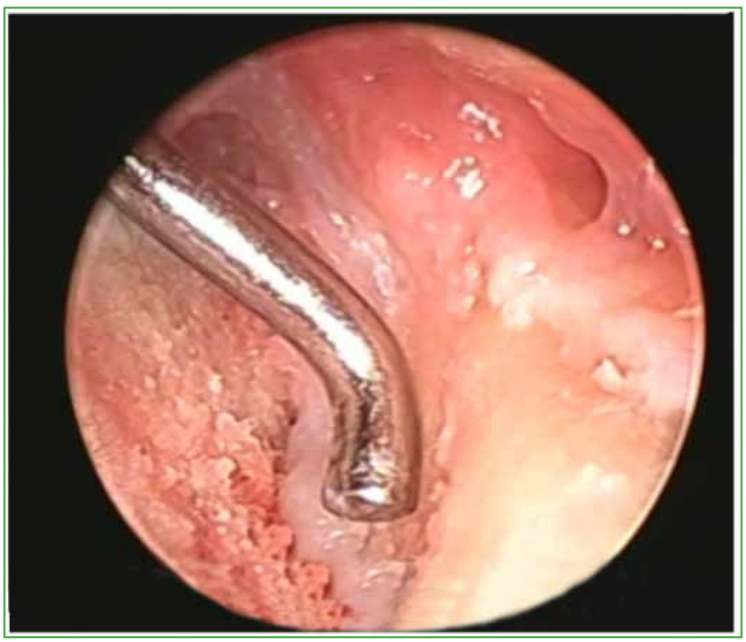
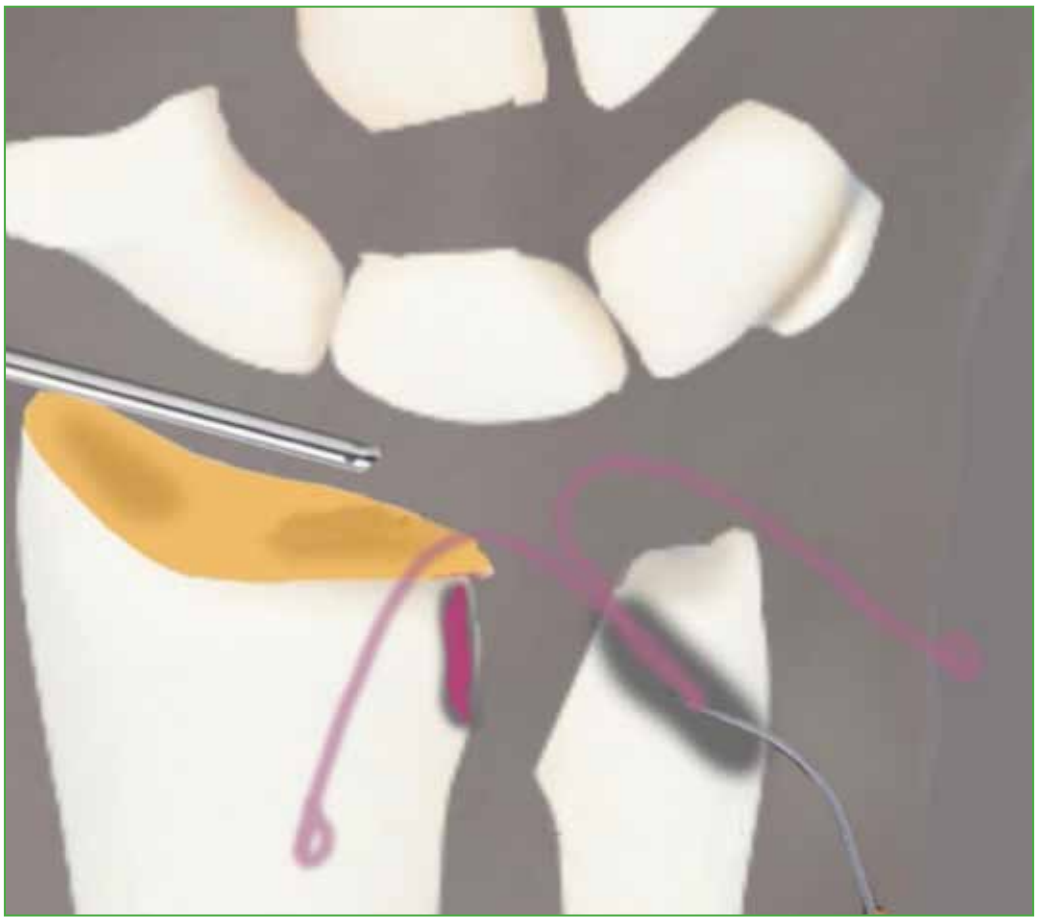


Figure 9. Space for graft placement.



Scheme 4. Suture retrievers passing through the ulnar tunnel.

Two harpoons are then placed toward the sigmoid cavity. These two harpoons are placed slightly obliquely at approximately 5 mm from the radiocarpal joint. We use harpoons with needles 2.2 mm wide and 8 mm long. One harpoon is introduced through portal 6R and the other through portal 6U to obtain a good angle of placement (Figure 10, Scheme 5).

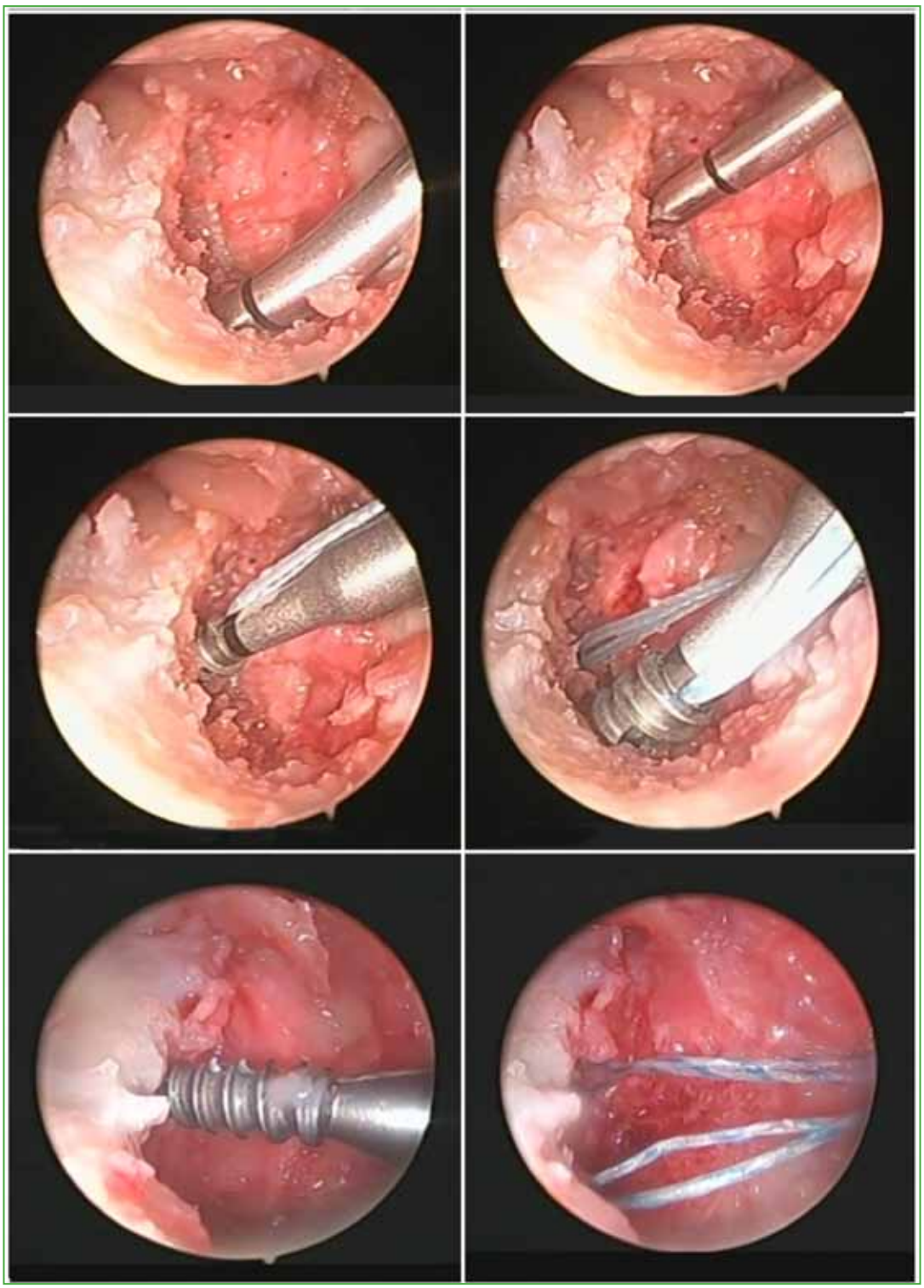


Figure 10. Placement of harpoons.

Scheme 5. Placement of two harpoons in the lesser sigmoid cavity.

The next step is the assembly of the woven polyester cylinder with the palmaris longus tendon inside. The tendon remains inside the cylinder with its ends even in length on both sides, with Krackow sutures at both ends of the tendon (Figure 11).

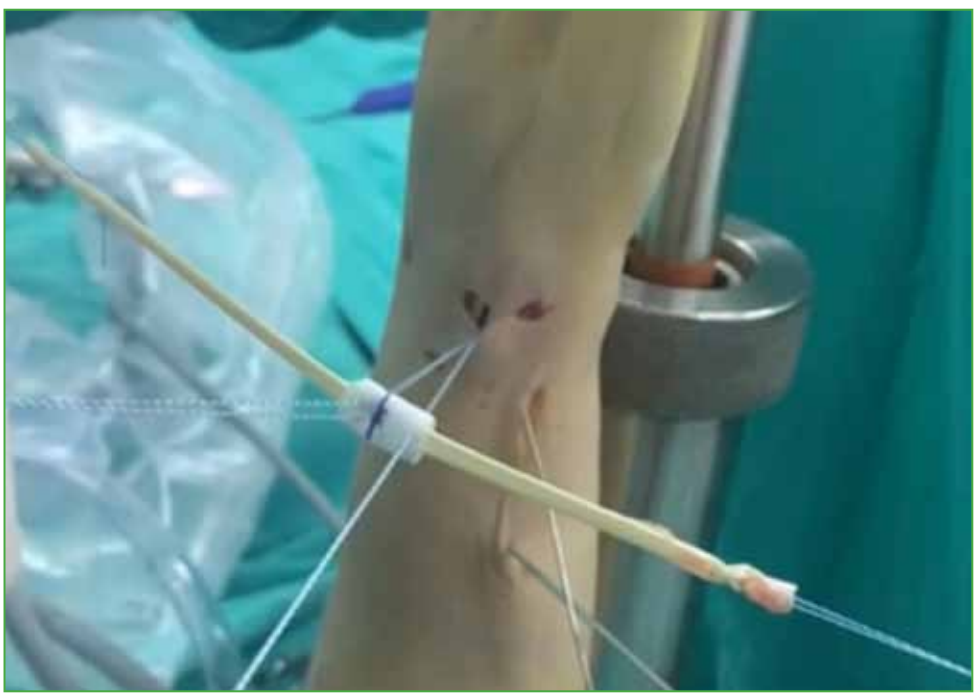


Figure 11. Graft prepared for entry through portal 6R.

Then the 4 threads of the harpoons are removed through the 6R portal and the threads of the harpoons are sutured to the cylinder and tendon graft. They are sutured taking part of the cylinder and the superior and inferior tendon in a symmetrical way. With the aid of the feeler, the cylinder and graft are entered through the 6R portal into the DRUJ joint and rested over the sigmoid cavity of the radius. At this point, the graft is held inside the joint with a feeler and the 4 wires are tensioned (Figure 12, Scheme 6).

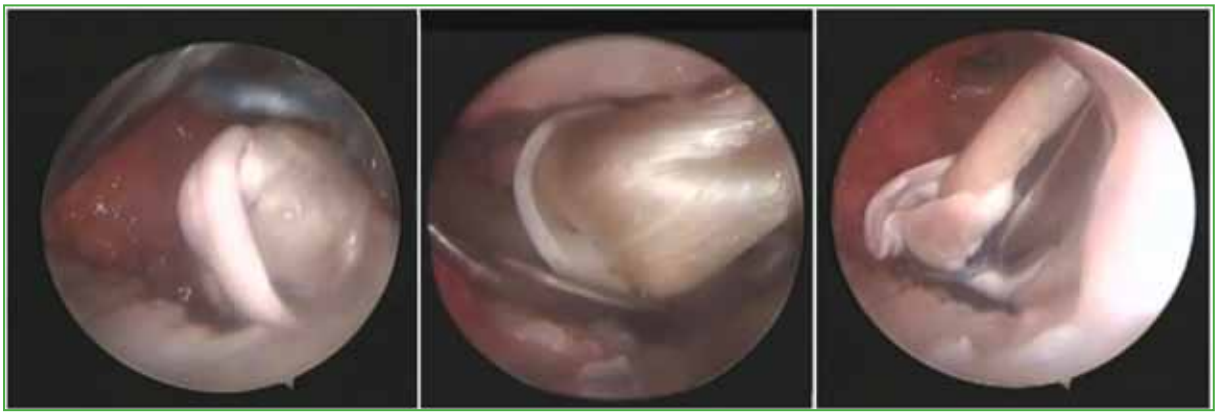
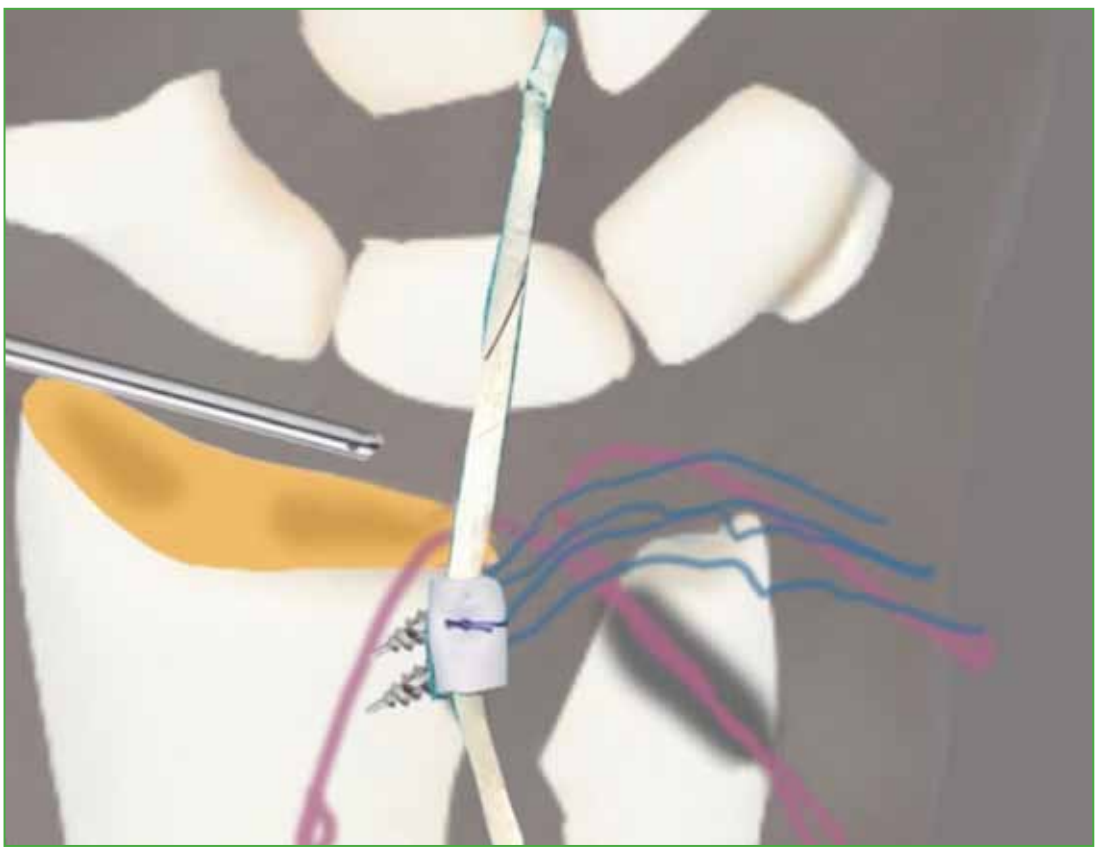


Figure 12. Woven polyester cylinder with the tendon inside the joint.



Scheme 6. Entry of the graft through portal 6R.

The volar strand is retrieved from the palmaris longus through the 6U portal and placed into the suture retriever. It is pulled from the proximal end of the suture retriever and the graft strand is passed through the ulnar tunnel. The procedure is repeated with the palmaris longus strand left through portal 6R. This is passed through the suture retriever outside the 6R portal and the retriever is pulled through the ulnar tunnel obtaining the passage of the dorsal strand of the graft. Two sliding knots are then tied with the harpoon sutures to fix the cylinder to the lesser sigmoid cavity. The threads are slid by means of a wrist knot through the 6R portal (Figure 13, Scheme 7).

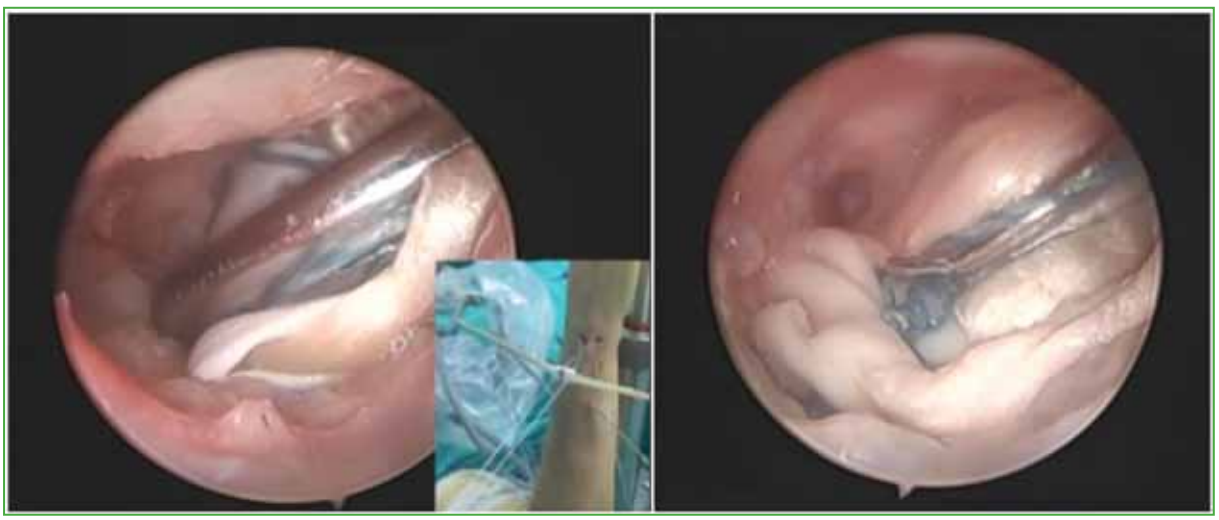
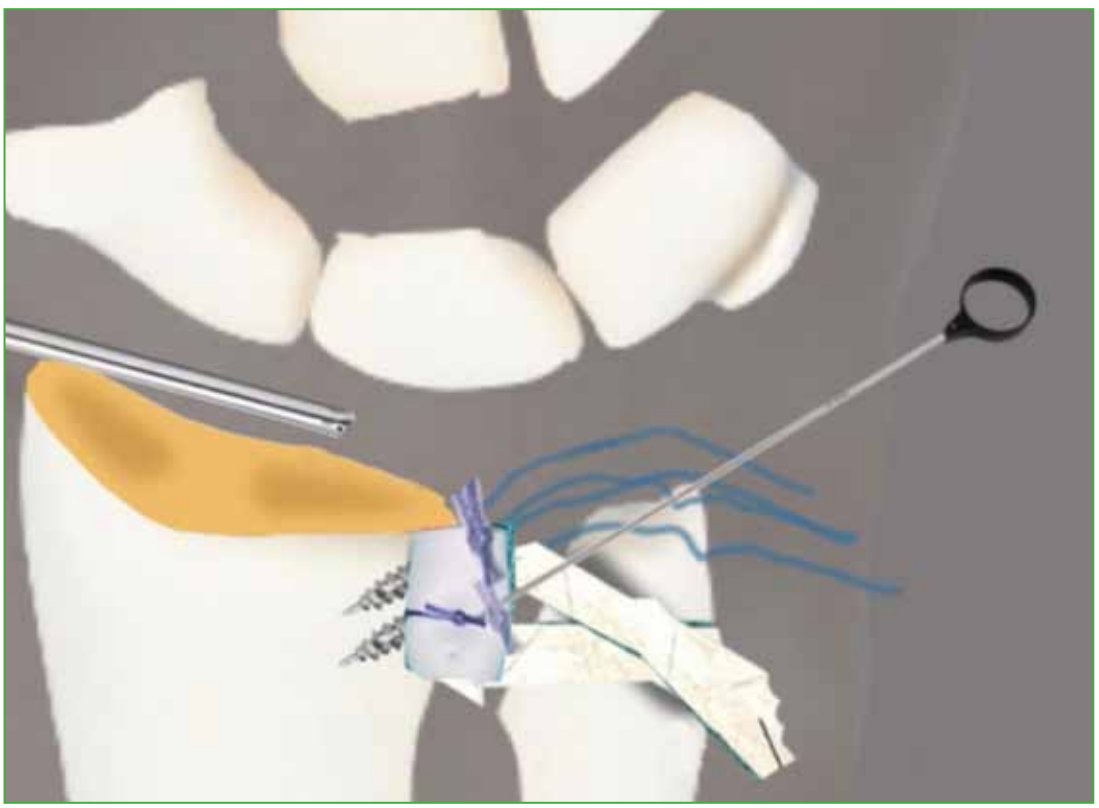


Figure 13. Fixation of the polyester cylinder by means of arthroscopic knots.



Scheme 7. Graft fixation by means of anchorage with sliding knots by 6R and 6U portals.

Correct placement and anchorage of the graft is verified by full pronosupination by traction with the proximal-to-distal probe to check the tension of the graft (Figure 14).

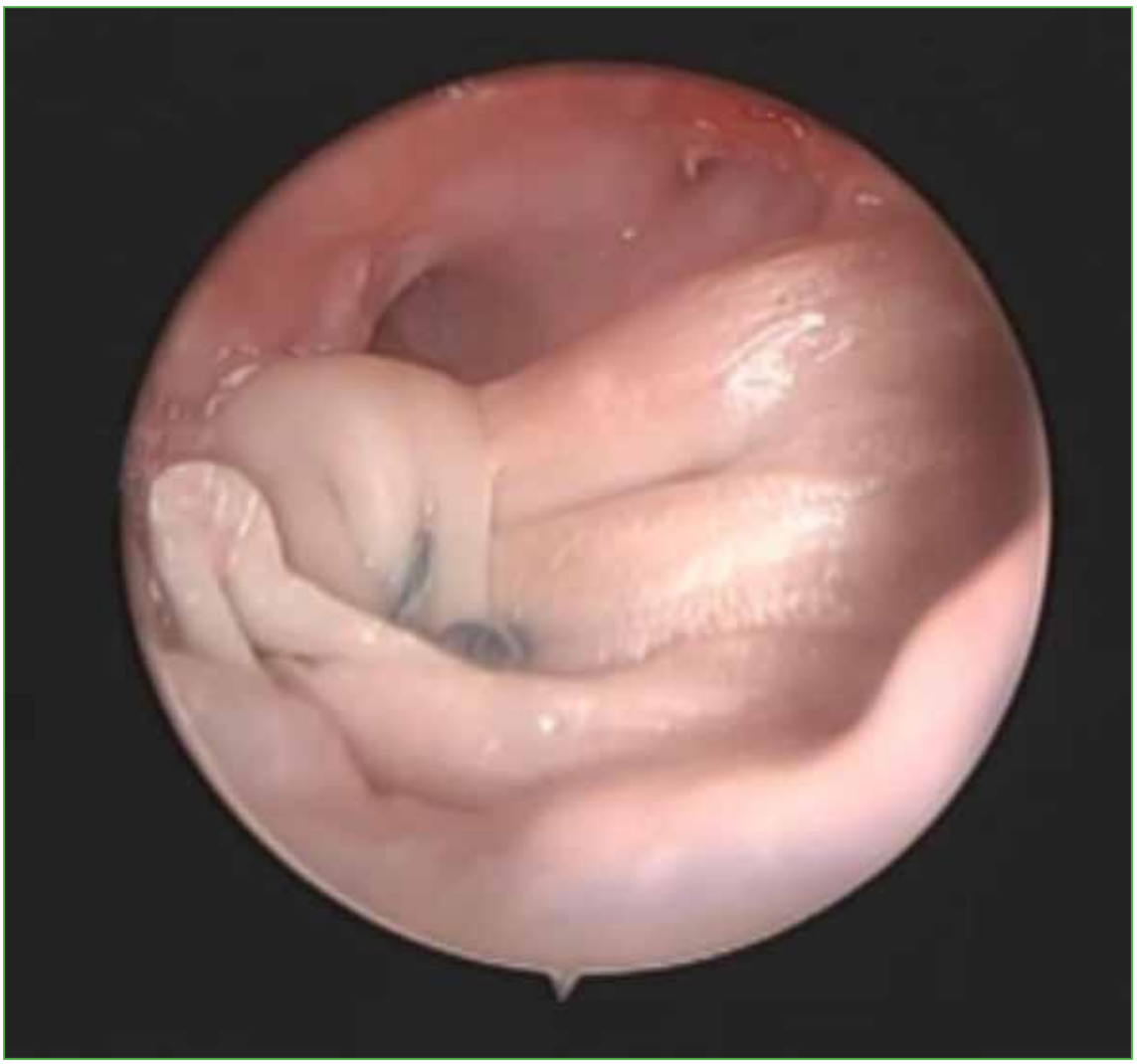
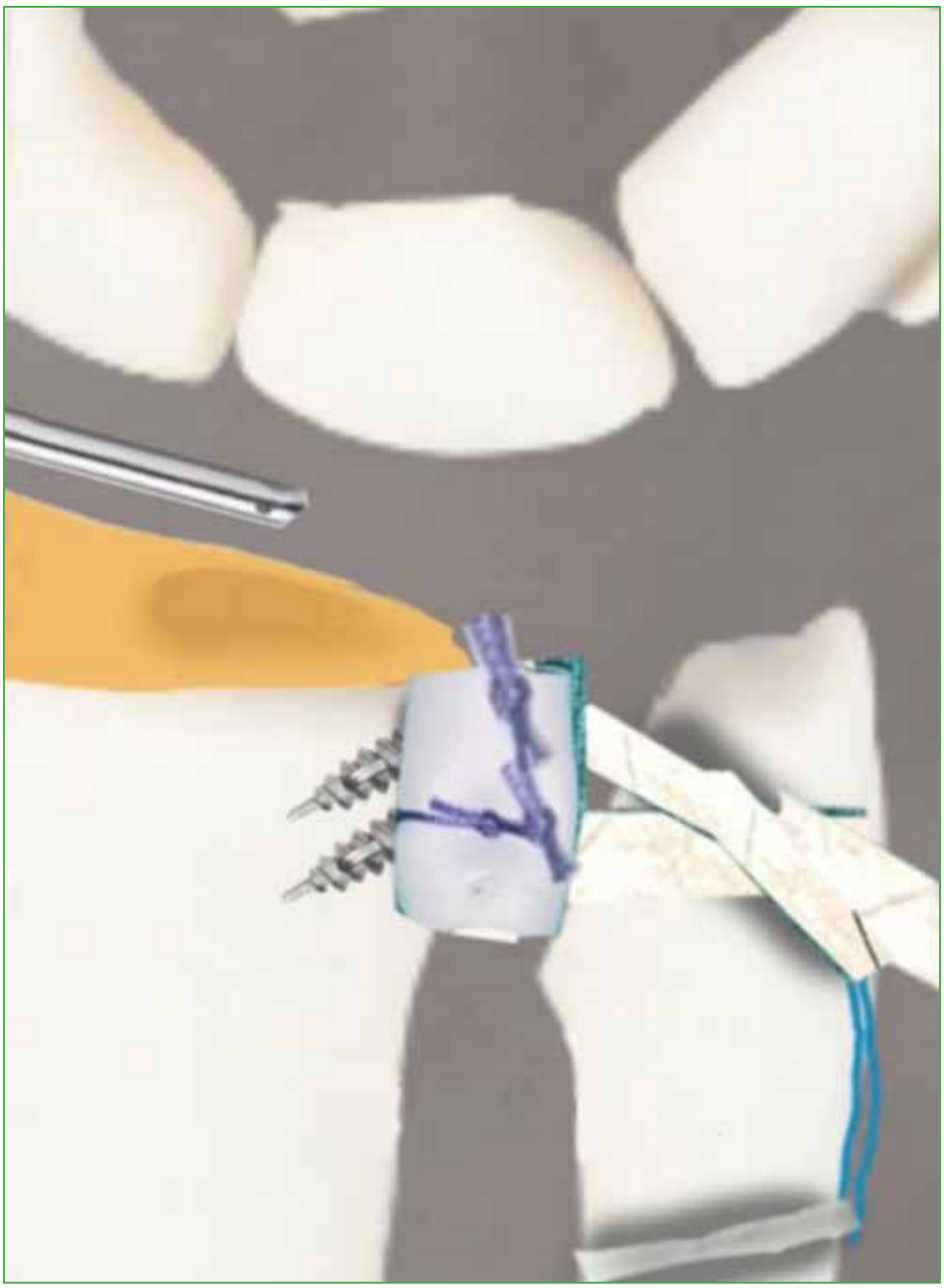


Figure 14. Fixed polyester cylinder at the distal radioulnar joint with the two tendon strands entering the ulna.

If the graft is taut, the excess threads are cut with arthroscopy scissors.

To finalize the technique, both strands of the graft previously passed through the ulnar tunnel are tensioned from the ends of their threads and fixed to the ulnar metaphysis with a knotless anchor. This step is performed with an impacted 2.5 mm knotless anchor device, which consists of a biodegradable screw inside a shaft with an eyelet at the end. The 4 ends of the sutures of the tendon strands are placed inside the eyelet of the fixation system. A 2.2 mm bone tunnel is created using a drill guide to avoid damage to the dorsal sensory branch of the ulnar nerve. This hole is made horizontally on the ulnar metaphysis 1 cm below the previously created ulnar tunnel (Scheme 8).



Scheme 8. Final fixation of the graft in the ulnar metaphysis by means of a knotless anchor.

The traction exerted on the wrist is removed and the fixation device with the sutures inside it is introduced, tightening the 4 ends of the sutures and impacting with a hammer. The shaft of the device is removed and the free ends of the sutures are pulled to make sure that the screw has been inserted correctly.

Finally, the wrist is placed in traction again and the stability and pronation of the joint are evaluated after fixed glider interposition. (Figure 15) (Video).

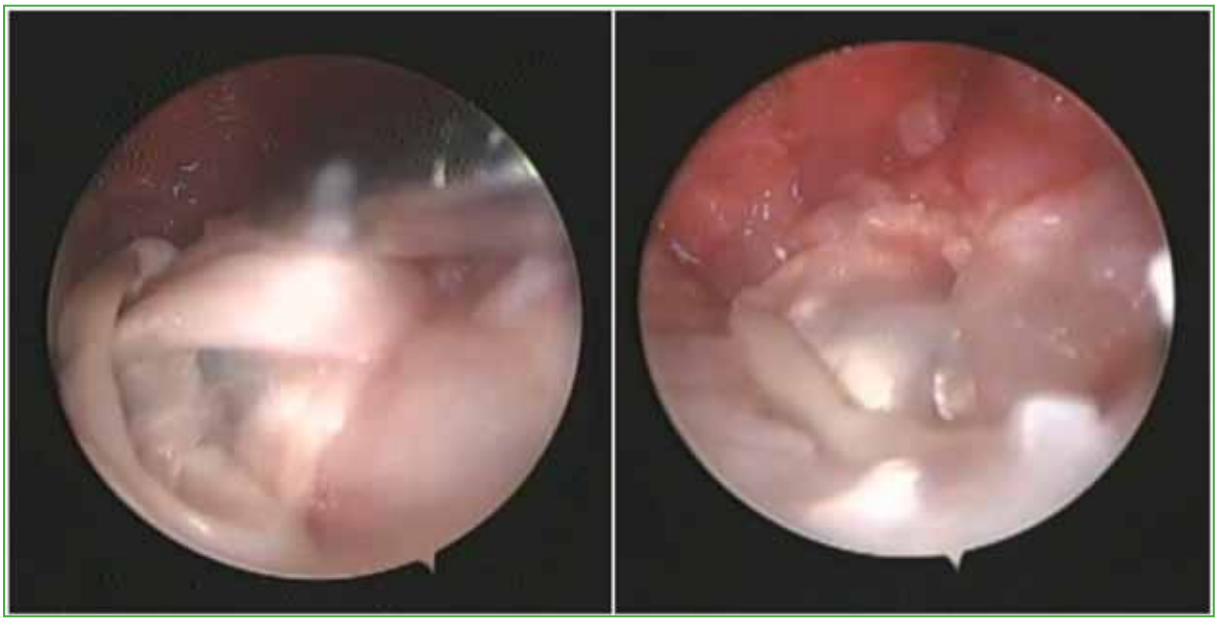


Figure 15. Fixation of the polyester cylinder with both strands entering the ulna stabilizing the distal radioulnar joint.

Figure 16 shows the preoperative and postoperative radiographs of one patient and Figure 17 shows preoperative and postoperative images of another case in the series.

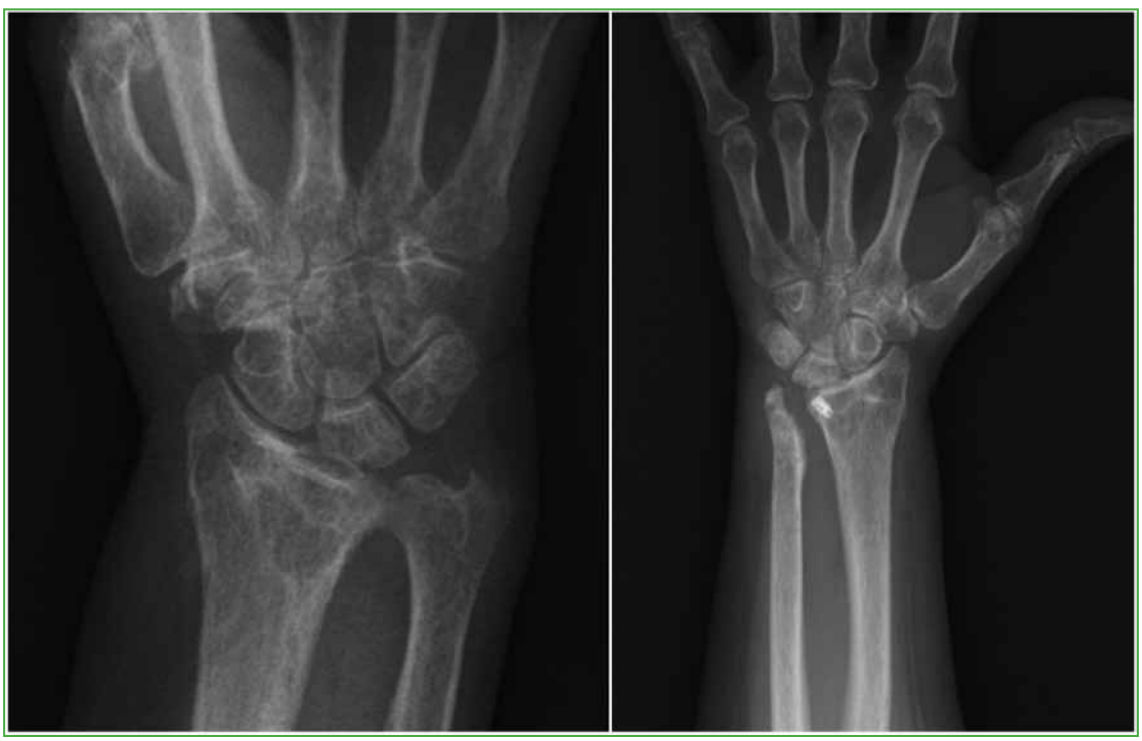


Figure 16. Wrist radiographs, AP view. **A.** Preoperative. **B.** Postoperative.

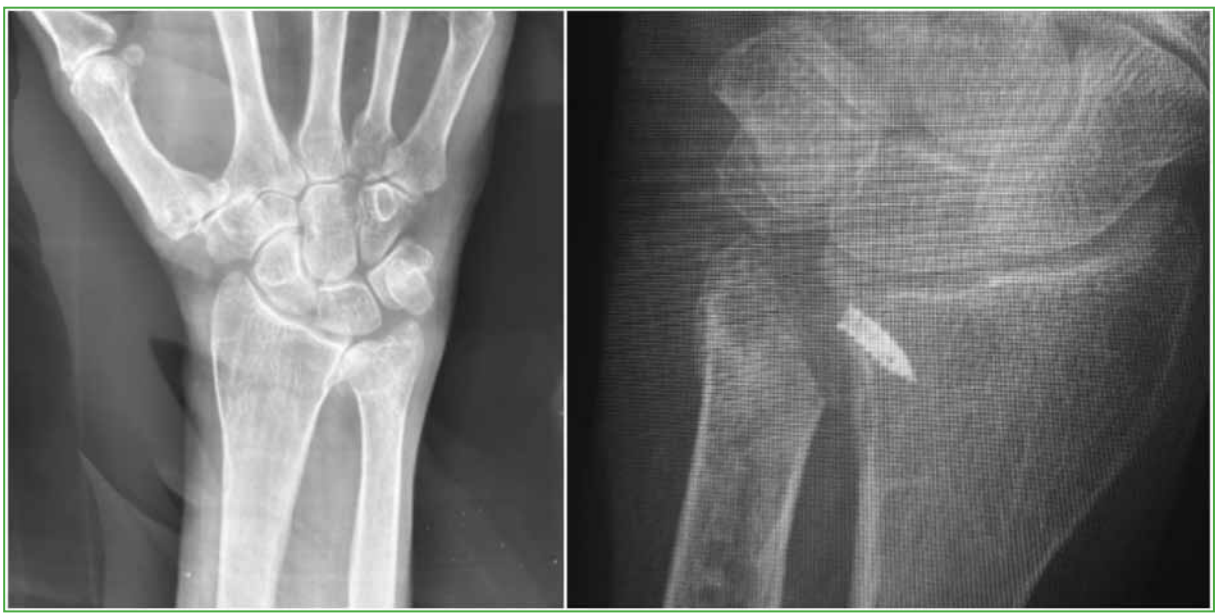


Figure 17. Wrist radiographs, AP view. **A.** Preoperative. B. Postoperative.

After the operation, the portals are closed with simple sutures, and a sugar-tong splint is applied for three weeks. Rehabilitation begins thereafter with the hand therapy team.

RESULTS

Five patients were evaluated retrospectively with follow-up periods ranging from 6 to 19 months (mean: 11 months). Four patients had osteoarthritis secondary to fractures, while one patient presented with primary osteoarthritis.

In all cases, the time between injury and surgery exceeded one year. Wrist arcs of motion were measured using a standard PVS hand goniometer, with the following results: 75° of pronation, 70° of supination, 80° of extension, and 70° of flexion.

Grip strength was assessed using a standard hydraulic dynamometer (Baseline-Orthowell®), revealing that patients achieved 70% of the grip strength of their contralateral hands. The mean DASH (Disabilities of the Arm, Shoulder, and Hand) questionnaire score improved from 56 preoperatively to 20 postoperatively. On the Mayo Wrist Score (MWS) scale, outcomes were rated as excellent in 83% of cases and good in 17%; no poor outcomes were observed. The visual analog scale (VAS) for pain decreased from 8 points before surgery to 3 points at the final follow-up. Screwdriver and Nakamura tests were negative in all patients.

No cases of infection, nerve paresthesia, or scarring complications were reported in the study population.

One complication occurred: a fracture of the ulnar styloid was identified in one patient through postoperative radiography. This fracture progressed to pseudoarthrosis but did not result in pain or functional impairments.

DISCUSSION

A retrospective study was conducted to analyze the surgical outcomes in five consecutive adult patients with DRUJ osteoarthritis treated using the glider arthroscopic interposition surgical technique. Good and excellent outcomes were achieved according to the MWS scale, with DASH scores improving postoperatively.

DRUJ osteoarthritis can arise from morphological or biomechanical changes. Certain morphological characteristics may predispose this joint to osteoarthritis. In wrists with a proximally oriented sigmoid notch, degenerative changes are more likely to develop in the DRUJ joint than in the ulnocarpal joint. Ulnar head morphology has been identified as the most statistically significant factor influencing the development of degenerative changes in the DRUJ. Bade et al. reported that the angle between the two facet joints of the ulnar head affects force transmission through the DRUJ. Greater inclination of the radial articular surface over the ulnar head increases force transmission.[13,14]

Several surgical options have been proposed for treating DRUJ osteoarthritis. The Darrach procedure is relatively simple but results in an unstable joint with reduced strength, ulnar translocation, radioulnar impingement, and extensor tendon rupture. It is generally suitable only for elderly patients with low functional demands.[6-8]

In 2019, we described the Darrach technique performed arthroscopically, which resulted in complications similar to those of the open technique.[15]

The Sauvé-Kapandji procedure is another option for DRUJ osteoarthritis, particularly in young, active patients with TFCC tears but without instability. It restores wrist mobility, stability, and grip strength, although it carries complications similar to those of the Darrach technique.[6-8,15]

In 2021, we presented case reports on the Sauvé-Kapandji technique performed arthroscopically. While the results were superior to the open approach, radioulnar impingement remained a complication.[16]

Ulnar and DRUJ prostheses are not available in our country and are therefore excluded from this discussion.[6-8]

DRUJ joint interposition techniques, such as the Bowers technique, preserve the soft tissue stabilizers around the DRUJ. These techniques use tendon interposition to maintain radioulnar separation and have shown favorable outcomes in preventing DRUJ impingement.[17]

Nawijn et al. evaluated 31 patients who underwent open Bowers interposition with an average follow-up of three years. The patients reported satisfaction with the technique.[18]

Similarly, Schober et al. studied 24 patients treated with the open Bowers technique between 1992 and 1997. They found improvements in mobility, strength, and pain scores, with good functional outcomes, although some patients experienced pain due to TFCC instability.[19]

The glider interposition surgical technique combines pain relief via ulnar osteotomy and DRUJ stabilization with a graft in a single procedure.

One advantage of this technique over the Bowers technique is its ability to stabilize the DRUJ joint through a graft with metaphyseal fixation in the ulna, achieving three objectives: pain relief, increased mobility, and joint stability.

Pillukat evaluated hemiresection interposition arthroplasty of the DRUJ and reported significant pain reduction, improved gross strength, and increased range of motion when preoperative turning motion was restricted. Although ulnar end instability may persist, it typically causes only minor symptoms. Patient satisfaction and functional outcomes were good.[19] Our series yielded similar results despite the small sample size and short follow-up period.

As demonstrated in most soft tissue interposition studies, these techniques provide pain relief without the complications of proximal radioulnar impingement but may result in some degree of DRUJ instability.

The strength of the glider technique lies in its minimally invasive, arthroscopic approach, which avoids opening the dorsal capsule. It provides pain relief through ulnar osteotomy, incorporates interposition for separation, and restores DRUJ stability via a tendon graft.

However, this technique requires a learning curve in arthroscopic surgery and involves high costs due to the fixation and interposition materials. Additionally, a limitation of this study is the small sample size and short follow-up duration.

CONCLUSIONS

The glider arthroscopic interposition technique offers an alternative to current joint salvage procedures. It is minimally invasive, preserves soft tissue structures, is reproducible, relieves DRUJ pain, and provides additional joint stability, resulting in acceptable mobility and good functional outcomes. An added advantage is its ability to avoid the proximal radioulnar impingement often seen with other salvage techniques.

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

A. D. Ledesma ORCID ID: https://orcid.org/0009-0000-2519-7127

REFERENCES

1. Green DP Wolfe SW. *Green´s operative hand surgery*, 5th ed. New York: Elsevier Inc.; 2013.
2. Spies CK, Langer MF, Unglaub F, Mühldorfer-Fodor M, Müller LP. Carpus and distal radioulnar joint, clinical and radiological examination. *Unfallchirurg* 2016;119(8):673-89. https://doi.org/10.1007/s00113-016-0206-0
3. Isaacs JE, Chhabra A. *Arthritis & arthroplasty: The hand, wrist and elbow*. Philadelphia, PA: Elsevier; 2011.
4. Chung KC. *Hand and upper extremity reconstruction*. Philadelphia, PA: Elsevier Health Sciences; 2010.
5. Luchetti R, Khanchandani P, Da Rin F, Borelli PP, Mathoulin C, Atzei A. Arthroscopically assisted Sauve-Kapandji procedure: An advanced technique for distal radioulnar joint arthritis. *Tech Hand Upper Extrem Surg* 2008;12(4):216-20. https://doi.org/10.1097/BTH.0b013e31818ee28a
6. Gupta RK, Soni A, Masih GD. "Quadrangular-construct" modification of Sauve-Kapandji procedure. *Indian J Orthop* 2017;51(1):99-102. https://doi.org/10.4103/0019-5413.197556
7. Guo Z, Wang Y, Zhang Y. Modified Sauve-Kapandji procedure for patients with old fractures of the distal radius. *Open Med (Wars)* 2017;12:417-23. https://doi.org/10.1515/med-2017-0060
8. Tomori Y, Sawaizumi T, Nanno M, Taka S. Functional outcomes after the Sauvé-Kapandji procedure for distal radio-ulnar post-traumatic instability: a case-control comparison of three different operative methods of stabilization of the ulnar stump. *Int Orthop* 2028;42:2173-9. https://doi.org/10.1007/s00264-018-4042-4
9. Tolat AR, Stanley JK, Trail IA. A cadaveric study of the anatomy and stability radioulnar joint in the coronal and transverse planes. *J Hand Surg Br* 1996;21(5):587-94. https://doi.org/10.1016/s0266-7681(96)80136-7
10. Schmidbauer S, Ladurner R, Hallfeldt KK, Mussack. Heavy weight versus low weight polypropylene meshes for open sublay mesh repair of incisional hernia. *Eur J Med Res* 2005;10(6):247-53. PMID: 16033714
11. Atzei A, Luchetti R. Foveal TFCC tear classification and treatment. *Hand Clin* 2011;27(3):263-72. https://doi.org/10.1016/j.hcl.2011.05.014
12. Kermarrec G, Cohen G, Upex P, Fontes D. Arthroscopic foveal reattachment of the triangular fibrocartilaginous complex. *J Wrist Surg* 2020;9(3):256-62. https://doi.org/10.1055/s-0040-1702929
13. Bade H, Koebke J, Schloter M. Morphology of the articular surfaces of the distal radio-ulnar joint. *Anat Rec* 1996;246(3):410-4. https://doi.org/10.1002/(SICI)1097-0185(199611)246:3<410::AID-AR12>3.0.CO;2-R
14. Hollevoet N, Verdonk R, Van Maele G. The influence of articular morphology on non-traumatic degenerative changes of the distal radioulnar joint. A radiographic study. *J Hand Surg Br* 2006;31(2):221-5. https://doi.org/10.1016/j.jhsb.2005.10.012
15. Kaempf R, Aita M, Delgado PJ. *Cirurgia minimamente invasiva. Artroscopia do Punho*; Rio de Janeiro: Di Livros Editora Limitada; 2022: cap. 17.
16. Sala JM, Ambrosi AD, Ledesma AD. Resultados del tratamiento de la artrosis radiocubital distal mediante técnica de Sauvé-Kapandji artroscópica. *Artroscopia.* 2021;28(4). Available at: https://www.revistaartroscopia.com.ar/index.php/revista/article/view/159
17. Yayac M, Padua FG, Banner L, Seigerman DA, Beredjiklian PK, Aita DJ, et al. Treatment outcomes in patients undergoing surgical treatment for arthritis of the distal radioulnar joint. *J Wrist Surg* 2020;9(3):230-4. https://doi.org/10.1055/s-0040-1702200
18. Nawijn F, Verhiel SHWL, Jupiter JB, Chen NC. Hemiresection interposition arthroplasty of the distal radioulnar joint: A long-term outcome study. *Hand (NY)* 2009;16(5):484-97. https://doi.org/10.1007/s00064-009-1913-2
19. Schober F, Van Schoonhoven J, Prommersberger KJ, Lanz U. Die Hemiresektions-Interpositionsarthroplastik nach Bowers zur Behandlung der posttraumatischen Arthrose des distalen Radioulnargelenks nach distalen Radiusfrakturen. [Bowers hemi-resection-interposition arthroplasty for treatment of post-traumatic arthrosis of the distal radio-ulnar joint after distal radius fractures]. *Handchir Mikrochir Plast Chir* 1999;31(6):378-82. https://doi.org/10.1055/s-1999-13557

Conservative Treatment of PASTA (Articular Partial Supraspinatus Tendon Avulsion) in a Patient with High Functional Demand: Case Report With a 6-year Follow-up

João A. Bonadiman, Italo J. Mejía Sabando, Marcos D. Oliveira Moura, Paulo C. Faiad Piluski, Carlos H. Castillo Rodríguez, Osvandré Lech

Instituto de Ortopedia e Traumatologia de Passo Fundo, Hospital São Vicente de Paulo, Passo Fundo, RS, Brazil

ABSTRACT

Partial Articular Surface Tendon Avulsion (PASTA) lesions are among the most common types of partial rotator cuff injuries. This case report examines a 30-year-old patient with high functional demands who was diagnosed with a PASTA lesion. The patient presented with pain and dysfunction, as assessed by functional scales. A conservative treatment plan was implemented, including medication and a physiotherapy regimen adapted to the patient's progress. Clinical follow-up and serial imaging with magnetic resonance imaging (MRI) were performed over a six-year period. The evolution of the lesion showed no progression, and significant functional improvement was documented. A review of the literature and this case's outcomes underscore the potential for conservative management in treating PASTA lesions. This case highlights the need for further research comparing the effectiveness of conservative and surgical interventions.

Keywords: Rotator cuff tear; conservative treatment; PASTA lesion; case report.

Level of Evidence: IV

Tratamiento conservador de una lesión PASTA (*partial articular supraspinatus tendon avulsion*) en una paciente con alta demanda funcional. Presentación de un caso con un seguimiento de 6 años

RESUMEN

Las lesiones PASTA son una de las lesiones parciales del manguito rotador más comunes. Se presenta a una paciente de 30 años con alta demanda funcional, que tenía dolor y disfunción según las escalas funcionales, a quien se le diagnosticó una lesión PASTA. Se optó por un tratamiento conservador, que incluyó medicación y fisioterapia adaptada a la evolución, con controles clínicos y por imágenes durante 6 años. La evolución del tratamiento conservador, monitoreado por resonancia magnética seriada, mostró que la lesión no progresó y la función mejoró significativamente. Este caso resalta la necesidad de realizar más investigaciones que comparen las intervenciones conservadoras y las quirúrgicas.

Palabras clave: Lesión del manguito rotador; tratamiento conservador; lesión PASTA.

Nivel de Evidencia: IV

INTRODUCTION

Partial rotator cuff injuries have an incidence ranging from 17% to 37% in the general population, with a higher prevalence of up to 80% in individuals in their eighth decade of life.[1,2] These injuries are a common cause of shoulder pain and functional limitations in daily activities.[3]

Received on May 29th, 2024. Accepted after evaluation on August 28th, 2024 • Dr. JOÃO A. BONADIMAN • joaoartur10@gmail.com https://orcid.org/0000-0001-8613-4461

How to cite this article: Bonadiman JA, Mejía Sabando IJ, Oliveira Moura MD, Faiad Piluski PC, Castillo Rodríguez CH, Lech O. Conservative Treatment of PASTA (Articular Partial Supraspinatus Tendon Avulsion) in a Patient with High Functional Demand: Case Report With a 6-year Follow-up. *Rev Asoc Argent Ortop Traumatol* 2024;89(6):626-631. https://doi.org/10.15417/issn.1852-7434.2024.89.6.1974

Partial lesions can be classified using the Ellman system,[4] which categorizes them based on their location (articular, bursal, or intratendinous) and the degree of tendon involvement (Grade I: <3 mm, Grade II: 3–6 mm, Grade III: >6 mm). Snyder proposed a similar grading system, incorporating lesion location (A = articular surface, B = bursal surface, C = complete) and arthroscopic visualization (Grades 0–4).[5]

Among these, PASTA (partial articular supraspinatus tendon avulsion) injuries are particularly noteworthy, comprising up to 91% of all partial rotator cuff injuries.[6] This type of lesion results from a combination of intrinsic, extrinsic, and traumatic factors. Intrinsic factors include changes in the vascularity of the rotator cuff and metabolic alterations associated with aging, which have been extensively studied.[7] Extrinsic factors encompass shear stresses on the supraspinatus tendon caused by narrowing of the coracoacromial arch, repetitive microtrauma (especially linked to overhead activities), and internal impingement.[6] These injuries are commonly observed in athletes who engage in throwing sports, such as volleyball players and baseball pitchers.[8]

The natural progression of PASTA lesions remains unclear, but spontaneous resolution of partial rotator cuff injuries is considered unlikely,[6] 53% of PASTA lesions tend to progress in size over time, often necessitating surgical intervention. [3,9]

In this context, we present a rare case of complete healing of a PASTA lesion managed conservatively, with a 6-year follow-up (2018–2024). Clinical evaluations and periodic assessments with serial MRIs, performed every three years, demonstrated improved functional scale scores and satisfactory healing on imaging. To our knowledge, no previously published case has documented such long-term follow-up with periodic MRIs every three years under conservative management.

CLINICAL CASE

A 25-year-old right-handed woman with a body mass index of 21, a regular volleyball player (three times per week), presented with pain and functional limitation in her right shoulder, preventing her from performing overhead movements. On the initial physical examination (2018), the patient demonstrated active and passive range of motion in the right shoulder, with 180° elevation, 100° external rotation, and internal rotation reaching T12. Mild signs of ligamentous hyperlaxity were noted, confirmed by a positive sulcus test. Neer and Hawkins impingement tests, as well as the supraspinatus strength test (Jobe), were positive. MRI of the right shoulder (Figures 1 and 2) revealed a partial articular tear of the supraspinatus tendon.

Based on clinical and imaging findings, a diagnosis of a PASTA lesion of the right rotator cuff was made. In collaboration with the patient, conservative management was chosen. Initially, with the aim of reducing inflammatory and painful symptoms, non-steroidal anti-inflammatory drugs and physiotherapy focusing on posterior capsule stretching were prescribed. The patient was also instructed to perform daily home exercises. After four weeks, once the inflammatory stage had subsided, physiotherapy transitioned to a strengthening phase targeting the pectoralis, latissimus dorsi, trapezius, and particularly the serratus anterior muscles.

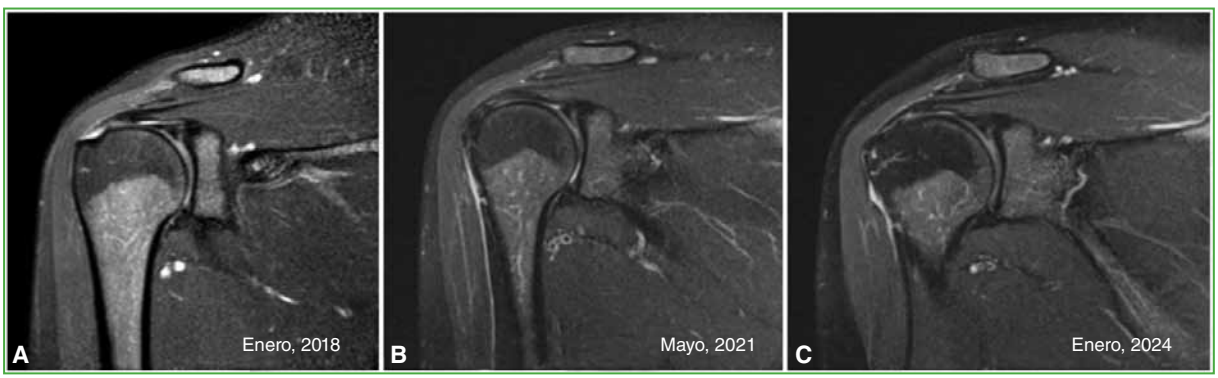


Figure 1. MRI of the right shoulder, coronal section, in T2 sequence.

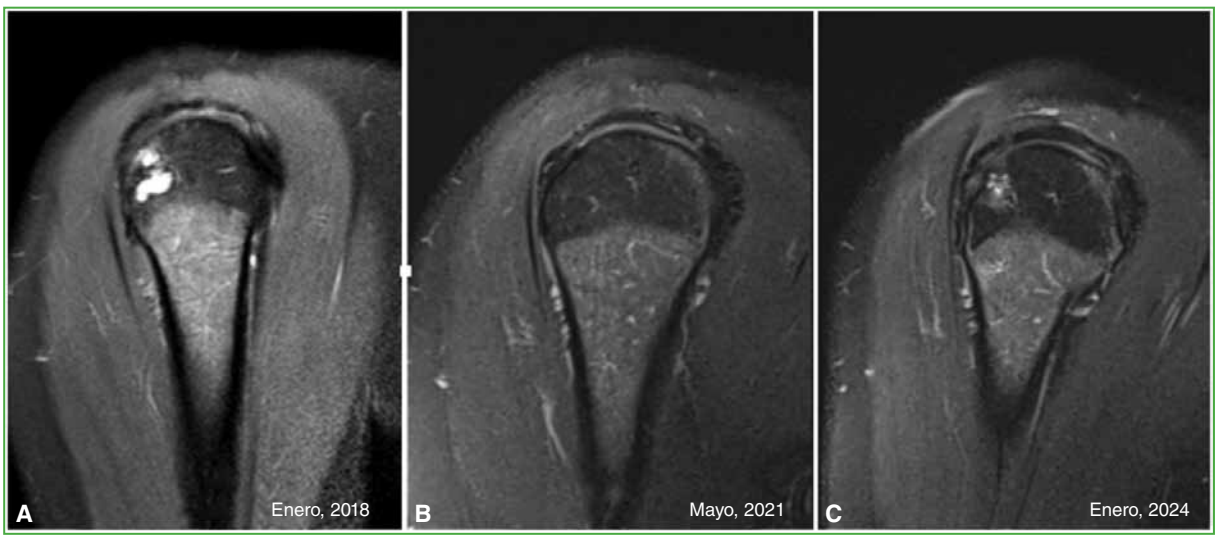


Figure 2. Magnetic resonance imaging of the right shoulder, sagittal view, T2 sequence.

During the entire treatment period, the patient was monitored in outpatient settings using two functional scales: ASES (*American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form*)[10] (Figure 3) and SANE - (*Single Alpha Numeric Evaluation*)[11] (Figure 4).

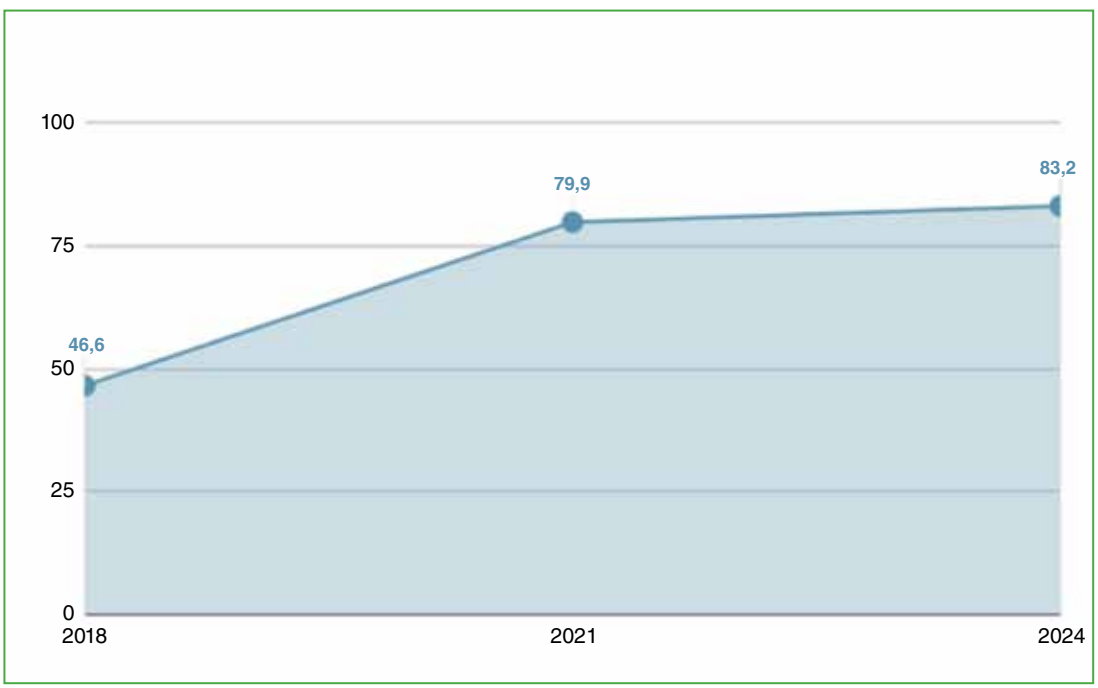


Figure 3. Evolution of the ASES score over the 6 years of follow-up.
ASES = *American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form.*

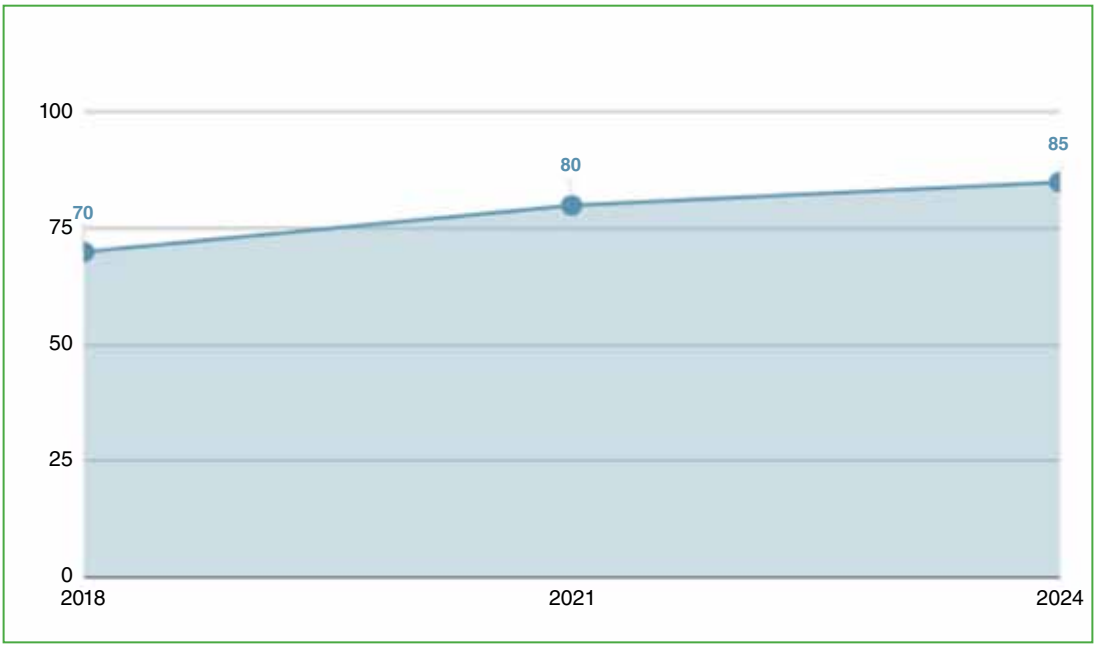


Figure 4. Evolution of the SANE score over the 6 years of follow-up.
SANE = *Single Alpha Numeric Evaluation.*

In addition to clinical evaluations, serial MRIs were performed at three-year intervals (January 2018, May 2021, and January 2024) (Figures 1 and 2), showing progressive clinical and radiological improvement.

After 12 months, pain and range of motion had significantly improved, allowing a gradual return to sports. Weight training for muscle strengthening was continued.

At the third year of follow-up (2021), the SANE score reached 80, and the ASES score was 79.9, indicating substantial functional improvement. MRI (Figures 1 and 2) showed almost complete tissue repair compared to the initial study.

The patient returned in March 2024 for re-evaluation and reported being pain-free, participating in recreational volleyball twice a week without functional limitations. Clinical examination revealed full active and passive range of motion, with negative Neer, Hawkins, and Jobe tests. The SANE score increased to 85. MRI (Figures 1 and 2) confirmed stabilization of the lesion and satisfactory healing.

DISCUSSION

Partial rotator cuff injuries are a common cause of shoulder pain, limitations in daily activities, and absences from work.[8] Despite progress in understanding the pathophysiology of PASTA rotator cuff injuries, their exact mechanisms remain elusive. These injuries commonly occur at the junction of the tendon fibers of the supraspinatus and infraspinatus muscles.[1,12]

Scientific studies have demonstrated a greater prevalence and size of blood vessels in the bursal region of the rotator cuff compared to the articular surface, which is described as a relatively hypovascularized area.[13,14] Histological analyses also indicate that collagen fibers in the articular surface are thinner and less organized than those in the bursal region.[14] These findings support the hypothesis that the articular surface is only about half as robust as the bursal surface.[15] This evidence explains the higher prevalence of PASTA lesions (91%) among partial rotator cuff injuries.[6]

According to Sher et al., diagnosing PASTA lesions clinically can be challenging due to the possibility of asymptomatic cases.[12] Pain is typically elicited during resisted abduction with the shoulder positioned at 90° of abduction, aligned with the scapular plane, and in internal or external rotation. For identifying supraspinatus tendon injuries, Itoi et al. recommend using the Jobe maneuver.[16] Positive results may also be observed with impingement tests, such as those described by Neer and Hawkins.[17]

Various imaging modalities are used to evaluate these injuries. Ultrasonography is a cost-effective and accurate diagnostic tool, but magnetic resonance imaging (MRI) remains the most sensitive imaging method for diagnosing partial rotator cuff injuries.[4,12]

Ellman and Snyder et al. proposed the two most widely used classifications for PASTA lesions; however, both focus exclusively on quantifying ruptures in the coronal plane on MRI.[4,5] Tennent and Green argue that the lack of a comprehensive classification system for these lesions contributes to ongoing uncertainty regarding their optimal management.[18]

The therapeutic approach to PASTA lesions is still controversial. Most surgeons agree that treatment should be tailored to the lesion's severity and stage, with initial management typically being conservative. Surgical repair is generally indicated for symptomatic patients when more than 50% of the supraspinatus tendon thickness is involved (Grade III according to Ellman or Snyder).[9,18]

To date, no studies have been published describing the natural course of PASTA lesions or techniques to identify which lesions are most likely to progress with conservative treatment.[18] Ji et al. reported that 53% of partial lesions tend to enlarge over time, eventually requiring surgical intervention.[3] Similarly, Yamanaka et al. found that 80% of partial lesions treated conservatively progressed to full-thickness tears in a follow-up study with arteriography.[19] These findings highlight the rarity of the case presented in this report: complete healing of a PASTA lesion achieved through conservative treatment, confirmed clinically and radiologically. The conservative treatment in this case consisted of an initial phase focusing on rest, cessation of pain-inducing movements, non-steroidal anti-inflammatory drugs, and joint mobilization physiotherapy to reduce pain, protect the muscle, and restore range of motion. Subsequently, the treatment progressed to physiotherapy aimed at strengthening the stabilizing muscles of the scapula and rotator cuff.

Reports of conservative treatment for PASTA lesions are scarce in the literature. To our knowledge, no previous case has documented such a prolonged follow-up with serial MRI evaluations every three years. This report, along with a brief literature review, may serve as a basis for future comparative clinical trials to evaluate surgical and conservative management strategies.

CONCLUSIONS

This article aimed to provide a concise literature review and document the evolution of a conservatively managed PASTA lesion. A 6-year follow-up with serial MRI demonstrated that the lesion did not progress, and the functional outcomes were satisfactory. Although conservative treatment is not extensively discussed in the literature, this case underscores the need for prospective research to compare the advantages and disadvantages of conservative and surgical approaches.

Conflict of interest: The authors declare no conflict of interest.

I. J. Mejía Sabando ORCID ID: https://orcid.org/0009-0008-4337-9061
M. D. Oliveira Moura ORCID ID: https://orcid.org/0009-0009-0382-5255
P. C. Faiad Piluski ORCID ID: https://orcid.org/0000-0002-1887-8861
C. H. Castillo Rodríguez ORCID ID: https://orcid.org/0000-0002-4968-8390
O. Lech ORCID ID: https://orcid.org/0000-0002-9727-2330

REFERENCES

1. Spargoli G. Partial articular supraspinatus tendon avulsion (PASTA) lesion. Current concepts in rehabilitation. *Int J Sports Phys Ther* 2016;11(3):462-81. PMID: 27274431
2. Yamamoto A, Takagishi K, Osawa T, Yanagawa T, Nakajima D, Shitara H, et al. Prevalence and risk factors of a rotator cuff tear in the general population. *J Shoulder Elbow Surg* 2010;19(1):116. https://doi.org/10.1016/j.jse.2009.04.006
3. Ji J, Choi C, You H, Parikh D, Oh S. Effects of arthroscopic atelocollagen insertion in high-grade partial articular supraspinatus tendon avulsion lesions: A retrospective cohort study with propensity score matching. *Orthop J Sports Med* 2023;11(11):23259671231212882. https://doi.org/10.1177/23259671231212882
4. Ellman H. Diagnosis and treatment of incomplete rotator cuff tears. *Clin Orthop Relat Res* 1990;(254):64-74. PMID: 2182260
5. Snyder SJ, Pachelli AF, Del Pizzo W, Friedman MJ, Ferkel RD, Pattee G. Partial thickness rotator cuff tears: Results of arthroscopic treatment. *Arthroscopy* 1991;7(1):1-7. https://doi.org/10.1016/0749-8063(91)90070-E
6. Manoharan A, Falgout D, Feldman M. Arthroscopic repair of a PASTA of the shoulder using a bursal split. *Arthrosc Tech* 2021;10(5):e1403-e1408. https://doi.org/10.1016/j.eats.2021.01.033.
7. Rathbun JB, Macnab I. The microvascular pattern of the rotator cuff. *J Bone Joint Surg Br* 1970;52(3):540-53. https://doi.org/10.1302/0301-620X.52B3.540
8. Ueda Y, Sugaya H, Takahashi N, Matsuki K, Tokai M, Hoshika S, et al. Prevalence and site of rotator cuff lesions in shoulders with recurrent anterior instability in a young population. *Orthop J Sports Med* 2019;7(6):2325967119849876. https://doi.org/10.1177/2325967119849876
9. Yuan T, Yang S, Qian H, Lai C, Jiang H, Meng J, et al. All-inside technique versus in situ transtendon repair for Ellman III partial articular supraspinatus tendon avulsion. *J Shoulder Elbow Surg* 2023;32(1):24-32. https://doi.org/10.1016/j.jse.2022.06.018
10. King GJW, Richards RR, Zuckerman JD, Blasier R, Dillman C, Fried RJ, et al. A standardized method for assessment of elbow function. Research Committee, American Shoulder and Elbow Surgeons. *J Shoulder Elbow Surg* 1999;8(4):351-4. https://doi.org/10.1016/S1058-2746(99)90159-3
11. Thigpen CA, Shanley E, Momaya AM, et al. Validity and responsiveness of the single alpha-numeric evaluation for shoulder patients. *Am J Sports Med* 2018;46(14):3480-5. https://doi.org/10.1177/0363546518807924
12. Sher J, Uribe J, Posada A, Murphy B, Zlatkin M. Abnormal findings on magnetic resonance images of asymptomatic shoulders. *J Bone Joint Surg Am* 1995;77(1):10-5. https://doi.org/10.2106/00004623-199501000-00002
13. Neer CS, Flatow E, Lech O. Tears of the rotator cuff: Long term results of anterior acromioplasty and repair. *Ortop Trans* 1988;12(3):735.
14. De Almeida Filho IA, Coelho DA. A cicatrização do manguito rotador. *Rev Bras Ortop (Sao Paulo)* 2021;56(3):291-8. https://doi.org/10.1055/s-0040-1713764
15. Clark J, Harryman D. Tendons, ligaments, and capsule of the rotator cuff. Gross and microscopic anatomy. *J Bone Joint Surg Am* 1992;74(5):713-25. https://doi.org/10.2106/00004623-199274050-00010
16. Itoi E, Kido T, Sano A, Urayama M, Sato K. Which is more useful, the "Full can test" or the "Empty can test," in detecting the torn supraspinatus tendon? *Am J Sports Med* 1999;27(1):65-8. https://doi.org/10.1177/03635465990270011901
17. Gartsman GM, Milne JC. Articular surface partial-thickness rotator cuff tears. *J Shoulder Elbow Surg* 1995;4(6):409-15. https://doi.org/10.1016/S1058-2746(05)80031-X
18. Tennent D, Green G. Partial articular supraspinatus tendon avulsion: Should we repair? A systematic review of the evidence. *Shoulder Elbow* 2020;12(4):253-64. https://doi.org/10.1177/1758573219864101
19. Yamanaka K, Matsumoto T. The joint side tear of the rotator cuff : A followup study by arthrography. *Clin Orthrop Relat Res* 1994;304(304):68-73. https://doi.org/10.1097/00003086-199407000-00012

Pronator Teres Syndrome Among Other Compressive Neuropathies of the Upper Limb: A Case Report

Íñigo Úbeda Pérez de Heredia
Traumatology Service, Clínica Beiman Sevilla, Sevilla, Spain

ABSTRACT
Pronator teres syndrome (PTS) is a condition involving entrapment of the median nerve as it passes between the muscular bellies of the pronator teres muscle. It is a rare condition, often misdiagnosed as other compressive neuropathies of the upper limb. We present a rare case of PTS associated with ulnar nerve compression at the elbow and median nerve compression at the wrist. Electrophysiological studies revealed entrapment of the median nerve at the wrist and ulnar neuropathy at the elbow. Dynamic ultrasound of the forearm confirmed morphological changes in the median nerve as it traversed the pronator teres muscle. The patient showed significant improvement following corticosteroid treatment, rehabilitation, and functional readaptation techniques. **Conclusions:** PTS should be considered in patients presenting with sensory disturbances in the forearm and wrist. Differentiating it from other compressive neuropathies is critical, as early diagnosis enables the implementation of conservative therapeutic measures to prevent progression to structural nerve damage.
Keywords: Nerve; median; pronator; neuropathy; syndrome; teres.
Level of Evidence: IV

Síndrome del pronador redondo en el contexto de otras neuropatías compresivas del miembro superior. Presentación de un caso

RESUMEN
El síndrome del pronador redondo consiste en un atrapamiento del nervio mediano en su recorrido entre los vientres musculares del músculo pronador redondo. Es un cuadro poco común que habitualmente se confunde con otras neuropatías compresivas del miembro superior. Se presenta un caso infrecuente de síndrome del pronador redondo asociado a la compresión del nervio cubital en el codo y del nervio mediano en la muñeca. El estudio electrofisiológico detectó un atrapamiento del nervio mediano en la muñeca y una neuropatía cubital a nivel del codo. La ecografía dinámica del antebrazo constató una afectación morfológica del nervio mediano a su paso por el músculo pronador redondo. El paciente mejoró con la aplicación corticoides y técnicas de rehabilitación y readaptación. **Conclusiones:** Se debe sospechar un síndrome del pronador redondo en pacientes que consultan por alteraciones sensitivas en el antebrazo y la muñeca. El diagnóstico diferencial con otras neuropatías compresivas es fundamental, porque la detección precoz permite indicar medidas terapéuticas conservadoras que eviten una progresión hacia la lesión estructural del nervio.
Palabras clave: Nervio mediano; pronador redondo; neuropatía; síndrome.
Nivel de Evidencia: IV

INTRODUCTION

Pronator teres syndrome (PTS) is characterized by entrapment of the median nerve between the heads of the pronator teres muscle.[1-4] It is an uncommon condition that rarely occurs in conjunction with other nerve compressions in the upper limb. In such cases, the symptomatology and physical examination findings may be inconclusive due to a complex amalgam of sensory alterations that patients often struggle to describe.[5-7] A thorough anamnesis, including detailed inquiry into the patient's history, onset, symptoms, and clinical signs, is essential to suspect PTS.

Received on January 3rd, 2024. Accepted after evaluation on September 15th, 2024 • Dr. ÍÑIGO ÚBEDA PÉREZ DE HEREDIA • dr.iubedap@gmail.com https://orcid.org/0000-0002-8525-424X
How to cite this article: Úbeda Pérez de Heredia Í. Pronator Teres Syndrome Among Other Compressive Neuropathies of the Upper Limb: A Case Report. *Rev Asoc Argent Ortop Traumatol* 2024;89(6):632-636. https://doi.org/10.15417/issn.1852-7434.2024.89.6.1872

Electrophysiological studies have limited sensitivity for sensory neuropathies,[8] but may be helpful in identifying other sites of nerve compression. Imaging studies can be valuable in visualizing the nerve pathway and pinpointing compression sites,[9] thereby facilitating a definitive diagnosis and enabling timely therapeutic interventions to prevent irreversible nerve damage.[10,11]

CLINICAL CASE

A 53-year-old white man, a university professor with no significant medical history, presented to our department with complaints of paresthesia, hypoesthesia, and dysesthesia in the right forearm and hand. These symptoms had worsened over the past two weeks, which the patient attributed to prolonged guitar playing as an amateur musician, practicing for several hours daily. The symptoms improved during nighttime rest but persisted throughout the day, exacerbating during activities such as typing on a computer keyboard and driving a car or motorcycle.

A functional examination of the cervical spine showed no muscle contractures, pain on apophyseal palpation, or limitations in range of motion. Radicular elongation tests reproduced sensory symptoms along the anterior aspect of the distal third of the right arm, as well as in the dorsal, palmar, and radial regions of the forearm and hand, and in the 1st–4th fingers. No motor deficits were observed. Joint assessments of the elbow and wrist, as well as median nerve compression tests at the wrist, were negative. However, neurodynamic tests for the ulnar nerve at the epitrochlear canal intensified paresthesia along the anteromedial border of the forearm and in the 2nd–5th fingers. Symptoms were also provoked by active pronosupination, assisted supination, and active flexion of the flexor digitorum superficialis (Figure 1).

Figure 1. Exploratory tests in pronator teres syndrome. **A.** Flexor digitorum superficialis test. **B.** Pressure test. **C.** Resisted supination test.

Complementary imaging studies, including plain radiographs and an MRI of the cervical spine, revealed mild degenerative changes without spinal or spinal cord involvement.

Electrophysiological studies (electromyography and electroneurography) of the right upper limb showed mild ulnar nerve entrapment at the olecranon-epitrochlear canal and mild median nerve compression at the carpal tunnel.

Comparative ultrasound of the elbows and forearms demonstrated altered morphology and thickness of the right median nerve as it passed beneath the superficial head of the pronator teres (Figure 2), consistent with findings in most cases of PTS (Figure 3).

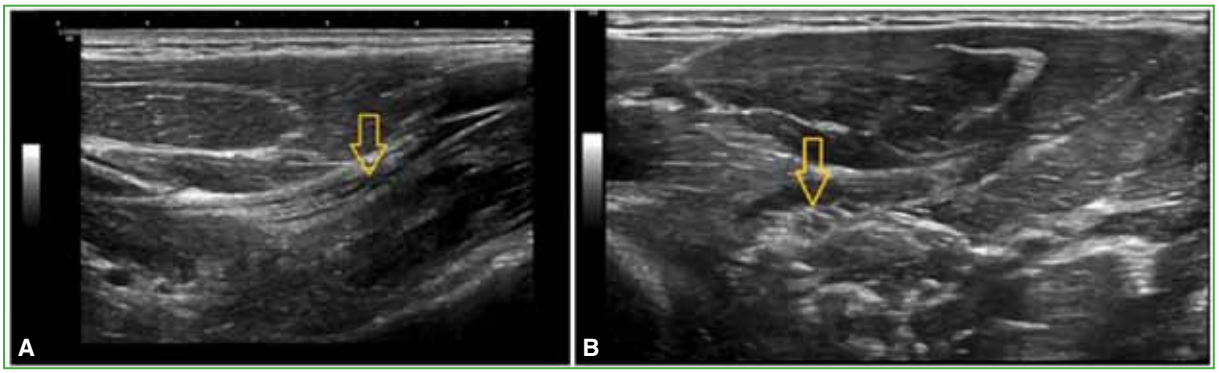


Figure 2. Ultrasound of the ventral aspect of the right forearm. **A.** Longitudinal section. **B.** Transverse section. The arrow shows compression of the median nerve as it passes between the heads of the pronator teres muscle.

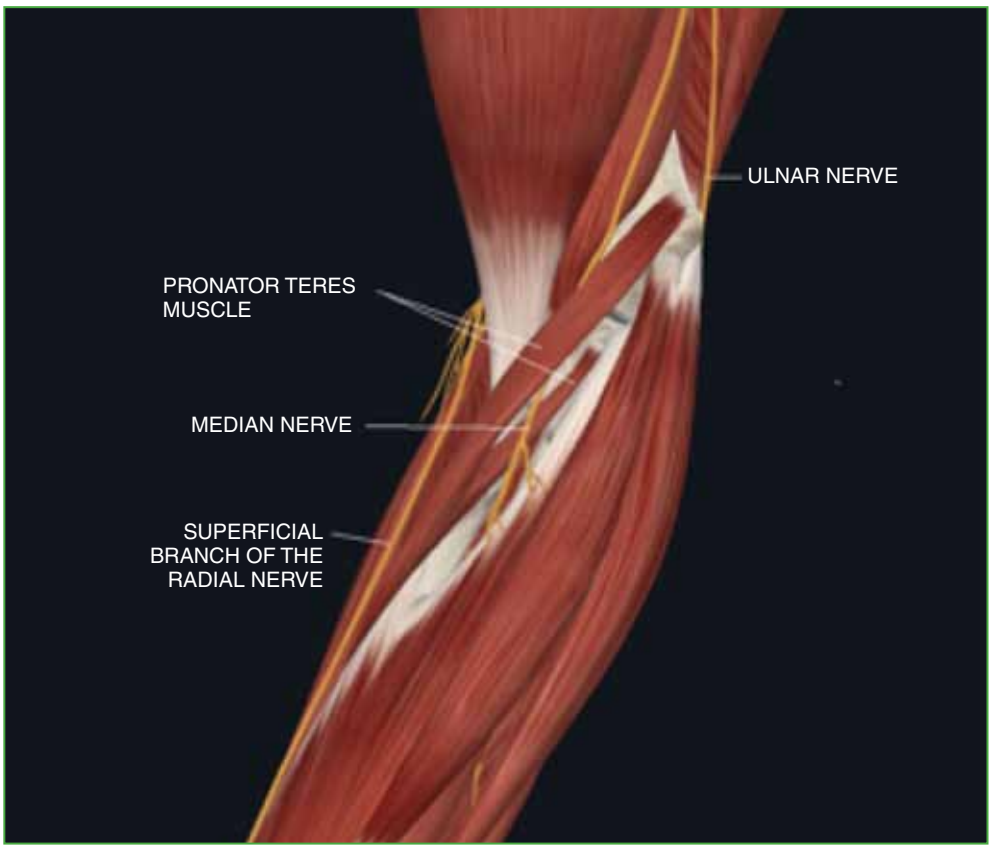


Figure 3. Median nerve in its path between the two heads of the pronator teres muscle. Source: *Complete Anatomy* interactive atlas, version 10.0.1, modified.

A primary diagnosis of PTS was established in the context of concurrent carpal tunnel syndrome and ulnar nerve neuropathy at the elbow. Conservative management was initiated, including: functional rest, avoiding repetitive pronosupination movements and refraining from musical activities; physiotherapeutic interventions, such as massage therapy, electrotherapy, and stretching exercises; pharmacological treatment with oral corticosteroids (oral deflazacort 30 mg/day for 5 days, followed by a tapered dosage over 20 days); and daily supplementation with a vitamin B complex combined with alpha-lipoic acid for 2 months.

After two months of conservative treatment, the patient experienced significant improvement and resumed his musical activities, adhering to recommendations for postural correction, technique refinement, stretching, and limiting prolonged practice sessions. At a follow-up visit three months later, he showed a good response to treatment and reported no symptoms of compressive neuropathy in the median or ulnar nerve territories.

DISCUSSION

The pronator teres muscle is located in the anterior and proximal region of the forearm. Its two heads originate from the medial epicondyle of the humerus and the medial border of the coronoid process of the ulna, respectively, and insert on the middle third of the lateral aspect of the radius via a single tendon. The muscle is innervated by the median nerve, which passes between the two heads in 74–82% of cases,[1-3] making it a predisposing factor for the development of pronator teres syndrome (PTS).[3]

PTS was first described by Henrik Seiffert in 1951. In 66% of cases, nerve entrapment occurs between the heads of the pronator teres,[4] presenting with paresthesias in the palm of the hand and the 1st–4th fingers, pain in the anterior forearm that worsens with activity and improves with rest, and, occasionally, weakness of the musculature innervated by the median nerve distal to the compression site.[5]

A differential diagnosis must be considered to distinguish PTS from conditions such as cervical radiculopathy, brachial plexus neuropathies, thoracic outlet syndrome, and other compressive neuropathies of the upper limb, including carpal tunnel syndrome.[6] In carpal tunnel syndrome, median nerve compression occurs below the transverse carpal ligament, typically causing nocturnal pain while sparing the palm's sensory function, as the palmar cutaneous branch does not traverse the carpal tunnel.[7] Additional causes of median nerve compression include the Struthers ligament, which connects the humerus to the medial epicondyle and may lead to pain and paresthesias in the forearm, hand, and fingers, exacerbated by forearm supination and elbow extension. *Lacertus fibrosus*, while a rare cause, can also compress the median nerve at the elbow.[12] Anterior interosseous nerve syndrome manifests with muscle weakness of the flexor group but typically lacks sensory involvement.[13] Compression of the median nerve in the fibrous arch of the flexor digitorum superficialis is more common and produces symptoms similar to PTS.[13] Furthermore, canalicular compressions of the ulnar or radial nerves should be included in the differential diagnosis, as pain and paresthesias do not always align with the classic dermatomal patterns.

Symptoms and clinical evaluation are critical for diagnosing PTS. Electrophysiological studies are of limited diagnostic value, with a sensitivity of only 10%. Among patients with clinically suspected PTS, fewer than 50% are confirmed by electrodiagnostic tests.[14] Nonetheless, electromyography and electroneurography can help rule out alternative compression sites in patients with distal sensory or motor symptoms. MRI and high-frequency ultrasound are recommended for definitive diagnosis, as they enable visualization of the nerve pathway and areas of compression.[15]

In cases of mild compression, conservative treatments—including anti-inflammatory medications, corticosteroids, and physiotherapy focused on muscle relaxation and nerve stimulation—can be effective. Promising results have been reported with ultrasound-guided hydrodissection of the median nerve using 5% dextrose,[10] and some authors suggest dry-needling techniques.[11] Surgical nerve decompression is reserved for severe cases or those unresponsive to conservative treatment.[9,16]

CONCLUSIONS

The case presented is notable because the median nerve was entrapped at both the pronator teres and the transverse carpal ligament, in addition to concurrent ulnar nerve compression at the elbow. This combination resulted in complex symptomatology and inconclusive findings during clinical examination. It is essential to recognize the low sensitivity of electromyography and understand that a negative result does not rule out PTS. Misinterpreting or overlooking this can lead to diagnostic errors.

A thorough clinical history, physical examination, and appropriate imaging studies are paramount. Clinicians should also consider the possibility of PTS coexisting with other canalicular syndromes of the upper limb. Prompt and accurate diagnosis of PTS enables effective conservative treatment, which can prevent progression to irreversible nerve damage and avoid the need for surgical intervention.

Conflict of interest: The author declares no conflicts of interest.

REFERENCES

1. Paulsen F, Waschke J. S*obotta. Cuaderno de tablas. Músculos, articulaciones y nervios*. 3.ª ed. UK: Elsevier Limited; 2019, p. 52-63
2. Olewnik L, Podgórski M, Polguj M, Wysiadecki G, Topol M. Anatomical variations of the pronator teres muscle in a Central European population and its clinical significance. *Anat Sci Int* 2018;93(2):299-306. https://doi.org/10.1007/s12565-017-0413-y
3. Sharma N, Pandit R, Subedi S. Median nerve passing below the ulnar head of pronator teres in cadavers of a Medical College in Western Nepal: A descriptive cross-sectional study. *JNMA J Nepal Med Assoc* 2022;60(245):31-4. https://doi.org/10.31729/jnma.7230
4. Dididze M, Tafti D, Sherman Al. Pronator teres syndrome. StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023.Available at: https://www.ncbi.nlm.nih.gov/books/NBK526090/
5. Özdemir A, Acar MA, Güleç A, Durgut F, Cebeci H. Clinical, radiological, and electrodiagnostic diagnosis of pronator syndrome concurrent with carpal tunnel syndrome. *J Hand Surg Am* 2020;45(12):1141-7. https://doi.org/10.1016/j.jhsa.2020.06.006
6. Balcerzak AA, Ruzik K, Tubbs RS, Konschake M, Podgórski M, Borowski A, et al. How to differentiate pronator syndrome from carpal tunnel syndrome: A comprehensive clinical comparison. *Diagnostics (Basel)* 2022;12(10):2433. https://doi.org/10.3390/diagnostics12102433
7. Zancolli ER, Zancolli EP, Perrotto CJ. New miniinvasive decompression for pronator teres syndrome. *J Hand Surg Am* 2012;37(8):1706-10. https://doi.org/10.1016/j.jhsa.2012.05.033
8. Sánchez Saba JE, Civit JF, Ramírez Vargas P, Melibosky Ramos F, Villavicencio Achurra A, Román Veas J, et al. Síndromes compresivos del nervio mediano. Revisión y actualización de la bibliografía. *Rev Asoc Argent Ortop Traumatol* 2023;88(4):451-6. https://doi.org/10.15417/issn.1852-7434.2023.88.4.1734
9. Rodner CM, Tinsley BA, O'Malley MP. Pronator syndrome and anterior interosseous nerve syndrome. *J Am Acad Orthop Surg* 2013;21(5):268-75. https://doi.org/10.5435/JAAOS-21-05-268
10. Montemayor MG, Rodríguez J, Valencia H. Neuropatías por atrapamiento. *Formación Médica Continuada en Atención Primaria* 2008;15(1):10-20. https://doi.org/10.1016/S1134-2072(08)70726-6
11. Adler J, Moriatis J. Proximal median nerve compression: Pronator syndrome. *Hand Surg J* 2020;45(12):1157-65. https://doi.org/10.1016/j.jhsa.2020.07.006
12. Chang KV, Wu WT, Hsu PC, Yang YC, Ozcakar L. Ultrasonography in pronator teres syndrome: Dynamic examination and guided hydrodissection. *Pain Med* 2022;23(1):227-8. https://doi.org/10.1093/pm/pnab143
13. Fernández-de-Las-Peñas C, López-de-Celis C, Rodríguez-Sanz J, et al. Safety of dry needling of the pronator teres muscle in cadavers: A potential treatment for pronator syndrome. *Pain* Medicine (Malden, Mass.) 2022;23(6):1158-61. https://doi.org/10.1093/pm/pnab274
14. Moura FSE, Agarwal A. A rare and severe case of pronator teres syndrome. *J Surg Case Rep* 2020;2020(10):397. https://doi.org/10.1093/jscr/rjaa397
15. Toyat S, Chong W, Kandiah S, Lakshen P, Zulkifli E, Kamil M, et al. A rare case of pronator teres syndrome & accompanying anterior interosseous nerve syndrome. *Malaysian Orthop J* 2018;12. https://doi.org/10.1093/jscr/rjaa397
16. Créteur V, Madani A, Sattari A, Bianchi S. Sonography of the pronator teres: Normal and pathologic appearances. *J Ultrasound Med* 2017;36(12):2585-97. https://doi.org/10.1002/jum.14306

Anterior Tibial Tuberosity Refracture in an Adolescent After Surgical Treatment. Case Report and Literature Review

Cristina Jiménez Nava, Araceli Mena Roson, Miguel Ángel Plasencia Arriba
Department of Traumatology and Orthopedic Surgery. Hospital Universitario Príncipe de Asturias, Alcalá de Henares, Madrid, Spain.

ABSTRACT
Refracture of the anterior tibial tuberosity in adolescents is a rare complication, particularly following surgical treatment, and has been scarcely reported in the literature. We present the case of an adolescent who sustained an anterior tibial tuberosity fracture, underwent surgical treatment at our center, and experienced a refracture four months later while playing sports. The patient underwent a second surgical procedure, which yielded favorable results. Although refracture is an uncommon complication, it is essential to recognize its possibility and to be prepared to manage it effectively. Further studies are required to identify the risk factors that may contribute to its occurrence.
Keywords: Refracture; anterior tibial tuberosity; surgery; adolescent.
Level of Evidence: IV

Refractura de la tuberosidad tibial anterior en un adolescente luego del tratamiento quirúrgico. Presentación de un caso y revisión bibliográfica

RESUMEN
La refractura de la tuberosidad tibial anterior en adolescentes es una complicación infrecuente y poco descrita en la bibliografía, más aún tras un tratamiento quirúrgico. Presentamos el caso de un adolescente que sufrió una fractura de la tuberosidad tibial anterior y fue operado en nuestro centro. A los 4 meses, tuvo una recidiva después de practicar deportes. Fue sometido a una nueva intervención y los resultados han sido buenos. Aunque la refractura es una complicación rara, es importante tenerla en cuenta y saber abordarla de forma adecuada. Es necesario llevar a cabo más estudios para dilucidar los factores de riesgo que puedan influir en esta complicación.
Palabras clave: Refractura; tuberosidad tibial anterior; cirugía; adolescente.
Nivel de Evidencia: IV

INTRODUCTION

Fractures of the anterior tibial tuberosity (ATT) are rare injuries, accounting for less than 1% of physeal fractures and less than 3% of pediatric fractures, although their incidence is rising.[1,2] They are ten times more frequent in males and typically occur during adolescence (ages 12–14), close to skeletal maturity.[3,4]

The most commonly used classification system is Ogden's, and treatment varies depending on the fracture pattern. Generally, Ogden types IA, IB, and IIA are managed conservatively, while the others require surgical intervention.[4,5]

Complications such as compartment syndrome have been widely reported in the literature. However, refractures, particularly following surgical treatment, are less commonly discussed.

The aim of this article is to present a case of a recurrent ATT fracture after surgical treatment and to review the relevant literature.

Received on March 25th, 2024. Accepted after evaluation on May 19th, 2024 • Dr. CRISTINA JIMÉNEZ NAVA • crisjnava@gmail.com https://orcid.org/0009-0000-3487-1689
How to cite this article: Jiménez Nava C, Mena Roson A, Plasencia Arriba MÁ. Anterior Tibial Tuberosity Refracture in an Adolescent After Surgical Treatment. Case Report and Literature Review. *Rev Asoc Argent Ortop Traumatol* 2024;89(6):637-646. https://doi.org/10.15417/issn.1852-7434.2024.89.6.1938

CLINICAL CASE

A 14-year-old male presented after sustaining a fall while playing soccer, with his knee in flexion. Clinical examination revealed joint effusion, knee flexion, and varus deformity. Radiographs demonstrated a complex Ogden type IVB ATT fracture (Figure 1).

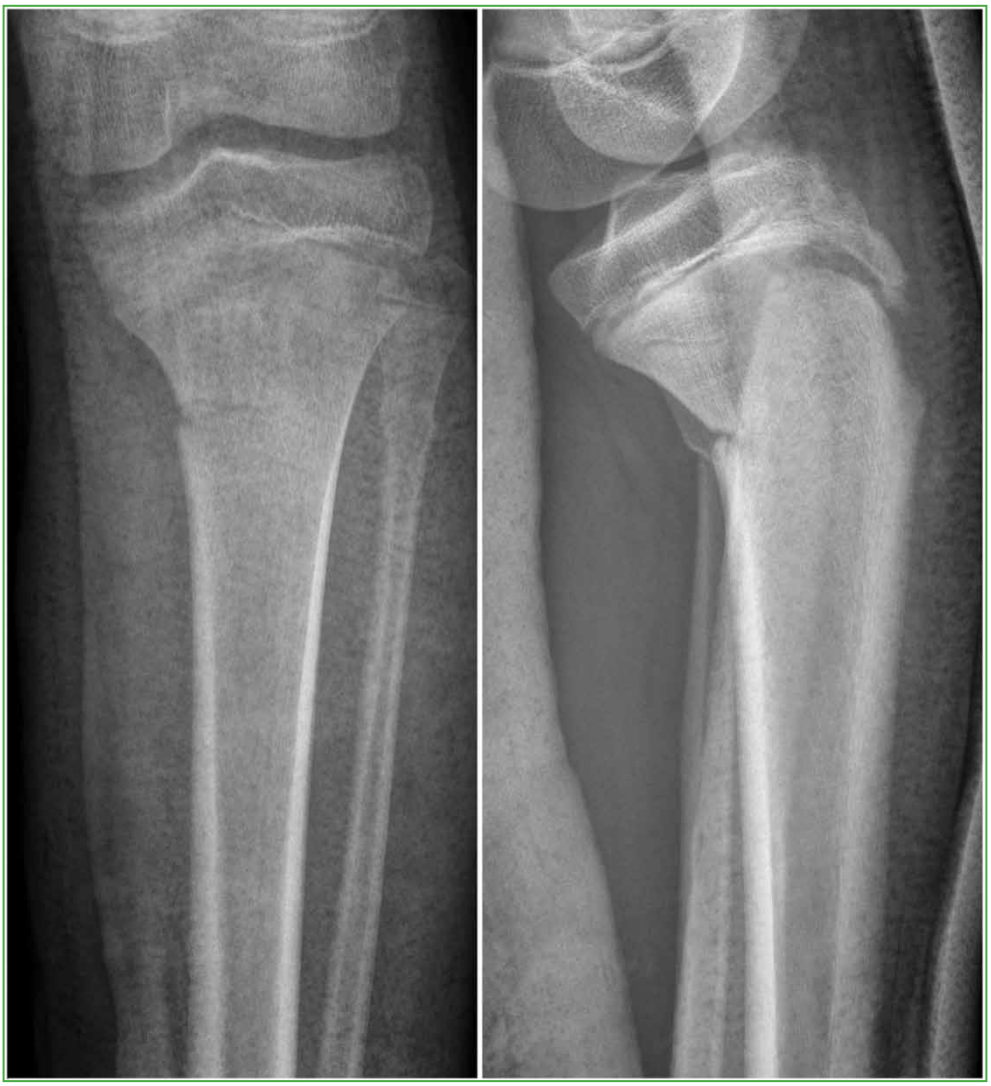


Figure 1. Anteroposterior and lateral radiographs of the proximal tibia. The initial fracture of the anterior tibial tuberosity is observed.

The patient underwent emergency surgery involving closed reduction and osteosynthesis with two 3.5 mm cannulated percutaneous partial-thread screws (Figure 2). The immediate postoperative period was uneventful. Partial weight-bearing was initiated early, and a gradual extension-flexion orthosis (0°–90°) was introduced from the third week, along with progressive quadriceps strengthening exercises under physiotherapeutic guidance. At 12 weeks, he was cleared to return to sporting activities.

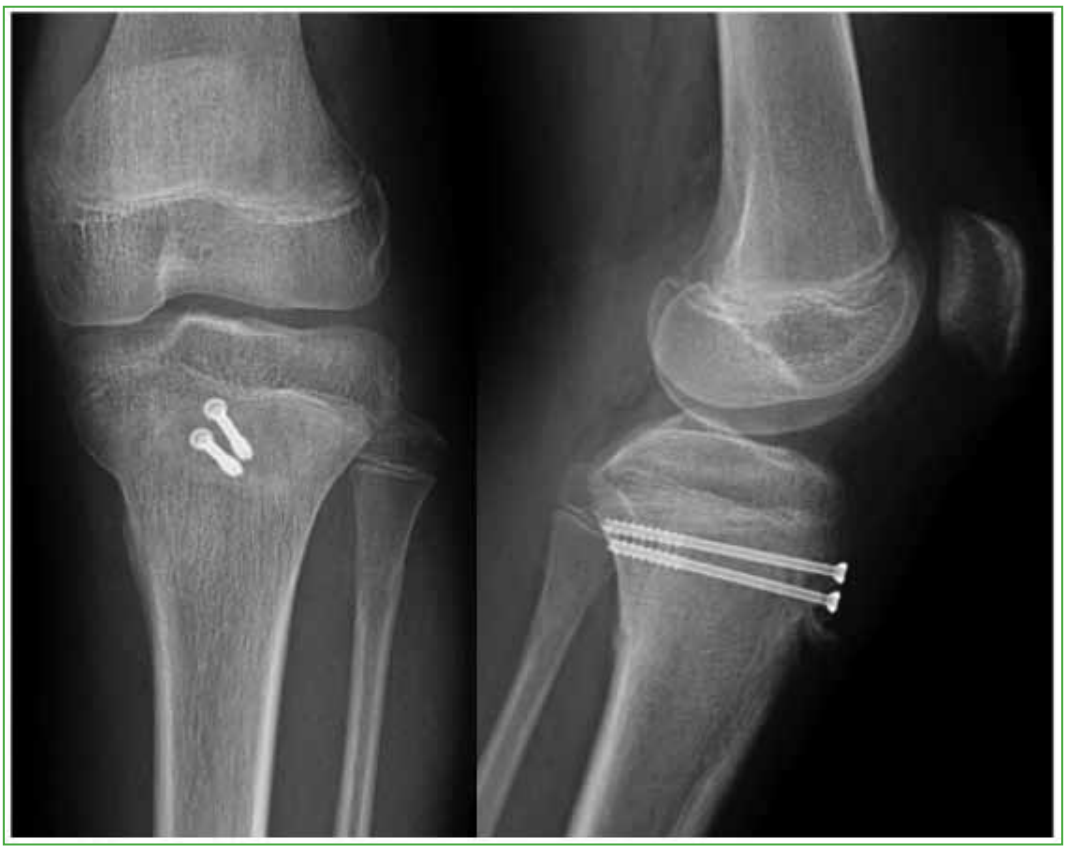


Figure 2. Anteroposterior and lateral radiographs of the knee. Postoperative control.

At four months postoperatively, the patient presented with pain and functional impairment in the left knee following hyperextension. Clinical examination revealed joint effusion, an ascending patella, and tenderness over the ATT. Radiographs showed an Ogden type IIB ATT fracture-avulsion. A CT scan ruled out intra-articular involvement and confirmed consolidation of the posterior line of the initial fracture (Figures 3 and 4).

A second surgery was performed using an anterior approach. The previous osteosynthesis material was removed, and the ATT bone fragment was osteosutured with a braided non-absorbable polyester suture (Orthocord®, Johnson & Johnson, Madrid, Spain). Two perpendicular tunnels were created in the tibia to pass the sutures. The fracture was reduced and fixed with two 4.5 mm bicortical cannulated partial-thread screws. The sutures were then tied securely. Finally, the patellar tendon was reanchored using a Krackow-type suture with No. 5 Ethibond® (Johnson & Johnson, Madrid, Spain) through two tibial tunnels, tied at 30° of knee flexion (Figures 5 and 6).

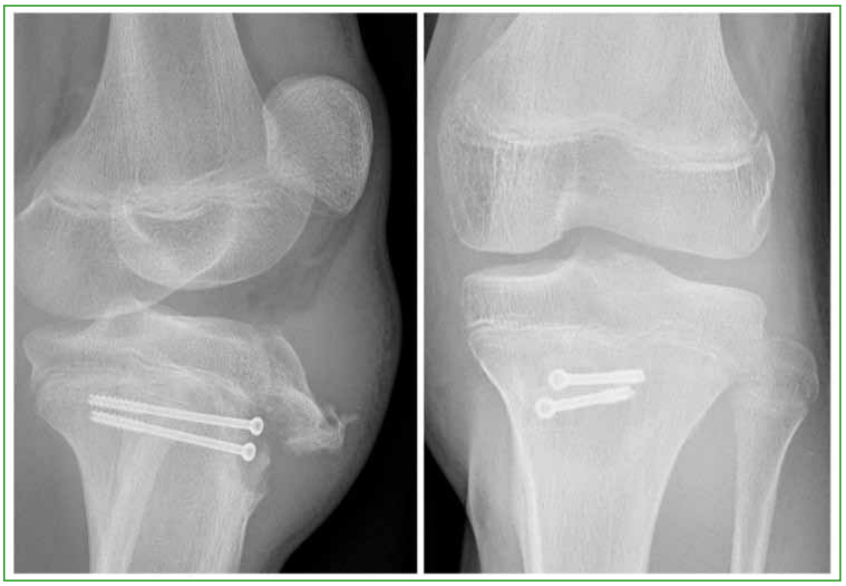


Figure 3. Anteroposterior and lateral radiographs of the knee. The refracture is observed.

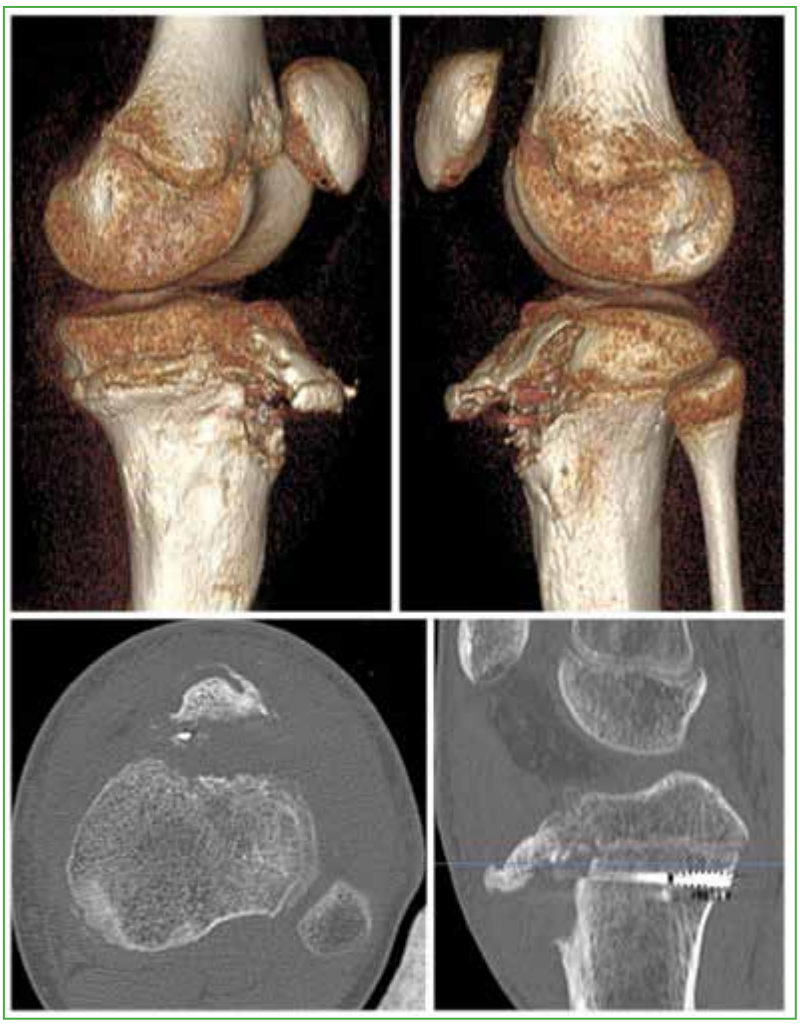


Figure 4. Computed tomography of the knee. The refracture with previous consolidated line is observed.

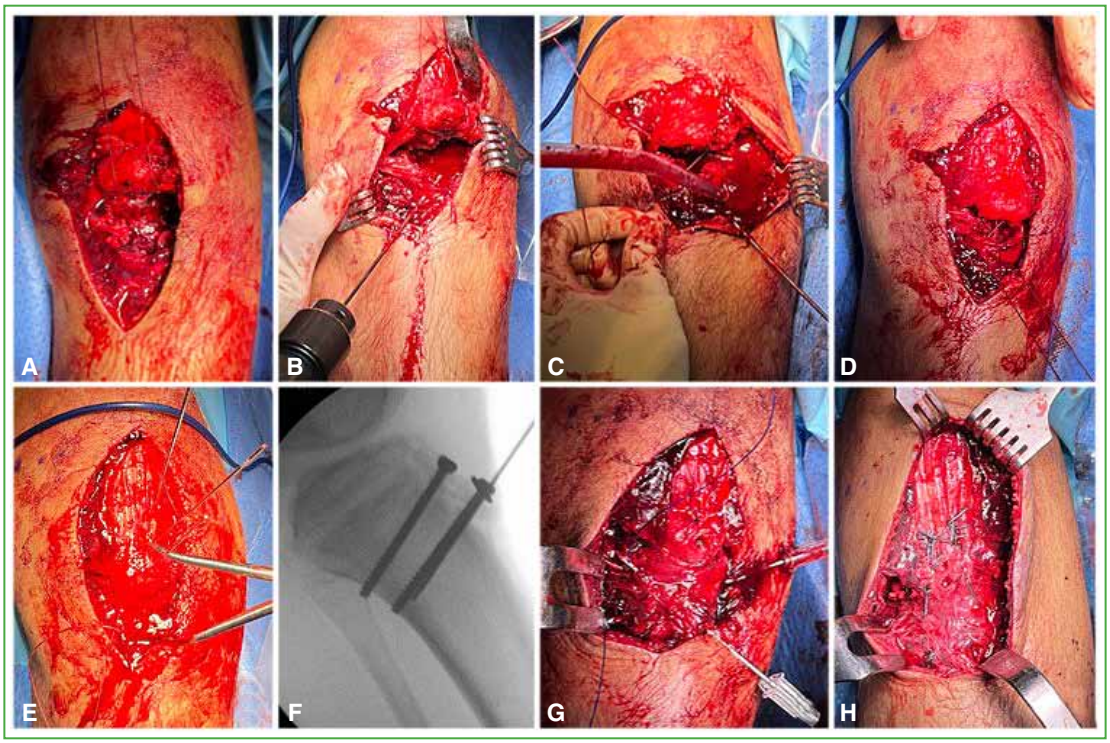


Figure 5. **A.** After removal of the osteosynthesis material, a suture with Orthocord® is passed through the bone fragment. **B and C.** Creation of two crossed tunnels with drill. **D.** Passage of the suture through the tunnels. **E.** Fracture reduction and temporary fixation with K-wires. **F.** Definitive fixation with 2 cannulated screws. **G.** Creation of two tunnels in the tibia for passage of the Ethibond® suture. **H.** Krackow type suture in the patellar tendon with 2 Ethibond® and knotting through tunnels with 30º of flexion.

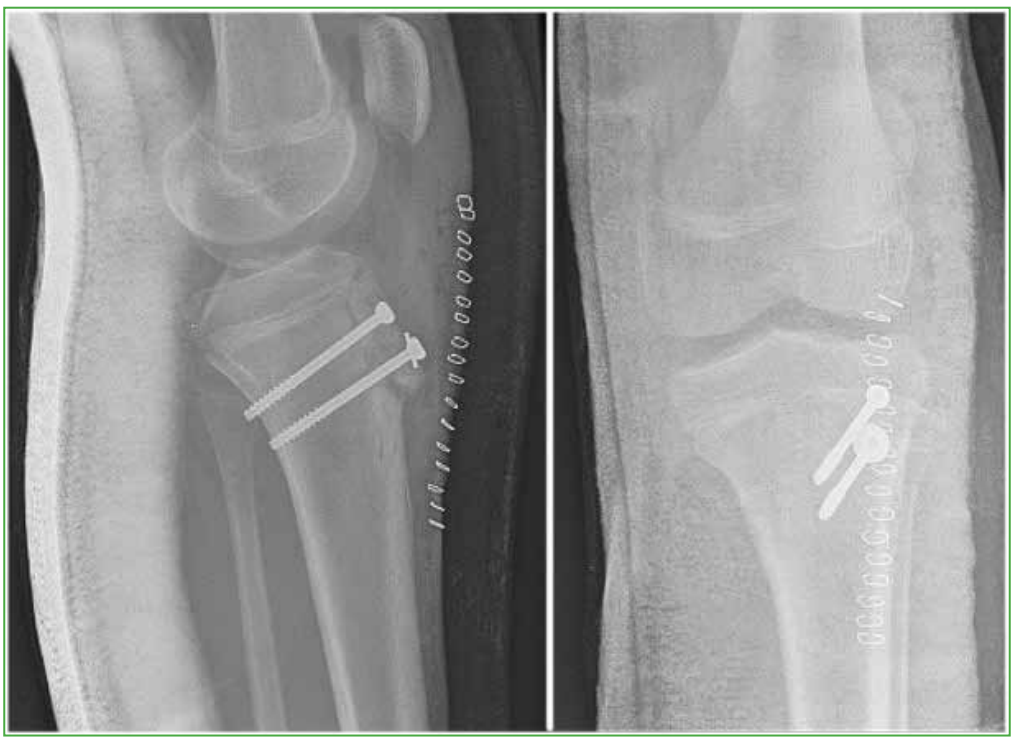


Figure 6. Anteroposterior and lateral radiographs of the knee. Control after the second operation.

The immediate postoperative period was uneventful. The knee was immobilized at 15° of flexion for three weeks, with non-weight bearing. Gradual weight-bearing and flexion using an articulated orthosis were introduced, reaching 90° over the following three weeks.

Four months postoperatively, the patient had regained full range of motion, was pain-free, and achieved full weight-bearing (Figure 7). At six months, he returned to his usual physical activities without any limitations.

Figure 7. Clinical control at 4 months.

DISCUSSION

The secondary ossification center of the proximal tibial epiphysis develops during the first days of life. The anterior tibial tuberosity (ATT) has a separate ossification center that typically appears between the ages of 7 and 12 years.[6] These ossification centers serve distinct functions: the primary center contributes to growth and shaping, while the secondary center serves as the insertion site for the patellar tendon. Fusion of these centers follows a specific sequence, with the ATT being the last to close—around 14 years of age in girls and 16 years in boys.[3]

ATT fractures most commonly occur in athletic settings, particularly during jumping. The two primary injury mechanisms are quadriceps contraction with the knee extended (at the jump's apex) or rapid passive flexion with the quadriceps contracted (upon landing).[5] The proximal tibial physis fuses from posterior to anterior, and the fracture pattern depends on the degree of skeletal maturity and knee flexion at the time of trauma. Generally, ATT fractures involving the proximal epiphysis occur at more than 30º of knee flexion (Figures 8 and 9).[7,8]

Although rare, ATT fractures are becoming increasingly frequent. They are particularly notable in fractures with posterior physeal or metaphyseal involvement. Types IV and V fractures were not described until 1985 by Ryu and Debenham and in 2003 by McKoy and Stanitski, respectively.[9] Previously, these injuries were classified as proximal tibial fractures using the Salter-Harris classification.[10]

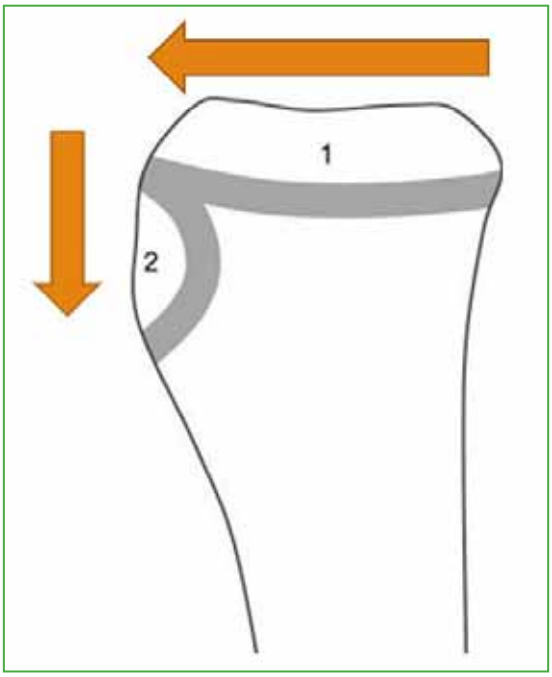


Figure 8. Direction of physeal closure.

Figure 9. Mechanisms of injury.

The first classification system for ATT fractures was proposed by Watson-Jones in 1976.[11] However, the most widely used system is the one published by Ogden in 1980,[12] with subsequent additions by Ryu and Debenham (type IV) and McKoy and Stanitski (type V) (Figure 10).[9,13] .

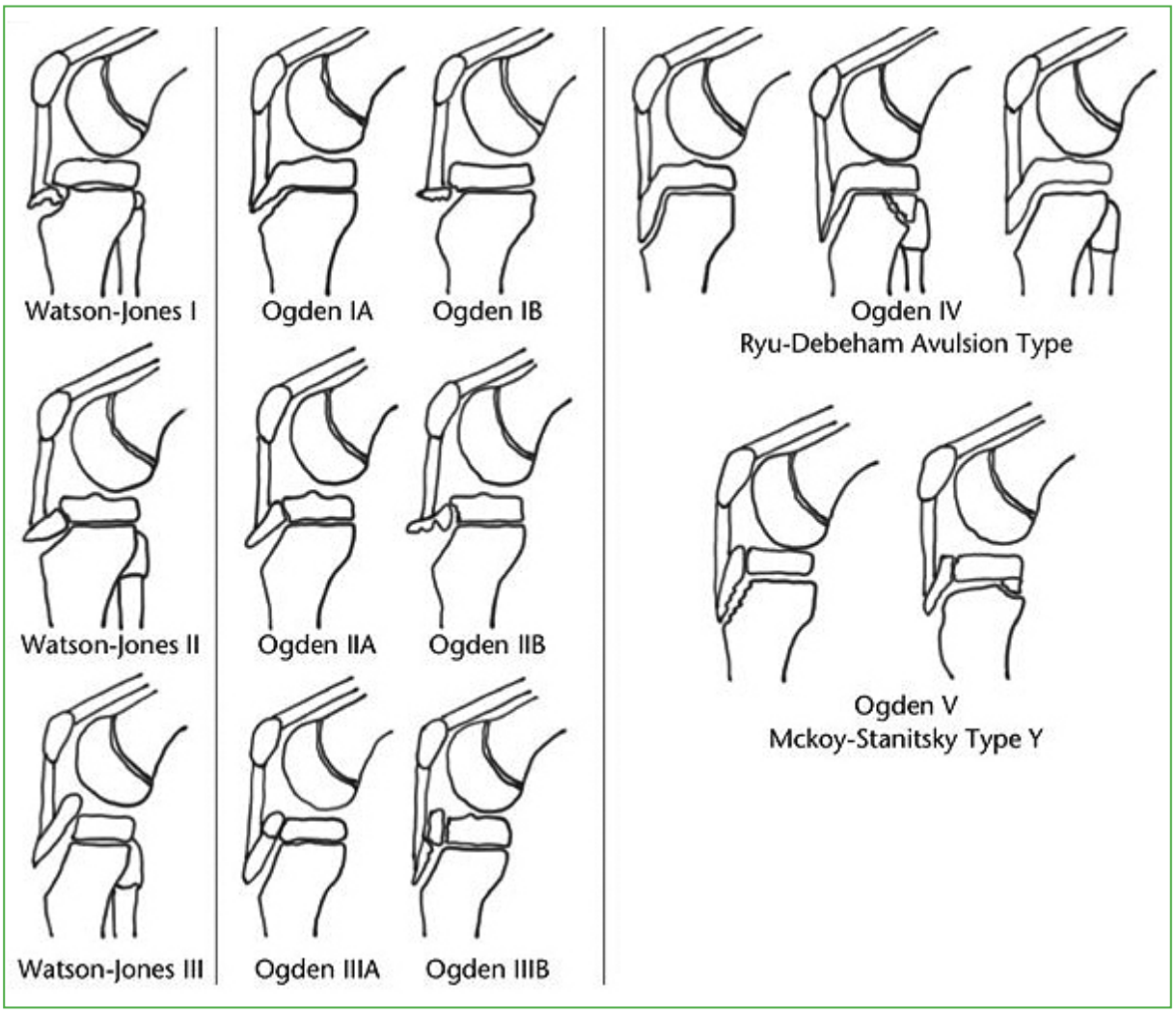


Figure 10. Classifications of anterior tibial tuberosity fractures. Image taken from Rodriguez I, Sepúlveda M, Birrer E, Tuca MJ. Fracture of the anterior tibial tuberosity in children. *EFORT Open Rev* 2020;5(5):260-7. https://doi.org/10.1302/2058-5241.5.190026

Numerous associated injuries have been reported, including anterior cruciate ligament (ACL) involvement, quadriceps and patellar tendon avulsions (2%), and meniscal injuries (2%).[2,10,14,15] The most critical associated injury is compartment syndrome, due to the proximity of the anterior tibial recurrent artery. Its reported incidence ranges from 4% (Pretell-Mazzini et al.[16]) to 20% (Frey et al. and Polakoff et al.).[15] .

For diagnosis, routine anteroposterior and lateral radiographs are essential. If intra-articular fractures or recurrences are suspected, as in our patient, a CT scan is recommended. MRI is indicated when ligament or meniscal injuries are suspected.

The therapeutic goal is to restore the knee's extensor mechanism and articular surface while repairing any intra-articular structures. Conservative treatment is typically reserved for Ogden type I or II fractures with <2 mm displacement or for skeletally immature patients.[9,17]

Various surgical techniques have been described, but none has been proven superior. The most common approach is open or closed reduction with fixation using partial-thread screws (average diameter: 4–4.5 mm) to achieve compression. Arthroscopy can assist in reducing joint fragments, avoiding arthrotomy. Extensive periosteal involvement requires repair to enhance stability. Reattachment of the patellar tendon is necessary in cases of concomitant involvement. Other options include needle fixation (suitable for younger patients to reduce the risk of physeal injury),[2] tension bands, or combinations thereof. Plate osteosynthesis is primarily used for Ogden type IV fractures.[4]

Osteosynthesis material often needs removal due to discomfort caused by screw head irritation. Removal is recommended after physeal closure.[16,18]

The overall complication rate for ATT fractures is approximately 28%, with up to 56% of cases involving anterior pain or implant bursitis. The second most common complication is refracture (5%), mainly in Ogden types III, IV, and V fractures. Less frequent complications include infection, recurvatum deformity, and pseudoarthrosis (<1%).[3]

Refracture of an ATT initially treated with surgery is a rare complication and is scarcely addressed in the literature. This complication poses challenges in reconstructing the knee's extensor mechanism.[19] Stable fixation is crucial for restoring normal activities while respecting the physis to prevent complications like premature physeal closure. [18]

Several authors have described an association between a higher rate of complications and posterior metaphyseal involvement, including compartment syndrome and refracture.[3,10,20] In the study by Brey et al., a statistically significant association between posterior metaphyseal involvement and refracture was demonstrated. However, the initial treatment in that study was conservative, making the results not directly comparable to cases treated surgically.[10]

In 2018, Valenzuela et al. published a case of refracture following surgery, although with different characteristics from our case. In their report, the refracture occurred in the context of a complicated postoperative course, which resulted in tendon retraction and chronic ATT avulsion.[19] By contrast, in our patient, the refracture occurred after an initially satisfactory postoperative recovery.

According to the literature, the average recommended period before resuming sports activities is at least 3 months.[3] Therefore, it would not be reasonable to attribute the failure of osteosynthesis in our patient to premature return to sports or poor compliance. Alternatively, one could speculate that osteosynthesis using two 3.5 mm screws may have provided insufficient stability. However, there are currently no robust studies to support this hypothesis. Thus, further research is needed to identify potential causes of osteosynthesis failure in these cases.

CONCLUSIONS

ATT refracture is a rare complication in the evolution of this condition but should be carefully considered in these patients. It is essential to perform definitive surgical treatment that allows the patient to resume physical activity safely, incorporating measures to increase stability and relieve tension on the patellar tendon when necessary.

Additional studies are warranted, as many variables remain undefined. Identifying the risk factors associated with such complications will be critical to improving outcomes and guiding clinical decision-making.

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

A. Mena Roson ORCID ID: https://orcid.org/0000-0002-8128-2649
M. Á. Plasencia Arriba ORCID ID: https://orcid.org/0009-0004-3226-7428

REFERENCES

1. Koivisto ST, Laaksonen T, Ahola JA, Helenius I, Stenroos A. Epidemiology and management of proximal tibia fractures in children and adolescents: a population-based study based on the Kids' Fracture Tool. *Acta Orthop* 2022;93:826-30. https://doi.org/10.2340/17453674.2022.4879
2. Formiconi F, D'Amato RD, Voto A, Panuccio E, Memeo A. Outcomes of surgical treatment of the tibial tuberosity fractures in skeletally immature patients: an update. *Eur J Orthop Surg Traumatol* 2020;30(5):789-98. https://doi.org/10.1007/s00590-020-02629-y
3. Rodriguez I, Sepúlveda M, Birrer E, Tuca MJ. Fracture of the anterior tibial tuberosity in children. *EFORT Open Rev* 2020;5(5):260-7. https://doi.org/10.1302/2058-5241.5.190026
4. Pedrazzini A, Maserati I, Cesaro G, Visigalli A, Casalini D, Bertoni N, et al. Tibial tubercle avulsion fracture during sport activities in adolescent: a case report. *Acta Biomed* 2022;92(S3):e2021571. https://doi.org/10.23750/abm.v92iS3.12580
5. Ares O, Seijas R, Casas-Duhrkop, Catala J. Fractura de la tuberosidad anterior de la tibia en el adolescente. *Acta Ortop Mex* 2012;26(2):121-4. PMID: 23323303
6. Beaty JH, Kumar A. Fractures about the knee in children. *J Bone Joint Surg Am* 1994;76:1870-80. https://doi.org/10.2106/00004623-199412000-00016
7. Jakoi A, Freidl M, Old A, Javandel M, Tom J, Realyvasquez J. Tibial tubercle avulsion fractures in adolescent basketball players. *Orthopedics* 2012;35(8):692-6. https://doi.org/10.3928/01477447-20120725-07
8. Borch-Madsen P. On symmetrical bilateral fracture of the tuberositas tibiae and eminentia intercondyloidea. *Acta Orthop Scand* 1954;24(1-4):44-9. https://doi.org/10.3109/17453675408988551
9. McKoy BE, Stanitski CL. Acute tibial tubercle avulsion fractures. *Orthop Clin North Am* 2003;34(3):397-403. https://doi.org/10.1016/s0030-5898(02)00061-5
10. Brey JM, Conoley J, Canale ST, Beaty JH, Warner WC Jr, Kelly DM, et al. Tibial tuberosity fractures in adolescents: is a posterior metaphyseal fracture component a predictor of complications? *J Pediatr Orthop* 2012;32(6):561-6. https://doi.org/10.1097/BPO.0b013e318263a370
11. Mostofi SB. *Fracture classifications in clinical practice*. London: Springer-Verlag London; 2006.
12. Ogden JA, Tross RB, Murphy MJ. Fractures of the tibial tuberosity in adolescents. *J Bone Joint Surg Am* 1980;62(2):205-15. PMID: 7358751
13. Ryu RK, Debenham JO. An unusual avulsion fracture of the proximal tibial epiphysis. Case report and proposed addition to the Watson-Jones classification. *Clin Orthop Relat Res* 1985;(194):181-4. PMID: 3978913
14. Frey S, Hosalkar H, Cameron DB, Heath A, David Horn B, Ganley TJ. Tibial tuberosity fractures in adolescents. *J Child Orthop* 2008;2(6):469-74. https://doi.org/10.1007/s11832-008-0131-z
15. Polakoff DR, Bucholz RW, Ogden JA. Tension band wiring of displaced tibial tuberosity fractures in adolescents. *Clin Orthop Relat Res* 1986;209(209):161-5. PMID: 3731588
16. Pretell-Mazzini J, Kelly DM, Sawyer JR, Esteban EMA, Spence DD, Warner WC, et al. Outcomes and complications of tibial tubercle fractures in pediatric patients: A systematic review of the literature: A systematic review of the literature. *J Pediatr Orthop* 2016;36(5):440-6. https://doi.org/10.1097/BPO.0000000000000488
17. Abalo A, Akakpo-numado KG, Dossim A, Walla A, Gnassingbe K, Tekou AH. Avulsion fractures of the tibial tubercle. *J Orthop Surg (Hong Kong)* 2008;16(3):308-11. https://doi.org/10.1177/230949900801600308
18. Little RM, Milewski MD. Physeal fractures about the knee. *Curr Rev Musculoskelet Med* 2016;9(4):478-86. https://doi.org/10.1007/s12178-016-9370-7
19. Valenzuela ML, López Soto V, Molina IL. Cirugía de rescate en casos de desplazamiento secundario crónico de la tuberosidad tibial anterior en la adolescencia: a propósito de un caso. *Rev Soc Andal Traumatol Ortop* 2018;35(1):49-53. Available at: http://www.revista.portalsato.es/index.php/Revista_SATO/article/view/61/pdf
20. Andrews KA, Gillette M, Shah RV, Mckean LA, Sanford CG. Type IV tibial tubercle fracture-Salter-Harris type II variant. *J Surg Case Rep* 2019;2019(7):rjz209. https://doi.org/10.1093/jscr/rjz209

Focal Periphyseal Edema (FOPE) in an Adolescent Female: A Case Report

Carlos Navarro,[*] Santiago Sarzosa,[**] Juan David Paternina Carballo[**]
[*]*Knee Reconstruction and Traumatology Service, Ortovital Centro de Ortopedia y Rehabilitación, Barranquilla, Colombia.*
[**]*Department of Orthopedics and Traumatology, Universidad Libre - Barranquilla, Barranquilla, Colombia.*

ABSTRACT
Focal periphyseal edema (FOPE) zones are unusual imaging findings first described in 2011 by Zbojniewicz and Laor. They appear as areas of bone marrow edema centered on the physis of the knee in adolescents nearing skeletal maturity. This condition is clinically significant because knee pain is a frequent reason for consultation in adolescent patients. In many cases, physical examination and radiographs do not provide sufficient findings for a definitive diagnosis, leading to symptom-based treatment without a clear etiology. We report the case of a 13-year-old adolescent presenting with unilateral anterior knee pain without a history of trauma or underlying pathology. The patient had been previously evaluated multiple times without a conclusive diagnosis. Magnetic resonance imaging (MRI) revealed specific findings consistent with a FOPE lesion or zone. Symptomatic treatment was subsequently offered.
Keywords: Knee; growth plate; adolescent; edema; magnetic resonance imaging.
Level of Evidence: IV

Edema perifisario focal en una adolescente: reporte de un caso

RESUMEN
Las lesiones FOPE (*focal periphyseal edema*) son hallazgos infrecuentes, descritas, por primera vez, en 2011, por Zbojniewicz y Laor, como áreas de edema en la médula ósea centradas en la fisis de las rodillas de adolescentes que están cerca de la madurez esquelética. Esto es relevante, ya que el dolor de rodilla es un motivo común de consulta de los adolescentes y, en muchos de estos casos, el examen físico y las radiografías no revelan los hallazgos suficientes para dar un diagnóstico específico, y se opta por indicar un tratamiento para resolver los síntomas, sin una etiología clara. Se presenta el caso de una adolescente de 13 años con dolor anterior de rodilla unilateral, sin antecedente de trauma o enfermedades de base, que había sido evaluada en otras oportunidades, sin que se llegara a un diagnóstico. Una resonancia magnética muestra hallazgos específicos y se diagnostica lesión o zona FOPE. Se administra un tratamiento sintomático.
Palabras clave: Rodilla; placa de crecimiento; adolescente; edema; resonancia magnética.
Nivel de Evidencia: IV

INTRODUCTION

Knee pain is a common reason for consultation in adolescents. In many cases, physical examination and radiographs do not provide sufficient findings to establish a specific diagnosis. Consequently, treatment is often aimed at symptom resolution despite the absence of a clear etiology. In this age group, it is important to consider physeal abnormalities—whether traumatic or atraumatic—and, particularly, the condition described by Zbojniewicz and Laor as focal periphyseal edema (FOPE), albeit a rare finding.[1]

This report presents the case of an adolescent girl with anterior knee pain, ultimately diagnosed with a FOPE lesion based on imaging studies.

Received on March 15th, 2024. Accepted after evaluation on May 25th, 2024 • Dr. JUAN DAVID PATERNINA CARBALLO • juandpc-93@hotmail.com https://orcid.org/0000-0001-5743-545X
How to cite this article: Navarro C, Sarzosa S, Paternina Carballo JD. Focal Periphyseal Edema (FOPE) in an Adolescent Female: A Case Report. *Rev Asoc Argent Ortop Traumatol* 2024;89(6):647-650. https://doi.org/10.15417/issn.1852-7434.2024.89.6.1937

CLINICAL CASE

A 13-year-old adolescent with no relevant medical history presented to the Orthopedic Surgery Service with complaints of left knee pain. According to her mother, the patient had experienced spontaneous pain in her left knee for the past year without any history of trauma. She had visited the emergency department twice for the pain, where she was prescribed analgesics and advised to rest.

Physical examination revealed mild edema of the left knee, without joint effusion or skin changes. The arc of motion was 0° to 120° of flexion-extension, limited by pain. Tenderness was focalized in the distal third of the left thigh, corresponding to the area of the distal femoral metaphysis. There was no evidence of ligamentous instability, meniscal signs, or palpable masses. Peripheral pulses were intact, and no neurological deficits were observed in the lower limbs.

Magnetic resonance imaging (MRI) of the left knee revealed peripheral edema in the distal femur and proximal tibia, with no other abnormalities of clinical significance.

Based on these findings, two potential diagnoses were proposed: FOPE lesion or inflammatory monoarthritis of rheumatic origin. Management included the use of crutches, physical therapy, analgesics, and referral to the Rheumatology Service for further evaluation.

Three months later, the patient returned for follow-up after consultation with the Rheumatology Service, which did not yield a definitive diagnosis. She continued to report severe knee pain and had undergone a privately obtained MRI. This new MRI clearly identified a FOPE lesion in the distal femur, with no additional pathological findings (Figure). Based on this, a diagnosis of FOPE lesion involving the proximal tibia and distal femur of the left knee was confirmed. The patient and her mother were informed about the low prevalence of this condition. Management was focused on physical therapy and analgesics to alleviate symptoms.

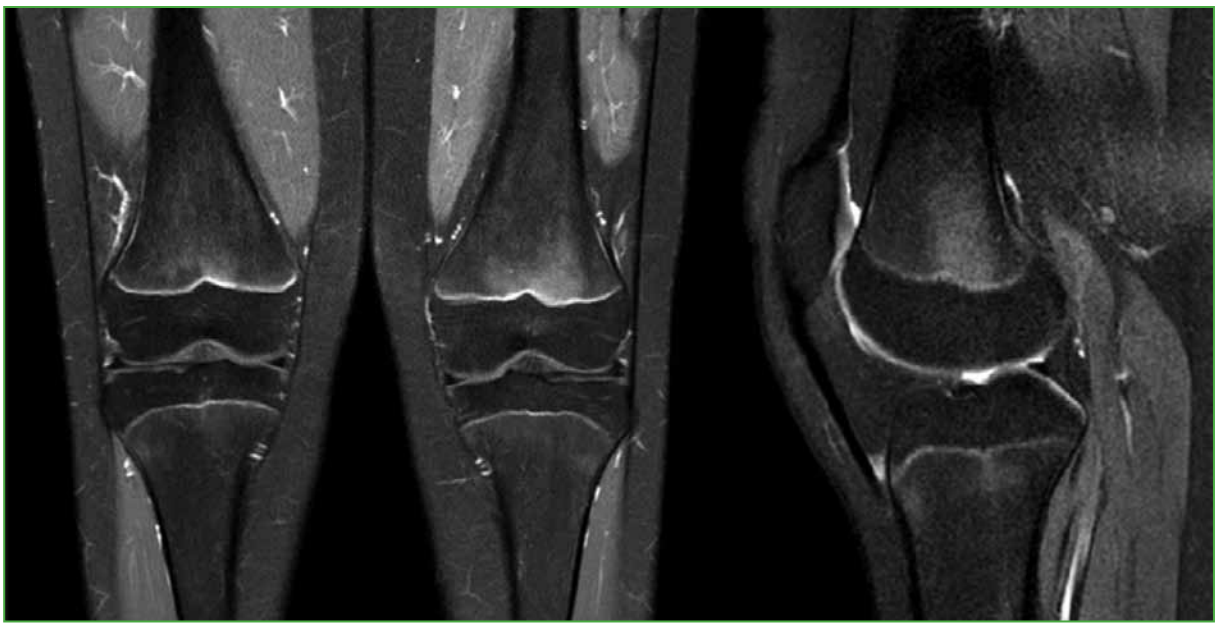


Figure. MRI of the knee. Central and symmetric bone marrow edema in the bilateral distal femoral metaphysis, intensified in the left knee.

DISCUSSION

FOPE lesions were first described in 2011 by Zbojniewicz and Laor, who identified areas of bone marrow edema centered in the physis of the knees in adolescents nearing skeletal maturity, particularly between the ages of 12 and 16—the age range to which our patient belongs.[1] These areas have been associated with painful symptoms in young patients but are also linked to the normal process of physeal closure in adolescents, suggesting that they may represent a physiological rather than pathological phenomenon. [2,3]

While there is no specific pathophysiological mechanism connecting FOPE lesions to the female sex, it is notable that many reported cases involve female patients.[4,5] FOPE lesions most commonly occur around the knee (distal femur, proximal tibia, proximal fibula), though they have also been described in other locations, such as the greater trochanter.[6,7]

The edema observed in the central region of the physis may result from increased stress on the bone tissue due to reduced elasticity in this area, compounded by microtrauma. The isolated descriptive findings of FOPE lesions on MRI, along with episodes of pain, support this as a plausible explanation for the associated symptoms. [8]

Plain radiographs are generally not helpful for confirming the diagnosis, as they are often normal or fail to reveal alterations that correlate with the clinical presentation. MRI, on the other hand, is more valuable due to its detailed findings. FOPE lesions exhibit the following MRI characteristics:[4]

- Areas of edema in the metaphyseal and epiphyseal regions of the physis
- Symmetric edema
- Hypointensity on T1-weighted sequences and hyperintensity on T2-weighted sequences
- Variable extension
- Location in the central portion of the physis or slightly eccentric
- A slightly open, narrow physis in the area of edema

These imaging features are particularly useful for differentiating FOPE lesions from other conditions, such as osteomyelitis, tumors, or traumatic injuries, which typically present with more asymmetrical imaging findings and are less likely to span the physis.[9]

In some adolescents, the degree of edema may be insufficient to cause noticeable symptoms. Consequently, many FOPE lesions may go undiagnosed if they do not result in pain or limitations in physical or athletic activities. [3]

FOPE lesions are self-limiting, and once diagnosed, follow-up imaging or further studies are generally unnecessary. Most cases resolve spontaneously with physeal closure, though residual knee pain can persist for up to three years in some patients. [4]

Treatment primarily involves rest and limiting physical activity for approximately four weeks, as was recommended for this patient. Physical activities can be gradually resumed as symptoms decrease in intensity.[2]

CONCLUSIONS

FOPE lesions, or FOPE zones, represent a physiological event occurring in the physis of patients nearing skeletal maturity. Although poorly described in the literature, they should be considered a potential cause of anterior knee pain in adolescents.

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

C. Navarro ORCID ID: https://orcid.org/0009-0000-4360-7919
S. Sarzosa ORCID ID: https://orcid.org/0009-0001-9325-1647

REFERENCES

1. Zbojniewicz A, Laor T. Focal periphyseal edema (FOPE) zone on MRI of the adolescent knee: A potentially painful manifestation of physiologic physeal fusion? *AJR Am J Roentgenol* 2011;197(4):998-1004. https://doi.org/10.2214/AJR.10.6243
2. Ueyamaa H, Kitanob T, Nakagawab K, Aonoa M. Clinical experiences of focal periphyseal edema zones in adolescent knees: case reports. *J Pediatr Orthop B* 2018;27(1):26-30. https://doi.org/10.1097/BPB.0000000000000388

3. Giles E, Nicholson A, Sharkey M, Carter C. Focal periphyseal edema: Are we overtreating physiologic adolescent knee pain? *J Am Acad Orthop Surg Glob Res Rev* 2018;2(4):e047. https://doi.org/10.5435/JAAOSGlobal-D-17-00047
4. Speirs J, Shields T, Morrison III M. Focal periphyseal edema: An uncommon cause of adolescent knee pain. A report of three cases. *JBJS Case Connect* 2019;9(3):e0391. https://doi.org/10.2106/JBJS.CC.18.00391
5. Bochmann T, Forrester R, Smith J. Case report: imaging the clinical course of FOPE—a cause of adolescent knee pain. *J Surg Case Rep* 2016;11:1-2. https://doi.org/10.1093/jscr/rjw178
6. Sakamoto A, Matsuda S. Focal periphyseal edema zone on magnetic resonance imaging in the greater trochanter apophysis: A case report. *J Orthop Case Rep* 2017;7(4):29-31. https://doi.org/10.13107/jocr.2250-0685.836
7. Sanghvi D. Periphyseal edema: always pathology or sometimes physiology? *Jpn J Radiol* 2020;38(10):1004-1005. https://doi.org/10.1007/s11604-020-00992-8
8. Beckmann N, Spence S. Unusual presentations of focal periphyseal edema zones: Report of bilateral symmetric presentation and partial physeal closure. *Case Rep Radiol* 2015;2015:465018. https://doi.org/10.1155/2015/465018
9. Staheli LT. Features of the immature skeleton. In: Staheli LT (ed.). *Fundamentals of pediatric orthopedics*. Philadelphia, PA: Lippincott, Williams & Wilkins; 2008, p. 18-23.

Cervical Osteochondroma and Myelopathy in Children: A Case Report and Literature Review

Santiago Aguer, Javier Dal Lago, Matías L. Cullari, Facundo Aguirre, Eduardo Levy, Ruy Lloyd
Spinal Pathology Department, Hospital Británico de Buenos Aires, Autonomous City of Buenos Aires, Argentina.

ABSTRACT
Osteochondroma is the most common benign skeletal tumor, with the cervical spine being the most frequent site for spinal osteochondromas. Spinal exostoses typically arise from the lamina of cervical vertebrae. Although rare, cervical myelopathy can occur and may lead to significant neurological consequences. Surgical intervention is often considered for asymptomatic lesions to prevent potential neurological deterioration. We report the case of an 11-year-old patient with an incidentally discovered cervical osteochondroma originating from the left lamina of C4, causing spinal cord compression. Magnetic resonance imaging (MRI) of the cervical spine revealed a lesion protruding into the canal, leading to a reduction in canal diameter. The patient underwent surgical resection of the C4 posterior arch with decompression, performed without fusion. At two years post-surgery, no local recurrence or neurological symptoms were observed.
Keywords: Osteochondroma; spine; hereditary multiple exostoses; myelopathy; children.
Level of Evidence: IV

Osteocondroma cervical y mielopatía en niños: reporte de un caso y revisión de la bibliografía

RESUMEN
El osteocondroma es el tumor benigno más común del esqueleto. La columna cervical es la ubicación más frecuente para el osteocondroma espinal. Las exostosis espinales surgen, con más frecuencia, de las vértebras cervicales, aparecen típicamente en la lámina. Aunque la mielopatía cervical es un cuadro raro, puede tener serias consecuencias neurológicas. Si se descubren lesiones asintomáticas, se puede considerar la intervención quirúrgica para prevenir el deterioro neurológico. Se detectó incidentalmente un osteocondroma cervical en una paciente de 11 años. Este se originaba en la lámina de C4 y comprimía la médula espinal. La resonancia magnética de columna cervical mostró el osteocondroma en la lámina izquierda de C4 que sobresalía en el canal, lo que reducía su diámetro. La paciente fue sometida a una resección del arco posterior de C4 y a descompresión sin fusión. A los 2 años de la cirugía, no había evidencia de recurrencia local ni síntomas neurológicos.
Palabras clave: Osteocondroma; columna vertebral; exostosis múltiple hereditaria; mielopatía: niños.
Nivel de Evidencia: IV

INTRODUCTION

Osteochondroma is the most common benign tumor of the skeletal system. It can occur as a solitary lesion or as part of an autosomal dominant hereditary syndrome known as hereditary multiple exostoses (HME). This condition primarily affects the growth plate, typically presenting during adolescence, and its progression halts upon reaching skeletal maturity. Generally, osteochondromas are asymptomatic and rarely undergo malignant transformation. They predominantly occur in the metaphyses of long bones, with spinal involvement being uncommon (1–4%). However, in cases of HME, spinal involvement increases to approximately 7–9%.[1] Among spinal osteochondromas, the cervical spine is most frequently affected, comprising 50–58% of cases, with 64% involving the posterior elements of the spine. Although rare, 0.5–1% of patients may experience progressive

Received on June 4th, 2024. Accepted after evaluation on July 27th, 2024 • Dr. MATÍAS L. CULLARI • matiaslcullari@gmail.com https://orcid.org/0000-0002-6058-6686
How to cite this article: Aguer S, Dal Lago J, Cullari ML, Aguirre F, Levy E, Lloyd R. Cervical Osteochondroma and Myelopathy in Children: A Case Report and Literature Review. *Rev Asoc Asoc Argent Ortop Traumatol* 2024;89(6):651-656. https://doi.org/10.15417/issn.1852-7434.2024.89.6.1979

symptoms of myelopathy or radiculopathy, which, if left undiagnosed and untreated, can lead to severe complications.[2]

This report presents the case of an 11-year-old female patient with HME and cervical osteochondroma, who underwent surgery due to spinal cord compression. A literature review on this topic is also provided.

CLINICAL CASE

An 11-year-old girl diagnosed with HME had been under care at the Children's Orthopedic Service since 2010, presenting with multiple lesions on both arms and legs (Figure 1).

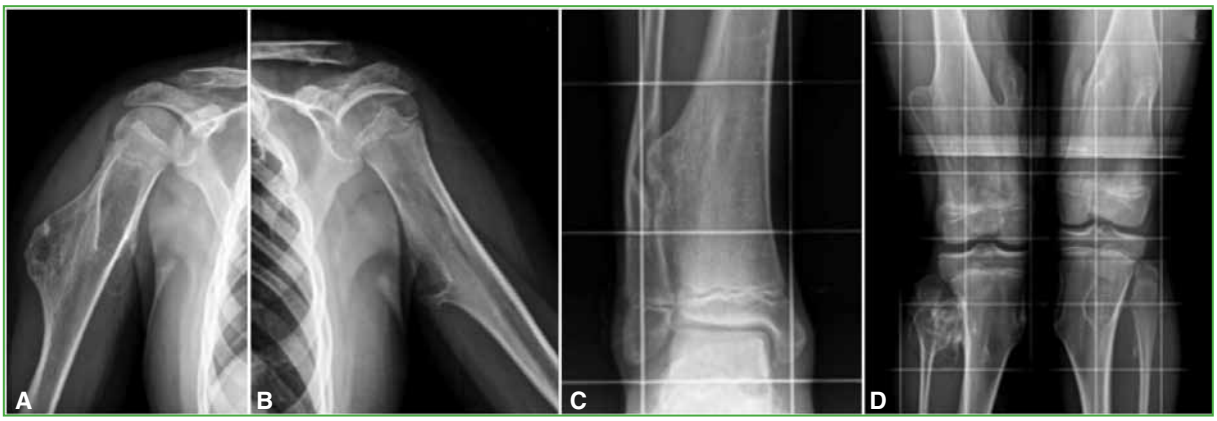


Figure 1. Radiographs of both shoulders, AP view (**A and B**), right ankle, AP view (**C**) and both knees, AP view (**D**). Multiple osteochondromatous lesions.

In May 2020, she was referred to the Spine Pathology Service after an incidental finding of a cervical osteochondroma on a routine computed tomography (CT) scan. At the time, the patient had no cervical symptoms, and neurological examination revealed normal findings, including present reflexes and negative Hoffman, Clonus, and Babinski signs. CT imaging showed an osteochondroma in the left lamina of C4, extending into the spinal canal (Figure 2). Additionally, a pedunculated osteochondroma in the posterior wall of T1 and an osteochondroma in the spinous process of C2 were identified, both extending into the spinal canal. Magnetic resonance imaging (MRI) confirmed that the C4 lesion reduced canal diameter and demonstrated a hyperintense signal on T2 sequences (Figure 3).

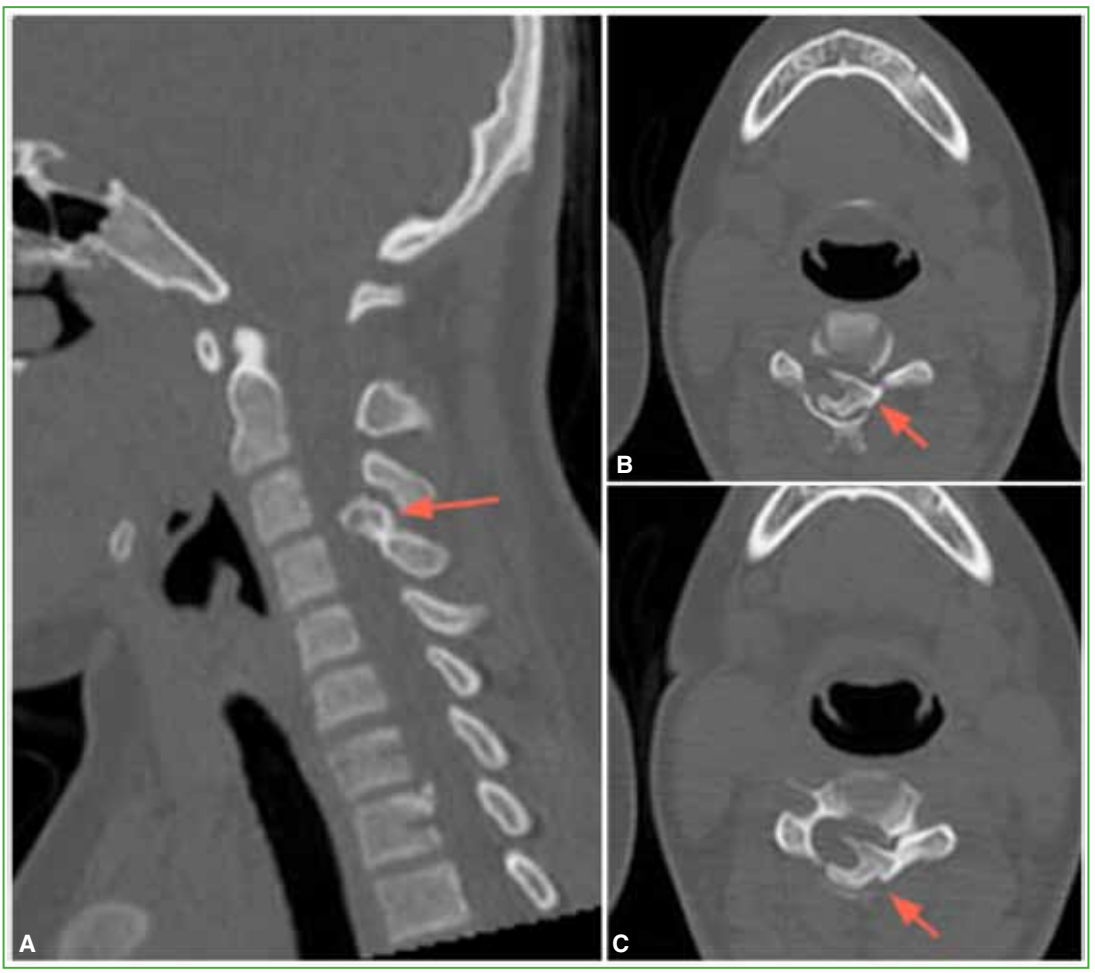


Figure 2. Computed tomography of the cervical spine, sagittal (**A**) and axial (**B and C**) sections. Osteochondroma of the left lamina of C4 with narrowing of the spinal canal (red arrow).

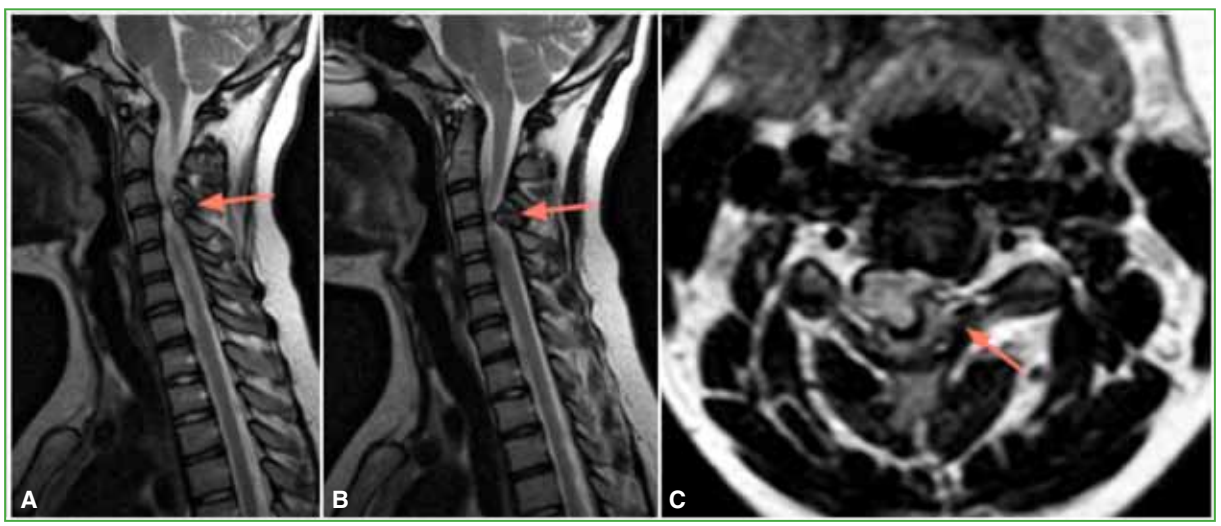


Figure 3. Magnetic resonance of cervical spine, sagittal **(A and B**) and axial (**C**) slices. Osteochondroma of the left lamina of C4 with narrowing of the spinal canal and hyperintense signal of the spinal cord at that level (red arrow).

The T1 and C2 osteochondromas did not exhibit spinal cord involvement on MRI. Subsensory evoked potentials from all four extremities indicated decreased amplitude. Given these findings, posterior cervical decompression and resection of the posterior arch of C4 were performed without instrumentation (Figure 4).

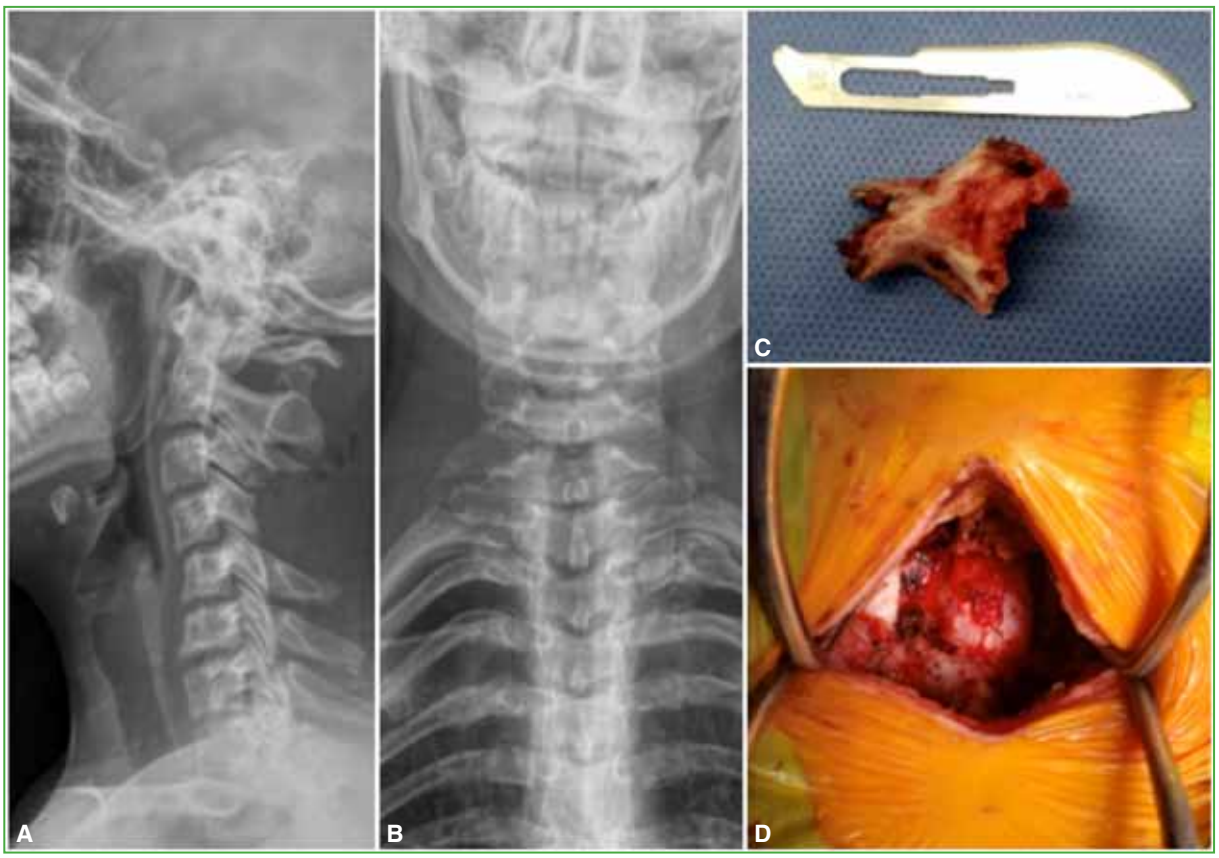


Figure 4. Anteroposterior and lateral radiographs of the cervical region in the immediate postoperative period (**A and B**) and image of the resection of the posterior arch of C4 (**C and D**).

The patient experienced no neurological complications and was discharged on postoperative day three. A rigid cervical collar was used for two months. Pathological examination confirmed the diagnosis of osteochondroma. Three months after surgery, the patient developed local kyphosis at the C4–C5 segment, which is currently being monitored. At two years postoperatively, there was no evidence of local recurrence on CT or MRI (Figure 5).

Both the T1 pedunculated osteochondroma and the finding in the spinous process of C2 remained stable, and conservative treatment was continued.

Currently, the patient is pain-free and actively participates in sports.

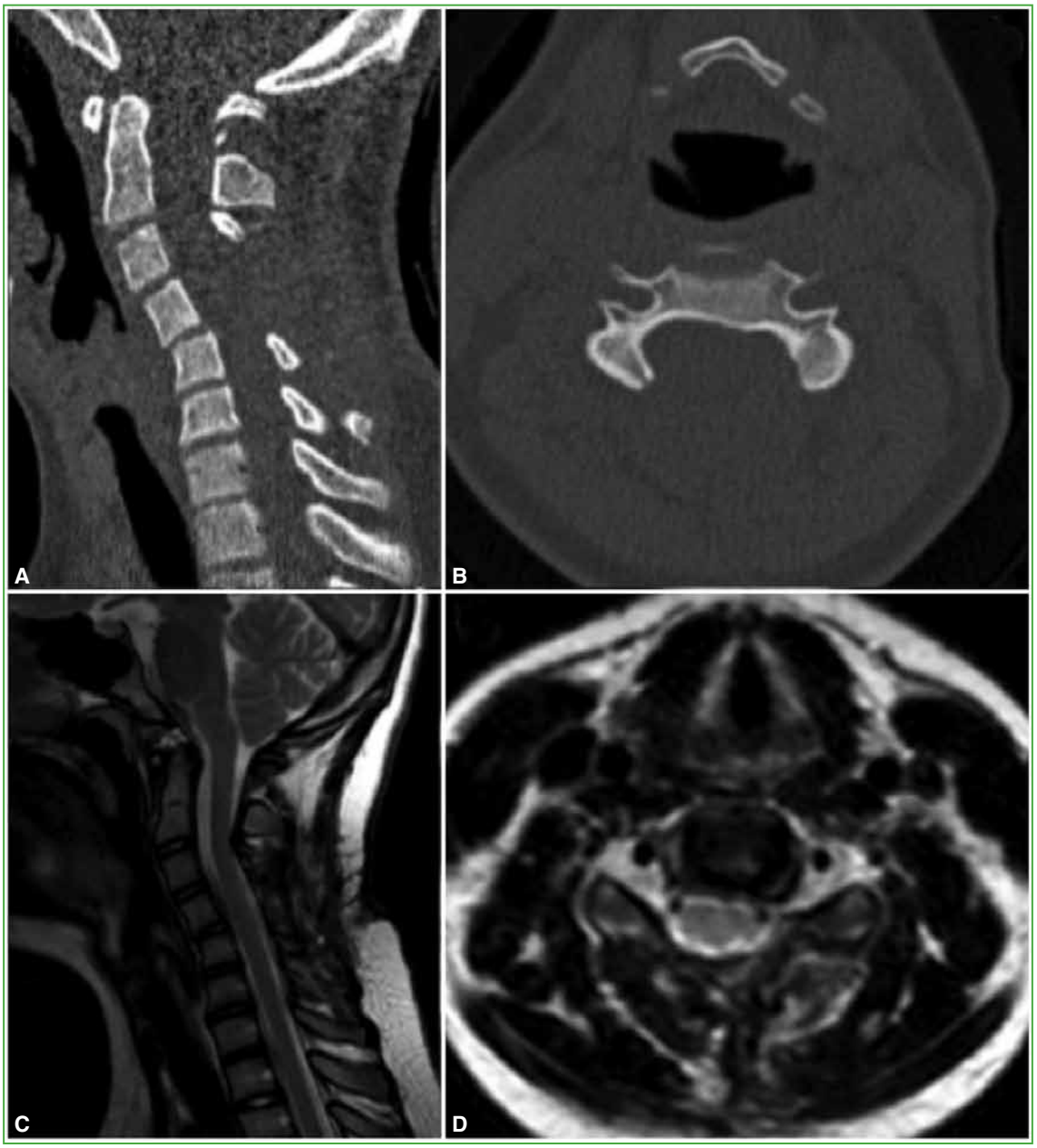


Figure 5. Computed tomography of the cervical spine, sagittal (**A**) and axial (**B**) slices, and magnetic resonance of the cervical spine, sagittal, T2 (**C**) and axial T2 (**D**) slices. Postoperative control at 24 months.

DISCUSSION

The first documented case of myelopathy associated with HME was published by Reid in 1843.[3] In 1907, Ochsner and Rothstein described the first case of cervical myelopathy secondary to HME treated with decompression.[4] Spinal osteochondromas most commonly affect the cervical region, followed by the thoracic and lumbar spine. Within the cervical spine, C2 (29%) and C5 (24%) are the most commonly affected levels, while C4 involvement, as seen in our patient, is less frequent (17%).[1,5] These lesions often originate from the lamina and extend outward, rarely causing myelopathy. The incidence of myelopathy in such cases is low (0.5–1%) and

typically manifests in the second or third decade of life. Myelopathy in pediatric patients with HME is uncommon. Roach et al. evaluated 44 asymptomatic HME patients using MRI or CT and found that 38% had spinal osteochondromas, with 27% showing canal involvement.[6] This highlights the potential underreporting of spinal lesions in HME. Based on these findings, annual spinal MRI is recommended for patients with HME, especially during puberty. In this case, the patient's cervical osteochondroma was incidentally discovered on a CT scan, as spinal monitoring had not been performed previously. For asymptomatic lesions, prophylactic surgery may be considered to prevent neurologic deterioration. Surgical options include laminoplasty, isolated laminectomy, or laminectomy with arthrodesis.[7] During surgery, lesion location, resection and residual stability are critical considerations. Complete resection, including the cartilage cap, is essential to minimize recurrence risk associated with incomplete excision.[8] Laminectomy is often the preferred approach, with the decision to include posterior arthrodesis made on a case-by-case basis to prevent deformities such as cervical kyphosis.[9,10]

CONCLUSIONS

Although cervical myelopathy due to osteochondroma is rare, it can result in significant neurological complications in patients with HME. Annual spinal MRI is recommended for early detection of lesions. If surgery is required, laminectomy, with or without posterior fusion, is the preferred treatment option.

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

S. Aguer ORCID ID: https://orcid.org/0000-0001-9079-1966
J. Dal Lago ORCID ID: https://orcid.org/0000-0002-0868-5505
F. Aguirre ORCID ID: https://orcid.org/0009-0008-7148-9575
E. Levy ORCID ID: https://orcid.org/0000-0002-9158-8617
R. Lloyd ORCID ID: https://orcid.org/0000-0003-3897-3628

REFERENCES

1. Kamiya Y, Horii E, Sakai Y, Inoue H. Cervical cord compression in pediatrics with hereditary multiple exostoses: a report of two cases and review of the literature. *J Pediatr Orthop B* 2016;25(3):267-70. https://doi.org/10.1097/BPB.0000000000000220
2. Giudicissi-Filho M, de Holanda CV, Borba LA, Rassi-Neto A, Ribeiro CA, de Oliveira JG. Cervical spinal cord compression due to an osteochondroma in hereditary multiple exostosis: case report and review of the literature. *Surg Neurol* 2006;66 Suppl 3:S7-S11. https://doi.org/10.1016/j.surneu.2006.05.057
3. Reid J. Case of disease of the spinal cord from an exostosis of the second cervical vertebra. *Lond Edinb Mon J Med Sci* 1843;3:194-8.
4. Ochsner EH, Rothstein T. XII. Multiple exostoses, including an exostosis within the spinal canal with surgical and neurological observations. *Ann Surg* 1907;46(4):608-16. https://doi.org/10.1097/00000658-190710000-00012
5. Burki V, So A, Aubry-Rozier B. Cervical myelopathy in hereditary multiple exostoses. *Joint Bone Spine* 2011;78(4):412-4. https://doi.org/10.1016/j.jbspin.2011.02.021
6. Roach JW, Klatt JW, Faulkner ND. Involvement of the spine in patients with multiple hereditary exostoses. *J Bone Joint Surg Am* 2009;91(8):1942-8. https://doi.org/10.2106/JBJS.H.00762
7. Fukushi R, Emori M, Iesato N, Kano M, Yamashita T. Osteochondroma causing cervical spinal cord compression. *Skeletal Radiol* 2017;46(8):1125-30. https://doi.org/10.1007/s00256-017-2633-6
8. Fowler J, Takayanagi A, Siddiqi I, Ghanchi H, Siddiqi J, Veeravagu A, et al. Cervical osteochondroma: surgical planning. *Spinal Cord Ser Cases* 2020;6(1):44. https://doi.org/10.1038/s41394-020-0292-7
9. Akhaddar A, Zyani M, Rharrassi I. Multiple hereditary exostoses with tetraparesis due to cervical spine osteochondroma. *World Neurosurg* 2018;116:247-8. https://doi.org/10.1016/j.wneu.2018.05.078
10. Veeravagu A, Li A, Shuer LM, Desai AM. Cervical Osteochondroma causing myelopathy in adults: Management considerations and literature review. *World Neurosurg* 2017;97:752.e5-752.e13. https://doi.org/10.1016/j.wneu.2016.10.061

Case Resolution

Reynier Ramírez Suárez,[*] Norys Tan Suárez,[**] Nidhessy Pagés Morales[#]
[*]Maxillofacial Surgery Service, Hospital Universitario "Manuel Ascunce Domenech", Universidad de Ciencias Médicas, Camagüey, Cuba
[**]School of Stomatology, Universidad de Ciencias Médicas, Camagüey, Cuba
[#]Imaging Service, Hospital Universitario "Manuel Ascunce Domenech", Universidad de Ciencias Médicas, Camagüey, Cuba

Case Presentation on page 560.

Pain in the Temporomandibular Region

ABSTRACT
Idiopathic calcified nodules originate from the accumulation of mineralized material within a thrombus due to vascular stagnation. They are rare in the maxillofacial region. These calcifications can go unnoticed for a long time unless their growth alters the facial appearance. They are typically evident in radiographic findings as rounded radiopaque bodies. In most cases, the recommended course of action is monitoring in the absence of symptoms.
Keywords: Phleboliths; vascular anomaly; calcifications; radiopaque.
Level of Evidence: IV

Dolor en la región temporomandibular

RESUMEN
Se presenta el caso de una mujer de 54 años de edad que acudió a la consulta por dolor en la articulación temporomandibular izquierda. Luego del examen clínico, se solicitaron estudios por imágenes y, en las radiografías, se observaron calcificaciones nodulares en la región interna de la rama mandibular izquierda. Se decidió indicar otros estudios por imágenes.
Palabras clave: Flebolito; anomalía vascular; calcificaciones; radiopaco.
Nivel de Evidencia: IV

DIAGNOSIS: Phleboliths.

DISCUSSION

To determine the exact location of the lesions and establish a diagnosis, a CT scan of the craniofacial region with 3D reconstruction was requested. The images revealed nodular calcifications medial to the left mandibular ramus, in relation to the medial pterygoid muscle (Figures 3 and 4).

Received on June 13th, 2024. Accepted after evaluation on September 2nd, 2024 • Dr. REYNIER RAMÍREZ SUAREZ • reynierramirez93@gmail.com https://orcid.org/0000-0002-3759-0249
How to cite this article: Ramírez Suárez R, Tan Suárez N, Pagés Morales N. Postgraduate Orthopedic Instruction - Imaging. Case Resolution. *Rev Asoc Argent Ortop Traumatol* 2024;89(6):657-660. https://doi.org/10.15417/issn.1852-7434.2024.89.6.1992

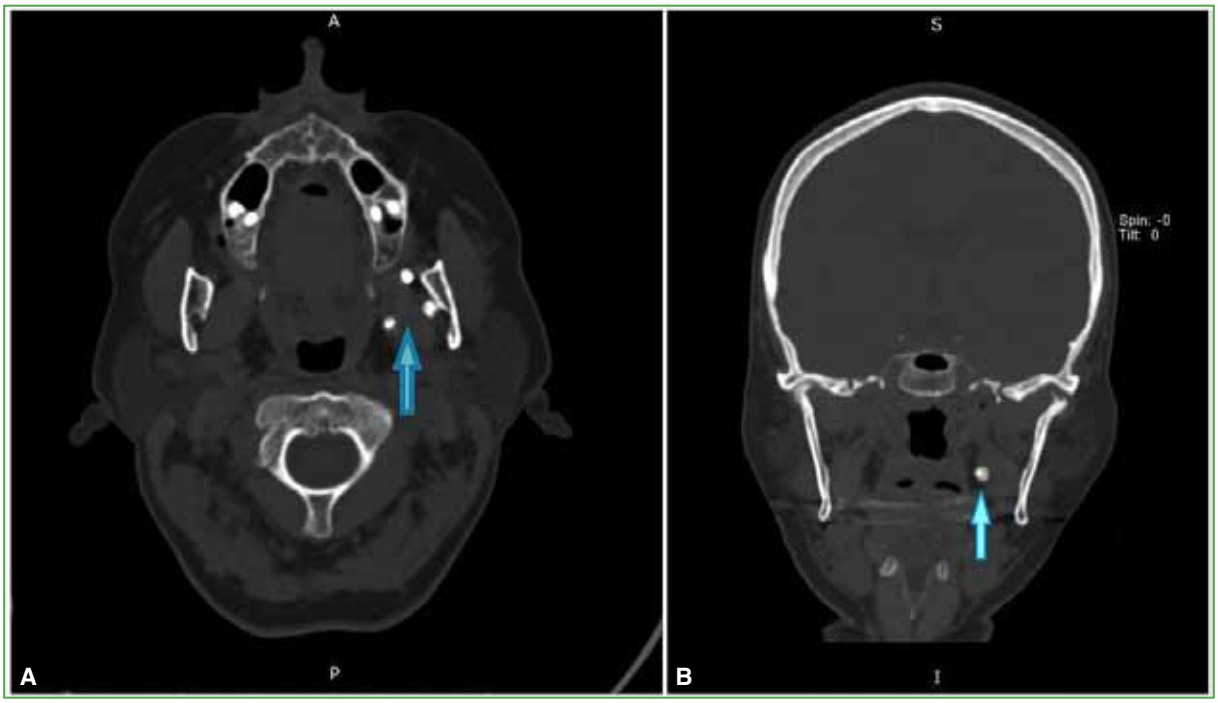


Figure 3. Computed tomography of the craniofacial region. **A.** Axial reconstruction. **B.** Coronal reconstruction.

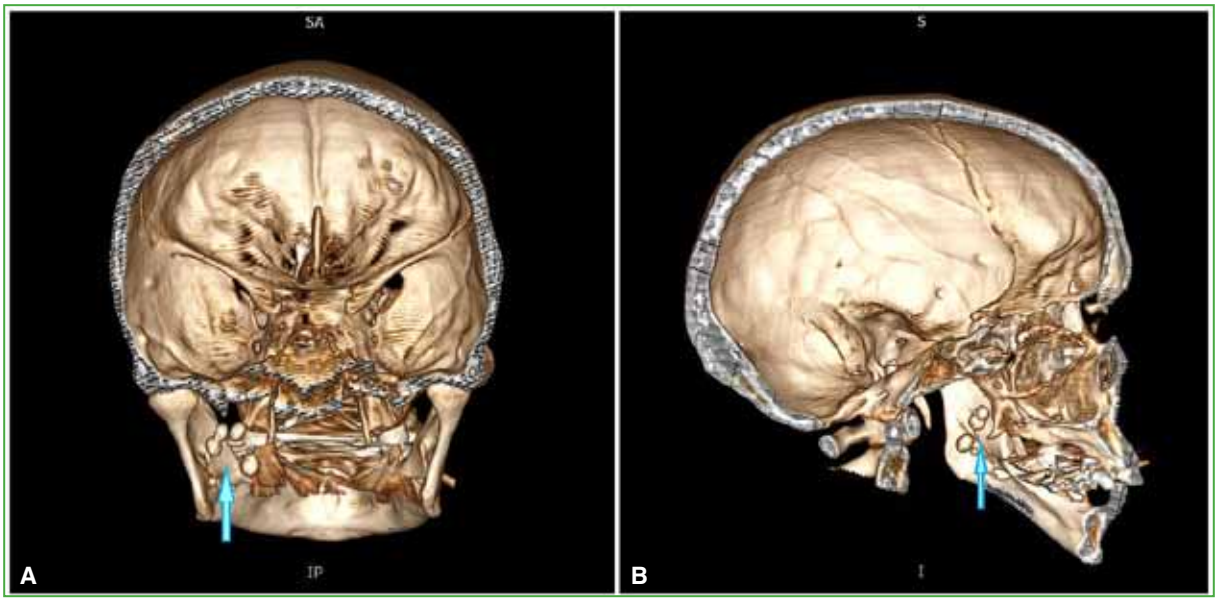


Figure 4. Computed tomography of the craniofacial region. **A.** Volumetric reconstruction, posterior view. **B.** Volumetric reconstruction, sagittal view.

Phleboliths are uncommon idiopathic calcified nodules in the maxillofacial region, characterized by oval or circular concentric radiolucent calcifications.[1-3] They result from the accumulation of mineralized material inside a thrombus due to vascular stagnation and are associated with vascular anomalies, hemangiomas, and trauma.[1,4] This condition is not linked to hereditary factors.[4]

A hallmark feature of phleboliths is their high degree of calcification. Structurally, they resemble a calcified mass of rounded or oval shape, often exhibiting a lamellar arrangement. The growth of a phlebolith occurs from the inside outward and is influenced by fibroblasts.[3]

The incidence of phleboliths in the head and neck region ranges from 5% to 20%, with an average of 13.5%.[3,4] These lesions are characterized by slow growth, are typically asymptomatic, and are often associated with the masticatory muscles and cheeks. Occurrence in the salivary glands is rare, though published cases have reported depressible masses accompanied by edema and even symptoms. Calcification can occur at any age, but it predominantly affects individuals during the first and third decades of life, with no predilection for race or sex.[5,6]

Phleboliths may remain undetected for extended periods unless their growth affects facial aesthetics. They are evident on radiographic findings as rounded radiopaque bodies. Larger phleboliths often exhibit multiple randomly distributed, circular laminations, with a radiopaque halo on the contour and a radiolucent center.[7]

Histological examination of phleboliths reveals concentric calcifications with a lamellar pattern resembling an onion, located within a vessel and sometimes likened to a bull's eye. The outer layer comprises smooth fibrous connective tissue, while the inner layer is shiny brown and elastic. This inner tissue is filled with laminated red blood cells that form an organized thrombus. At the center of the lesion lies a small body resembling an embedded stone, as the calcification grows incrementally.[1]

Diagnostic imaging studies include ultrasound and advanced imaging techniques, such as contrast-enhanced computed tomography (CT) and magnetic resonance imaging (MRI).[8] Differential diagnoses for phleboliths in the maxillofacial region include sialoliths, tonsilloliths, calcified lymph nodes, atherosclerotic plaques in the carotid artery, healed acne lesions, cysticercosis, and miliary osteoma cutis. [1,8]

In most cases of vascular anomalies, follow-up is the preferred approach due to the absence of symptoms. When phleboliths reach significant dimensions, sclerotherapy or surgical excision may be considered as treatment options.[8]

The patient in this case completed treatment for temporomandibular joint (TMJ) dysfunction, and the symptoms prompting consultation resolved. A watchful waiting approach was chosen regarding the phleboliths.

CONCLUSIONS

Phleboliths are calcified nodules associated with uncommon vascular anomalies in the maxillofacial region. These calcifications often go unnoticed due to the lack of symptoms, making follow-up the most appropriate course of action in many cases.

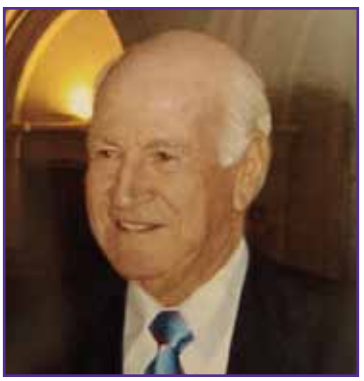
N. Tan Suarez ORCID ID: https://orcid.org/0000-0002-6328-0631
N. Pagés Morales ORCID ID: https://orcid.org/0009-0002-4092-4577

REFERENCES

1. Becerra-Heredia JL, Fiori Chíncaro GA, Agudelo-Botero AM. Flebolitos en la región maxilofacial, un desafío para el diagnóstico por imágenes: Una revisión. *Rev Cient Odontol (Lima)* 2021;9(4):e086. https://doi.org/10.21142/2523-2754-0904-2021-086
2. Sivrikaya EC, Cezairli B, Ayranci F, Omezli MM, Erzurumlu ZU. Buccal vascular malformation with multiple giant phleboliths: a rare case presentation and review of the literature. *Oral Maxillofac Surg* 2019;23(3):375-80. https://doi.org/10.1007/ s10006-019-00767-0
3. Sato S, Takahashi M, Takahashi T. A case of multiple phleboliths on the medial side of the right mandible. *Case Rep Dent* 2020;2020:6694402. https://doi.org/10.1155/2020/6694402
4. López Fernández R, Téllez Rodríguez J. ¿Flebolitos o sialolitos en la región maxilofacial? *Revista Mexicana de Cirugía Bucal y Maxilofacial* [Internet] 2016;12(1):28-32. Available at: http://www.medigraphic.com/cirugiabucal

5. Magaña FG, González JMM, Ugalde FAA, Ayala AA, Reyes AGI, Restrepo DV. Malformación venosa maxilar intraósea: reconstrucción microvascular (reporte de caso y revisión de la literatura). *Revista Mexicana de Cirugía Bucal y Maxilofacial* [Internet] 2018;14(2):77-83. Available at: http://www.medigraphic.com/cirugiabucal
6. Schwartz A, Salz N. Cavernous hemangioma associated with phleboliths in the masseter muscle. *Acta Radiol* 1955;43(3):233-4. https://doi.org/10.3109/00016925509172765.
7. Calle Morocho JR, Montoya Gonzales DD, Calle Velezmoro EM. Calcificaciones de tejidos blandos: consideraciones diagnósticas. *Revista Cubana de Estomatología* [Internet] 2020;57(2). Available at: https://revestomatologia.sld.cu/index.php/est/article/view/2940/1780
8. Abrantes TC, Barra SG, Silva LVO, Abrahão AC, Mesquita RA, Abreu LG. Phleboliths of the head and neck region - A case report. *Ann Maxillofac Surg* 2022;12(2):231-3. https://doi.org/10.4103/ams.ams_125_22

Dr. Héctor R. Malvárez (1935-2024)



Dr. Héctor R. Malvárez was born in the city of Tucumán on October 6, 1935. He earned his medical degree from the School of Medicine of the National University of Córdoba. Upon arriving in Buenos Aires, he joined the Orthopedics and Traumatology Department as a resident under the supervision of Professor Carlos E. Ottolenghi, becoming part of the inaugural group of residents at Hospital Italiano de Buenos Aires.

In 1964, at the recommendation of Dr. Ottolenghi, he pursued a fellowship at the Hospital for Sick Children in Toronto, Canada. There, he focused on the diagnosis and treatment of developmental dysplasia of the hip under the guidance of Dr. Robert Salter and on pediatric spinal deformities under the supervision of Dr. John Hall—both internationally renowned figures in pediatric orthopedics and scoliosis. Returning to Buenos Aires, Dr. Malvárez continued his career as a member of the Orthopedic Service at Hospital Italiano de Buenos Aires. Together with Dr. Jorge Animoso, he became part of the first team at the Scoliosis Center of the hospital (CEHIBA). This center, established in 1970 by Dr. Nora Bloise de Napolitano—its founder and head—was the first specialized institution in Argentina dedicated to treating spinal disorders in children and adolescents. CEHIBA has operated continuously since its inception, advancing the specialty academically, scientifically, and clinically.

Dr. Malvárez succeeded Dr. Bloise as the head of the Scoliosis Sector and led the Pediatric Orthopedics Sector until his retirement in 2000. During his distinguished career, he served as President of the Argentine Society of Pediatric Orthopedics and Traumatology (SAOTI) from 1992 to 1993, and he was an active member of the Argentine Society of Scoliosis (now the Argentine Society of Spine Pathology, SAPCV) and the Argentine Association of Orthopedics and Traumatology (AAOT). He was also a frequent guest lecturer at national and international courses and authored or co-authored numerous publications in both pediatric orthopedics and scoliosis.

Dr. Malvárez was a lover of golf and, above all, a devoted family man. He is survived by his wife, Sofía, his daughters, Cecilia and Lorena, and his grandchildren. On a personal note, Dr. Malvárez played a pivotal role in my professional journey. I first met him in 1979 as a resident and was later welcomed into the Scoliosis Sector in 1982, where he remained a constant source of mentorship and encouragement until his passing on Thursday, October 24, 2024. After 45 years of working together, I am left with countless shared memories and anecdotes, all marked by mutual respect. His charisma, empathy, and sociability defined him as a person and a colleague.

Today, I face the difficult task of bidding farewell to a cherished mentor and friend. I extend my heartfelt gratitude to the Argentine Association of Orthopedics and Traumatology for granting me the opportunity to express these sentiments.

Dr. Malvárez, I hope you found happiness in your life. Your legacy will endure in the hearts and minds of all who had the privilege of knowing you. Thank you for everything. Farewell, Rubén.

Dr. Rubén Maenza
Orthopedics and Traumatology Department, Hospital Italiano de Buenos Aires

Dr. RUBÉN MAENZA • ruben.maenza@hotmail.com https://orcid.org/0000-0001-7780-7556

How to cite this article: Maenza R. Obituary. Dr. Héctor R. Malvárez. *Rev Asoc Argent Ortop Traumatol* 2024;89(6):661. https://doi.org/10.15417/issn.1852-7434.2024.89.6.2066

Dr. Carlos Firpo (1930-2024)

His humanity is such that it is only because he was one of my teachers that I feel compelled to write about something so difficult to express in words.

To be precise, I will refer to one of the most beautiful passages in the history of medicine. In his old age, Ambroise Paré responded to the criticism of Gourmelen, the Dean of the Faculty of Medicine of Paris, who disqualified him for being a barber surgeon rather than a surgeon in long robes: "Dare you teach me surgery... You who have never come out of your study. Surgery is learned by the eye and hand. You, mon petit maître, know nothing else but how to chatter in a chair."

Carlos Firpo comes to mind, and with him, the memory of his hands working meticulously and methodically in the operating room. He performed his surgical tasks with precision while verbally teaching, generously sharing his knowledge without the slightest hint of selfishness. All of this defines him as a great man.

I also recall his involvement in projects that he conceived and allowed us to share. His calm demeanor, thoughtful speech, and constructive attitude set a course that we would respectfully strive to follow.

Carlos Firpo was born on February 22, 1930. He graduated from the University of Buenos Aires (UBA), where he also earned the rank of Associate Professor.

His hospital career included serving as Ward Chief at the Hospital General de Agudos "Carlos G. Durand"and Division Chief at both the Hospital General de Agudos "Dr. Cosme Argerich" and the Hospital Aeronáutico Central. Notably, he was also a Hand Surgery Consultant at the Hospital Nacional de Clínicas de Buenos Aires, where Prof. Dr. José Manuel del Sel was Chief of Service.

His contributions to professional societies are equally distinguished. He served as President of the AAOT (Argentine Association of Orthopedics and Traumatology) and later of the Argentine Congress of the AAOT. In 2001, the AAOT awarded him the title of Master Surgeon.

He held several prestigious positions, including:

President of the South American Society of Hand Surgery, of which he was a founding member.

President of the Argentine Society of Hand and Upper Limb Surgery.

President of the Argentine Shoulder and Elbow Society and the South American Shoulder and Elbow Society, both of which he also helped found.

He was named an Honorary Member of the Argentine Medical Association, the AAOT, and the Argentine Shoulder and Elbow Society.

Dr. Firpo received numerous accolades, including the Dr. Carlos Durand, Dr. Cosme Argerich, and Quinquela

Dr. OSCAR VARAONA • ovaraona@intramed.net https://orcid.org/0000-0001-9471-5485

How to cite this article: Varaona O. Obituary. Dr. Carlos Firpo (1930-2024). *Rev Asoc Argent Ortop Traumatol* 2024;89(6):662-663. https://doi.org/10.15417/issn.1852-7434.2024.89.6.2071

Martín Prizes. In 2010, he was recognized as an Outstanding Personality by the Legislature of the Autonomous City of Buenos Aires.

He authored 13 books, including the *Atlas de Técnicas Quirúrgicas en Ortopedia y Traumatología* and, most notably, *Lecciones de Cirugía de la Mano y Miembro Superior*, in which he masterfully described the surgical management of upper limb paralysis and rheumatoid arthritis. He also directed numerous postgraduate courses, both in Argentina and abroad.

This remarkable career and life trajectory could not have been achieved without the unconditional support of his wife, Wanda.

I first met Dr. Carlos Firpo at Hospital Durand during the South American Hand Society Fellowship, where he served as Director. I fondly remember his dedication, his patient teaching, and his ability to inspire those around him to strive for progress and improvement. He had a way of bridging the distance between master and student, and I am honored to have had the privilege of being by his side at some point in my career.

Dr. Oscar Varaona
Associate Professor of the National University of Buenos Aires

Index by Topic 2024

Lower Limb

General Topics

Obituaries

Index by Author 2024

The Journal of the Argentine Association of Orthopedics and Traumatology thanks the following authors for choosing us to publish their work. We look forward to continuing this valuable collaboration with them.

Reviewers 2024

The Journal of the Argentine Association of Orthopedics and Traumatology is grateful to the following reviewers for their considerable efforts in reviewing the received papers and hopes that they will continue to support our journal with their valuable contribution.

Abrego, Mariano	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Acosta, María Julia	Hospital Subzonal "Dr. Miguel Capredoni", San Carlos de Bolívar, Buenos Aires, Argentina
Albergo, José Ignacio	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Altube, Gonzalo	Sanatorio Allende, Córdoba, Argentina
Alvarado Gómez, Fernando	Fundación Santa Fe de Bogotá, Colombia
Amadei, Rafael	Hospital de Alta Complejidad Cuenca Alta "Néstor Kirchner", Cañuelas, Buenos Aires
Argüelles, Santiago	Hospital Municipal de Vicente López "Bernardo Houssay", Buenos Aires, Argentina
Bazán, Pedro L.	Hospital Interzonal General de Agudos "Gral. José de San Martín", La Plata, Buenos Aires, Argentina
Belluschi, Guillermo F.	Complejo Médico Churruca-Visca, Autonomous City of Buenos Aires, Argentina
Besse, Micaela	Sanatorio Franchín, Autonomous City of Buenos Aires, Argentina
Bittelman, Sacha	Instituto Seguridad del Trabajo, Viña del Mar, Chile
Bonilla, Gonzalo J. H.	Hospital Militar Central "Cirujano Mayor Dr. Cosme Argerich", Autonomous City of Buenos Aires, Argentina
Cagnone, Juan Carlos	Asociación Argentina de Cirugía de la Mano y Reconstructiva del Miembro Superior, Autonomous City of Buenos Aires, Argentina
Campos, Lucas	Sanatorio Allende, Córdoba, Argentina
Caruso, Juan	Clínica Bazterrica, Autonomous City of Buenos Aires, Argentina
Castellini, Jorge	Práctica Privada, Autonomous City of Buenos Aires, Argentina
Chiotta Romano, Mauricio E.	Hospital Universitario Austral, Pilar, Buenos Aires, Argentina
Clembosky, Gabriel	Hospital Británico de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Conti, Leonardo	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Coombes, Nicolás	Axial Grupo Médico, Autonomous City of Buenos Aires, Argentina
Costantini, Julián	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Cubecino, Adriana	Clínica Chapelco, Neuquén
Daroda, Sergio	Clínica de la Mano Gamma, La Plata, Buenos Aires, Argentina
De Elias, Manuel	Hospital Universitario Austral, Pilar, Buenos Aires, Argentina
Della Rosa, Luciano A.	Hospital Interzonal General de Agudos "Eva Perón" (Ex Castex), Buenos Aires, Argentina
Fernández, Claudio A.	Hospital de Niños "Sor María Ludovica", La Plata, Buenos Aires, Argentina
Fernández Comber, S.	Clínica Santa María, Santiago, Chile
Gallucci, Gerardo	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Gamarra, Débora	Casa de Auxilio de Ramos Mejía, Buenos Aires, Argentina
Gómez, Diego J.	Hospital Británico de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Guyot, Juan P.	Hospital Universitario Austral, Buenos Aires, Argentina
Iglesias, Santiago L.	Sanatorio Allende, Córdoba, Argentina

Lencina, Omar	Clínica Centro, Junín, Buenos Aires, Argentina
Locaso, Fernando	Hospital General de Agudos "Dr. Teodoro Álvarez", Autonomous City of Buenos Aires, Argentina
López, Juan José	Facultad de Medicina de la Universidad de Buenos Aires (UBA), Argentina
Lucero, Carlos M.	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Mangione, José I.	Hospital Italiano de Mendoza, Argentina
Mantilaro, Esteban	Hospital Provincial Neuquén, Neuquén, Argentina
Manzone, Patricio	Hospital Pediátrico "Dr. Avelino Lorenzo Castelán", Chaco, Argentina
Martínez, Carlos E.	Hospital Nacional "Prof. Alejandro Posadas", Buenos Aires, Argentina
Martorell, Gabriel	Sanatorio Otamendi, Autonomous City of Buenos Aires, Argentina
Masquijo, Julio J.	Sanatorio Allende, Córdoba, Argentina
Miscione, Horacio F.	Hospital de Pediatría S.A.M.I.C. "Prof. Dr. Juan P. Garrahan", Autonomous City of Buenos Aires, Argentina
Mizdraji, Luciano	Centro Artro, Buenos Aires, Argentina
Monteagudo de la Rosa, Manuel	Hospital Universitario Quironsalud, Madrid, Spain
Moya, Daniel	Hospital Británico de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Mur, Gonzalo	Asociación Argentina para el Estudio de la Cadera y la Rodilla, Autonomous City of Buenos Aires, Argentina
Nally, Francisco	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Natiello, Néstor	GETAP, Buenos Aires, Argentina
Nicolino, Tomás I.	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Ottolenghi, Juan M.	Hospital de Clínicas "José de San Martín", Autonomous City of Buenos Aires, Argentina
Paganini, Federico	Sanatorio Allende, Córdoba, Argentina
Patiño, Osvaldo	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Pedro Maraude, Antonio E.	Sanatorio Allende, Córdoba, Argentina
Pereira, Enrique E.	Instituto Argentino de Diagnóstico y Tratamiento, Autonomous City of Buenos Aires, Argentina
Pereira, Sebastián	Hospital Sirio Libanés, Autonomous City of Buenos Aires, Argentina
Pérez Alamino, Leonel	Centro Médico Monserrat, Autonomous City of Buenos Aires, Argentina
Perrone, Juan Martín	Complejo Médico Churruca-Visca, Autonomous City of Buenos Aires, Argentina
Piantoni, Lucas	Hospital de Pediatría S.A.M.I.C. "Prof. Dr. Juan P. Garrahan", Autonomous City of Buenos Aires, Argentina
Pioli, Ignacio	Sanatorio Allende, Córdoba, Argentina
Poitevin, Luciano	Facultad de Medicina de la Universidad de Buenos Aires (UBA), Autonomous City of Buenos Aires, Argentina
Rellán, Ignacio	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Rey-Funes, Manuel	Instituto de Biología Celular y Neurociencia "Prof. E. De Robertis" (IBCN), Facultad de Medicina, Universidad de Buenos Aires, CONICET, Autonomous City of Buenos Aires, Argentina
Reyes Sánchez, Alejandro A.	Instituto Nacional de Rehabilitación "Luis Guillermo Ibarra Ibarra", Mexico City, Mexico
Río, Marcelo W.	Clínica Zabala, Autonomous City of Buenos Aires, Argentina
Robador, Nicolás A.	Asunción Klinika, Spain
Rojas Llevano, Jorge L.	Hospital Universitario Fundación Santa Fe de Bogotá, Colombia
Romagnoli, Julián	Sanatorio San Lucas, San Isidro, Buenos Aires, Argentina
Rossi, Luciano A.	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Rupenian, Pablo R.	Instituto Argentino de Diagnóstico y Tratamiento, Autonomous City of Buenos Aires, Argentina
Sáez, Lara	Sanatorio Güemes, Autonomous City of Buenos Aires, Argentina
Sala, Juan Matías	Clínica del Valle SRL, Comodoro Rivadavia, Chubut, Argentina

Santamarta, Laura	Hospital Central de San Isidro "Dr. Melchor Ángel Posse", Buenos Aires, Argentina
Sanzana, Edgardo S.	Universidad de Concepción, Chile
Sarmiento, Hugo	Complejo Médico Churruca-Visca, Autonomous City of Buenos Aires, Argentina
Schwartz, Nadia	Hospital General de Agudos "Dr. Teodoro Álvarez", Autonomous City of Buenos Aires, Argentina
Segura, Florencio P.	Centro Privado de Ortopedia y Traumatología Segura, Córdoba, Argentina
Sepúlveda Oviedo, Matías	Hospital Base Valdivia, Chile
Silvano, Raúl E.	OTAMED - Medicina de Alta Complejidad, Mendoza, Argentina
Simesen de Bielke, Harold	Sanatorio Modelo de San Miguel de Tucumán, Argentina
Sotelano, Pablo	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Soutullo, Jorge L.	Instituto Argentino de Diagnóstico y Tratamiento, Autonomous City of Buenos Aires, Argentina
Sperone, Enzo D.	Clínica Zabala, Autonomous City of Buenos Aires, Argentina
Svarzchtein, Santiago J.	Centro Médico Integral Fitz Roy, Autonomous City of Buenos Aires, Argentina
Taype Zamboni, Danilo	Hospital Italiano de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Teruya, Gustavo	Hospital Británico de Buenos Aires, Autonomous City of Buenos Aires, Argentina
Tillet, Fernando	Instituto de Tratamiento y Rehabilitación Articular, Autonomous City of Buenos Aires, Argentina
Torres, Byron	Hospital Metropolitano, Quito, Ecuador
Tourn, Diego	Sanatorio Allende, Córdoba, Argentina
Trebino Molteni, Juan Manuel	Hospital Militar Campo de Mayo "Cirujano Primero Dr. Juan Madera", Buenos Aires, Argentina
Vaineras, Daniel E.	Grupo Médico Olleros, Autonomous City of Buenos Aires, Argentina
Vega Mayer, Rafael	Clínica San Carlos de Apoquindo, Santiago, Chile
Vindver, Gabriel	Hospital Sirio Libanés, Autonomous City of Buenos Aires, Argentina
Viollaz, Gonzalo M.	Centro Artro, Autonomous City of Buenos Aires, Argentina
Vivas, Mauro R.	Hospital de Alta Complejidad en Red "El Cruce", "Dr. Néstor C. Kirchner", Florencio Varela, Buenos Aires, Argentina
Yeregui, Santiago	Hospital Universitario CEMIC, Grupo Médico Vertebral, Autonomous City of Buenos Aires, Argentina
Yurac, Ratko	Clínica Alemana de Santiago, Santiago, Chile
Zancolli, Pablo	Fundación Favaloro, Autonomous City of Buenos Aires, Argentina