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.
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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

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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.
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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.

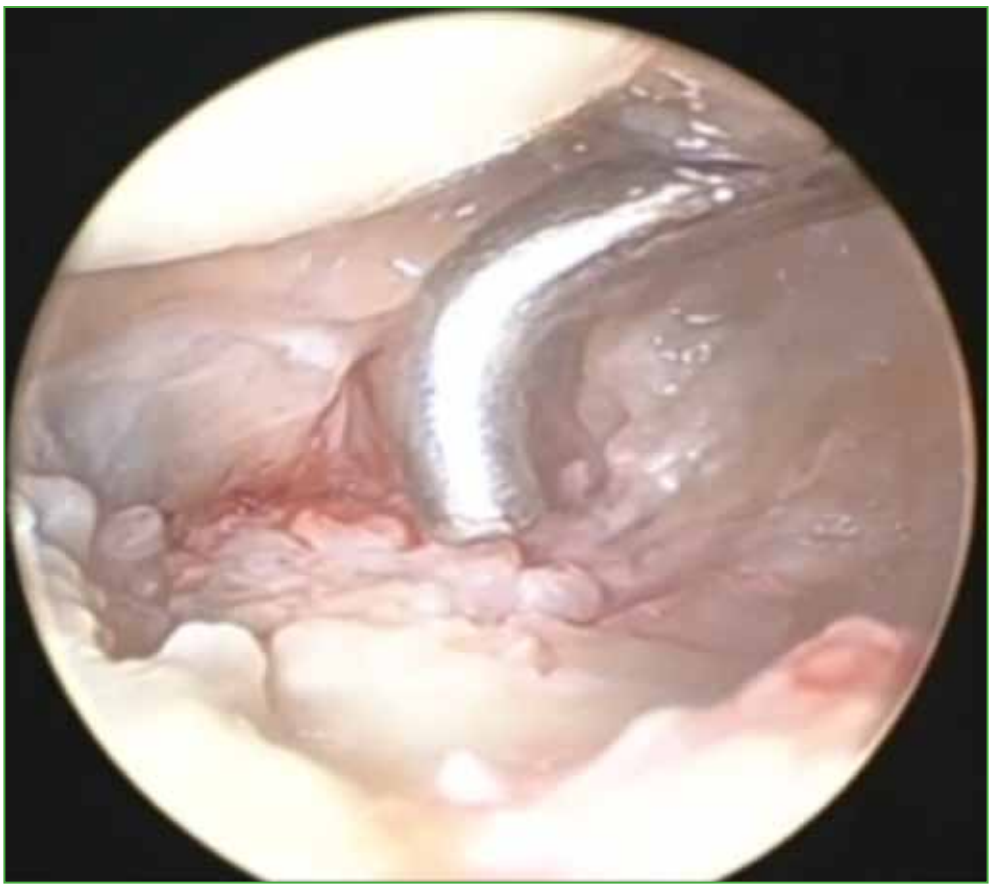

Figure 1. Radiocarpal and triangular fibrocartilage complex examination.

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.

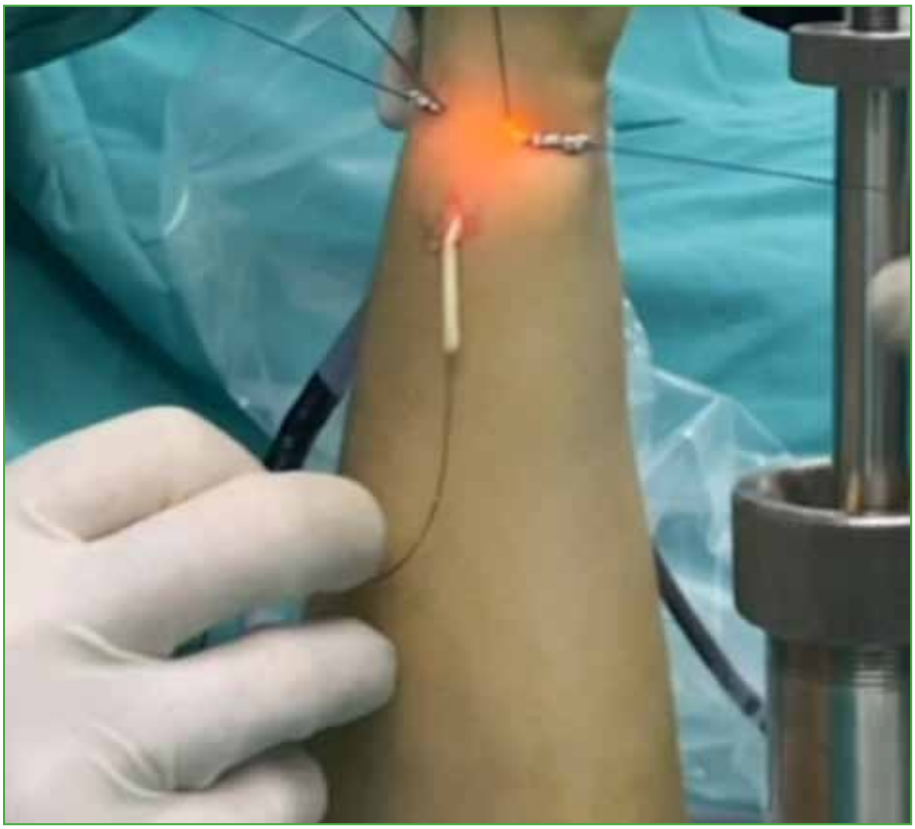

Figure 7. Graft retrieval through the bone tunnel.

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.

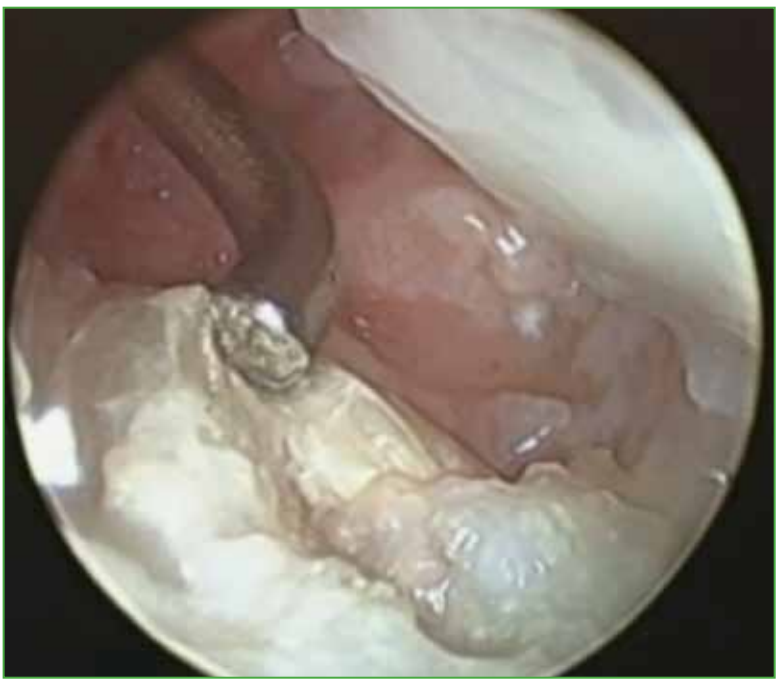

Figure 10. Inspection of the joint and tendon graft tension.

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

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