Article published online: 2022-11-23

All-Arthroscopic Triangular Fibrocartilage Complex Ligamentoplasty: Technique and Results

Vicente Carratalá, MD[1] Francisco Javier Lucas, MD[1] Ignacio Miranda, MD, PhD[2]
Cristóbal Martínez, MD[1,3] Eva Guisasola, MD[1]

[1] Hand and Upper Limb Surgery Unit, Hospital Quirónsalud Valencia, Valencia, Spain
[2] Hospital Arnau de Vilanova, Valencia, Spain
[3] Traumaunit, Teknon Clinic, Barcelona, Spain

Address for correspondence Vicente Carratalá, MD, Unidad de Cirugía de Mano y Miembro Superior, Hospital Quirónsalud Valencia, Av. Blasco Ibáñez 14, Valencia 46010, Spain (e-mail: vtecabaix@gmail.com).

J Wrist Surg 2023;12:104–112.

Abstract

Objective The aim of the study is to describe the modified all-arthroscopic technique for triangular fibrocartilage complex (TFCC) ligamentoplasty in chronic injuries of the TFCC with distal radioulnar joint (DRUJ) instability, and to present the results obtained.

Methods A prospective study was conducted including 11 consecutive patients with chronic TFCC injury with DRUJ instability who underwent an all-arthroscopic TFCC ligamentoplasty. During follow-up, the range of joint motion, grip strength, pain according to the visual analog scale (VAS), functional outcomes according to the Mayo Wrist Score (MWS), and the QuickDASH Score were measured, and any complications and necessary reinterventions were recorded

Results We analyzed 11 patients with distal radioulnar ligament injury treated using the all-arthroscopic ligamentoplasty technique. Mean follow-up was 31.5 ± 4.4 (range 12–58) months. The technique presented achieved DRUJ stability in 100% of cases at 12 months. Grip strength and pain, showed a statistically significant improvement between the preoperative score and the two postoperative assessments. Functional assessment using the QuickDASH score and the MWS also improved significantly.

Conclusion The all-arthroscopic technique for the reconstruction of irreparable peripheral TFCC tears is a reliable technique, intended not only to minimize the surgical trauma to reduce postoperative pain and to facilitate rehabilitation, but also to improve both the quality of the reconstruction and the functional outcome.

Keywords
- wrist arthroscopy
- triangular fibrocartilage complex
- distal radioulnar joint
- radioulnar ligaments
- TFCC ligamentoplasty

The triangular fibrocartilage complex (TFCC) is functionally composed of two components: the distal component (dc-TFCC), formed by the articular fibrocartilage and the ulnocarpal ligaments; and the proximal component (pc-TFCC), composed of the distal radioulnar ligaments (volar and dorsal).[1]

The volar and dorsal radioulnar ligaments have an important function as the primary stabilizers of the distal radioulnar joint (DRUJ) during pronosupination of the forearm, with an isometric point of insertion in the fovea and attachments to the volar and dorsal corners of the sigmoid notch of the radius. Lesions of the pc-TFCC can cause pain and DRUJ instability.

In chronic non-repairable TFCC tears with clinical DRUJ instability in which the articular cartilage is in good condition, ligament reconstruction with tendon graft is the treatment of choice, either by open or arthroscopy-assisted surgery. It is also the preferred treatment in cases of previous failed repair surgeries in patients with clinical DRUJ instability.

received
October 16, 2021
accepted after revision
June 28, 2022
article published online
November 23, 2022

Thieme Medical Publishers, Inc., 333 Seventh Avenue, 18th Floor, New York, NY 10001, USA

DOI https://doi.org/10.1055/s-0042-1757765.
ISSN 2163-3916.

Atzei and Luchetti published a new classification of Palmer class 1-B injuries, in which they differentiated these types of non-repairable tears of the proximal component with DRUJ instability, designating them as class 4.[2]

Several procedures have been described to restore the stability of the DRUJ through non-anatomical reconstructions, including dynamic muscle transfers using the pronator quadratus muscle,[3] extra-articular ulnocarpal plasty, and direct radioulnar fixation plasty to the joint.[4–6] These non-anatomical techniques are not as effective as anatomical reconstruction of the DRUJ ligaments using a tendon graft.

Adams[7] modified the technique previously presented by Mansat et al[8] for the reconstruction of post-traumatic DRUJ instability. The Adams technique is currently the gold standard treatment for this type of lesion.

On the basis of TFCC reconstruction technique described by Adams and Berger, Atzei developed a similar arthroscopic-assisted technique[9,10] that allowed—in addition to direct assessment of the TFCC tissue and the articular surfaces of the DRUJ—anatomical reconstruction, with direct vision of the foveal insertion, respecting the soft tissues and avoiding a broad approach at the joint level.

The authors have designed an all-arthroscopic technique[11] to reconstruct the pc-TFCC (volar and dorsal radioulnar ligaments). This technique avoids overly long transosseous tunnels, reducing the risk of potential complications, and avoiding several volar and dorsal approaches that are described in the Atzei arthroscopic-assisted technique.[9,10] The method attempts to perform a more anatomical reconstruction, with stable fixation. Arthroscopy has led to smaller (and therefore more esthetic) incisions, a more anatomical location of the tunnel position and less soft tissue damage.

The aim of this study was to describe the modified all-arthroscopic technique for TFCC ligamentoplasty in chronic injuries of the TFCC with DRUJ instability, and to present the results obtained.

Materials and Methods

A prospective study was conducted including 11 consecutive patients with chronic TFCC injury with DRUJ instability who underwent an all-arthroscopic TFCC ligamentoplasty.

DRUJ instability before and after surgery was measured clinically, using the ballottement test and piano key sign, and compared with the contralateral wrist.

The study protocol was approved by the hospital ethics committee.

Prospective follow-up of the patients was performed with systematic collection of data preoperatively and at 6 and 12 months.

Minimum follow-up was 12 months post-surgery (range 12–58 months).

During follow-up, the range of joint motion, grip strength, pain according to the visual analog scale (VAS), functional outcomes according to the Mayo Wrist Score (MWS), and the QuickDASH Score were measured, and any complications and necessary reinterventions were recorded.

Arthroscopic TFCC Ligamentoplasty

The indication for this technique is symptomatic DRUJ instability, irreparable TFCC tear, and healthy articular cartilage (Atzei's Classification Class 4[2]).

This situation may occur in:

- Massive ruptures of the TFCC which are therefore irreparable or degenerative tears that are so extensive that their debridement makes ligament reinsertion impossible.
- The existence of friable TFCC tissue after scarring or failure of a previous repair that makes new reinsertion or repair unfeasible.

The technique is not indicated when there are degenerative changes in the DRUJ (Atzei class 5) or the ulnocarpal joint, or in chronic Essex-Lopresti disease and axial instability of the forearm due to insufficiency of the interosseous membrane.

There are essentially three portals used to perform the TFCC reconstruction technique (►Fig. 1): radiocarpal portals 3 to 4 and 6R, and the volar distal radioulnar (VDRU) portal that provides direct access to the DRUJ.[12]

The VDRU portal is a safe portal, located approximately 5 to 10 mm proximal to the wrist crease, just on the ulnar edge of the flexor carpi ulnaris tendon and radial to the dorsal cutaneous branch of the ulnar nerve. The ulnar styloid marks the distal point of the portal.[12]

1. Exploratory Arthroscopy and Extraction of the Tendon Graft

It is essential to explore the TFCC and the condition of the tissue and cartilage. In cases of chronic and symptomatic instability, the TFCC tissue may be friable, with extensive

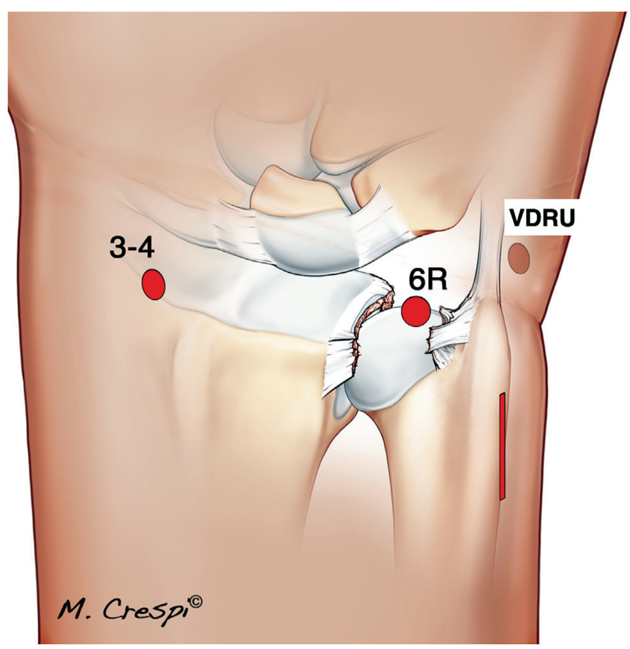

Fig. 1 Portals used to perform the TFCC reconstruction technique: 3 to 4 and 6R portal, and a VDRU (volar distal radioulnar portal) that gives direct access to the DRUJ. A proximal ulnar mini-incision is also made to create the ulnar tunnel. DRUJ, distal radioulnar joint; TFCC, triangular fibrocartilage complex.

capsular and foveal ulnar detachment. The remains of the TFCC and the insertion area in the ulnar fovea must be cleaned, so that they do not interfere in the creation of the bone tunnels and subsequent passage of the plasty. The ulnocarpal ligaments and the rest of the TFCC attachments are respected and remain intact.

A graft approximately 2 to 3 mm thick and 10 cm in length is usually enough to perform the technique.

As a tendon graft, the *palmaris longus* tendon of the homolateral forearm or a *flexor carpi radialis* hemitendon can be used.

2. Creating the Ulnar Tunnel

With the scope in the 3 to 4 portal, the position of the ulnar fovea is identified. A C-shaped guide is introduced through the 6R portal and the tip of the guide is placed in the position of the fovea insertion. The guidewire is inserted from outside in ►**Fig. 2**; drilling over the guidewire, a 4-mm tunnel is created. The entrance to the ulnar tunnel must be at the midpoint of the anteroposterior diameter of the distal ulna and at least 1.5 cm from the base of the ulnar styloid to avoid iatrogenic fractures during creation of the ulnar tunnel.

3. Creating the Radial Tunnels

The scope in the 3 to 4 portal provides a good view for inserting the guidewires for subsequent drilling of the tunnels in the volar and dorsal insertions of the radioulnar ligaments. It may be useful to exchange the view portal to either the 6R portal or to the VDRU portal, to check the correct placement of the guidewires.

The guidewires should be placed at the volar and dorsal edges of the radius, in a convergent direction and slightly angled (approximately 30–45 degrees) toward the radial metaphysis (►**Fig. 3**). The correct position of the wires should be confirmed before creating the bone tunnels, to ensure that enough bone wall is retained in the tunnels after drilling, to avoid damaging the articular surface of the radius and breaking the wall when inserting the graft and implants.

The radial tunnels are created using a 3-mm cannulated drill bit, drilling to a depth of approximately 1 to 1.5 cm.

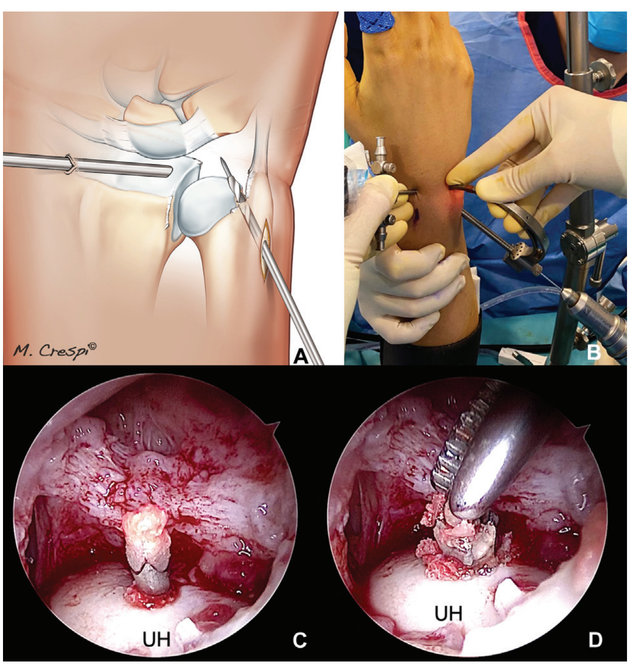

Fig. 2 With the scope in 3 to 4 portal. (**A**, **B**) A C-shaped guide is introduced through the 6R portal. (**C**) The guidewire is inserted from outside to inside under arthroscopic control. (**D**) Drilling over the guidewire to create a 4-mm tunnel. UH, ulnar head.

4. Passing the Tendon Graft to the Ulnar Tunnel

With the scope in 3 to 4 portal, a Micro SutureLasso (Arthrex, Naples, FL) is inserted straight through the ulnar tunnel (►**Fig. 4**), leaving the nitinol loop open over the DRUJ. A grasper or arthroscopic clamp is advanced from the 6R portal to the VDRU portal through the nitinol loop. The grasper is retrieved, grasping one end of the tendon graft and passing it through the loop, leaving one end in the 6R portal, the other in the VDRU portal, and the graft introduced in the nitinol loop.

Pulling the nitinol loop from the ulnar tunnel, a tendon loop is pulled out through the ulnar tunnel, leaving a dorsal end in the 6R portal and a volar end in the VDRU portal.

5. Fixing the Tendon Graft in the Radial and Ulnar Tunnels

With the scope in 3 to 4 portal, keeping the nitinol loop with the tendon loop in the ulnar tunnel, the two ends of the tendon graft (in which a Krakow-type stay stitch has been previously made) are introduced in the corresponding volar and dorsal radial tunnels using a Suture Passer needle (Arthrex, Naples, FL). Maintaining the tension of the sutures exiting at the radial edge of the wrist, the graft is fixed using 3-mm interference screws (►**Fig. 5**). The dorsal radial interference screw is inserted from the 6R portal and the volar screw from the VDRU portal.

After the tendon graft is fixed in the radial tunnels, maintaining the tension of the graft in the ulnar tunnel, the graft is fixed using a 4-mm interference screw (Arthrex, Naples, FL), completing the reconstruction of the proximal portion of the TFCC (►**Fig. 6**).

Postoperative Care

A long-arm splint is applied with the forearm in neutral pronosupination for 2 weeks. This is then replaced with a forearm splint, leaving the elbow free, for another week.

After removing the forearm splint, a removable orthosis is fitted and the patient starts the specific rehabilitation protocol (►**Table 1**).

Statistical Analysis

Data were gathered on a database created using Microsoft Excel 2016. IBM SPSS program version 26 was used for the statistical analysis. It consisted of a descriptive analysis of the variables, calculating the frequency distributions for the qualitative variables and the arithmetic mean and standard error of the mean for quantitative variables. To determine significant differences between the means at different evaluation time points, statistical comparisons were performed using one-way ANOVA (analysis of variance) for repeated

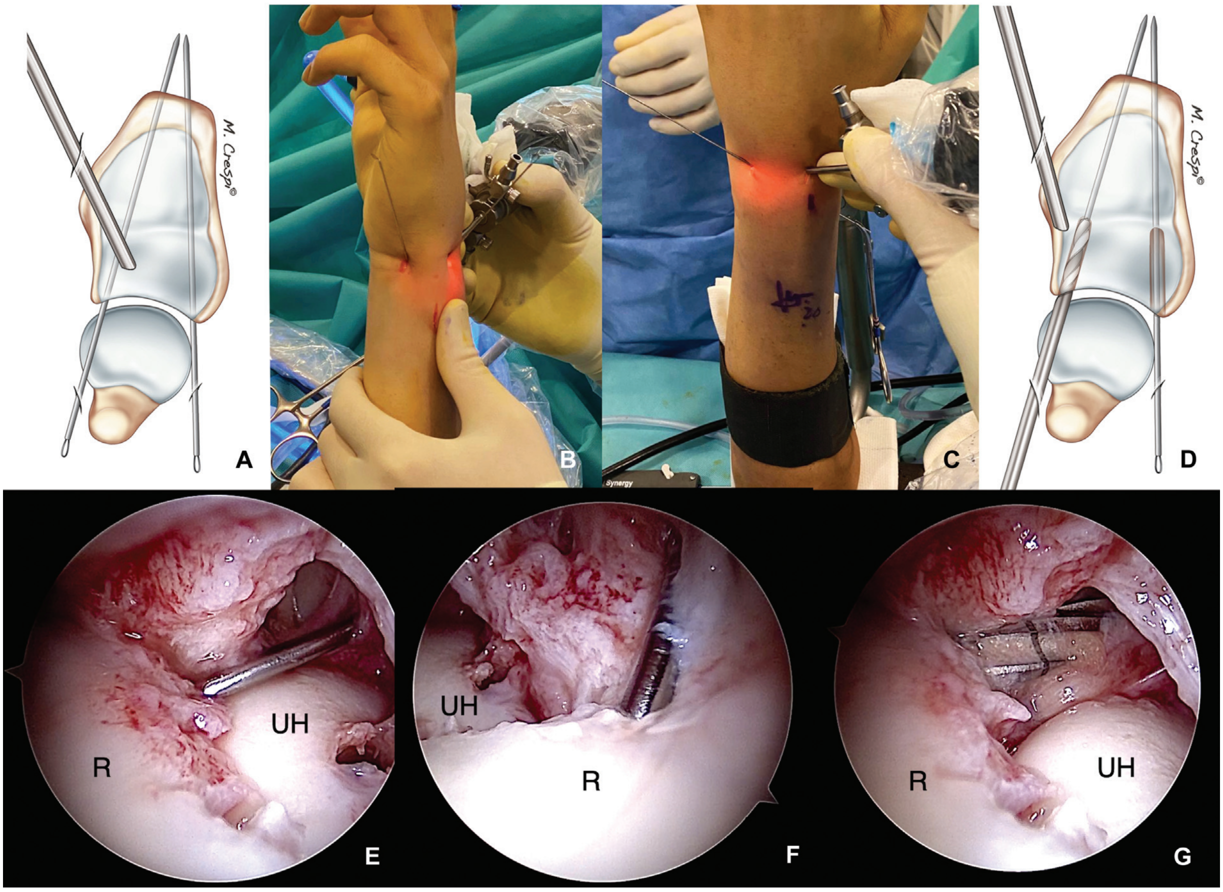

Fig. 3 (**A**) Direction of the guidewires inserted in the volar and dorsal edges of the radius. (**B**) With the scope in 3 to 4 portal the guidewires are inserted from the 6R portal and VDRU portal. (**C**) The guidewires must be placed in a convergent direction and slightly angled (approximately 30 to 45 degrees) toward the radial metaphysis. (**D**) Subsequent drilling of the tunnels is performed in the volar and dorsal insertions of the radioulnar ligaments. (**E**) Checking from the 3 to 4 portal the correct position of the volar guidewire. (**F**) Checking the correct position of the dorsal guidewire. (**G**) Drilling the 3-mm volar radial tunnel from the volar distal radioulnar portal. The scope is in 3 to 4 portal. R, radius; UH, ulnar head.

measures with Bonferroni's multiple comparisons *post hoc* test. A probability value of less than 0.05 was considered significant.

Results

We analyzed 11 patients with distal radioulnar ligament injury treated using the all-arthroscopic ligamentoplasty technique described herein. Mean patient age was 41.4 ± 2.2 (range 30–58) years and 73% were men. Ninety-one percent of the patients were right-handed, 55% had injured their right hand, and in 64% of the cases the injury occurred in the dominant limb. Four of the patients previously had a distal radius fracture, and in five cases an unsuccessful TFCC repair had been performed.

DRUJ stability was achieved in 100% of cases at 12 months.

Return to activity occurred in a mean of 5.7 ± 0.4 (range 4–9) months, and mean follow-up was 31.5 ± 4.4 (range 12–58) months.

Pain, as measured on the VAS scale, showed a statistically significant improvement between the preoperative score and the two postoperative assessments, and there was also a significant difference between the 6- and 12-month assessments (►**Fig. 7**).

Grip strength showed a statistically significant difference between the preoperative measurement and the two postoperative measurements, with a statistically significant increase in strength between 6 and 12 months (►**Fig. 7**). The range of motion (ROM) in flexion-extension was not excessively affected by this injury; nevertheless, compared with preoperative values, the surgery resulted in a statistically significant improvement in flexion-extension at 6 and 12 months; moreover, a statistically significant improvement was also observed between the two postoperative evaluations (►**Fig. 8A**). The ROM in pronosupination also improved in absolute numbers following the surgery (►**Fig. 8B** and **C**).

Functional assessment using the QuickDASH score (►**Fig. 9**) and the MWS (►**Fig. 9**) improved significantly between the preoperative and the 6- and 12-month assessments. A statistically significant improvement was noted in the QuickDASH score between 6 and 12 months that could not be observed with the MWS.

We have found no severe complications in our series to date.

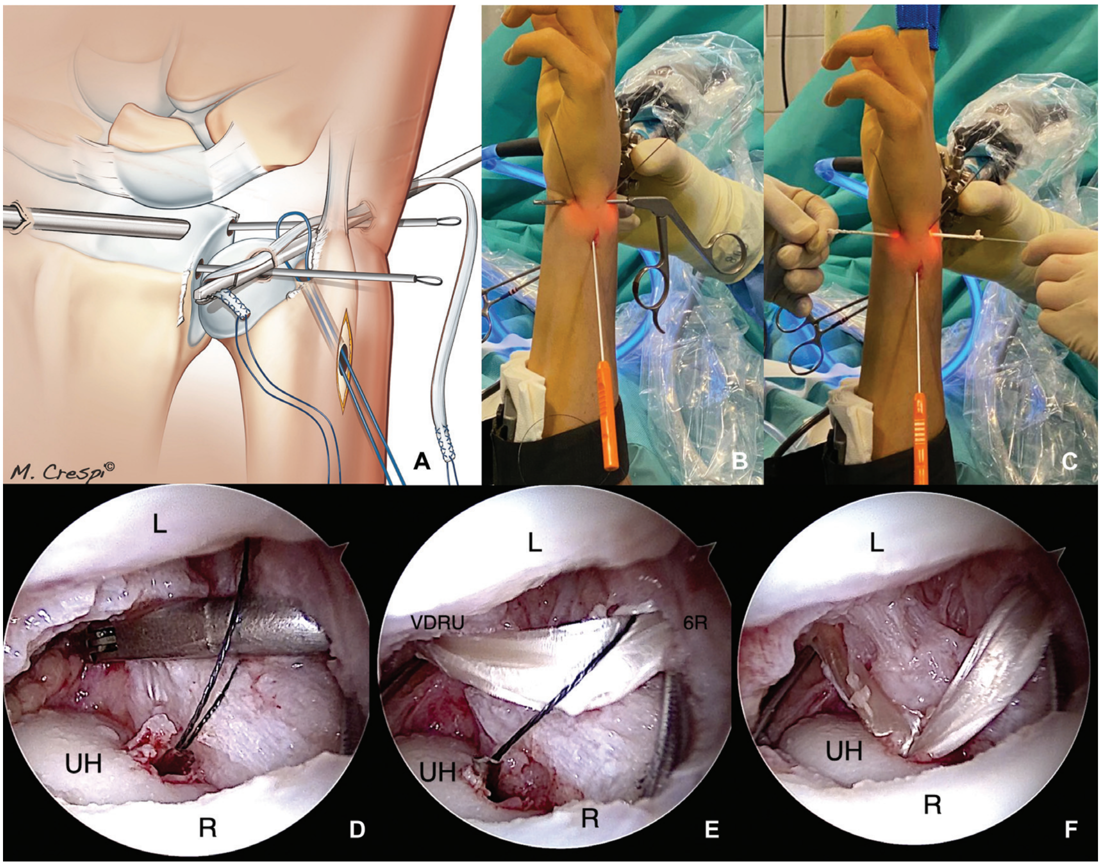

Fig. 4 Passing the tendon graft to the ulnar tunnel. (**A**) A grasper is advanced from the 6R portal to the volar portal through the nitinol loop. (**B**) The nitinol loop is previously introduced in the ulnar tunnel. (**C–E**) The grasper is retrieved, grasping one end of the tendon graft and passing it through the loop, leaving one end in the volar ulnar portal, the other in the 6R portal. (**F**) Pulling the nitinol loop, a tendon loop is pulled out through the ulnar tunnel. 6R, 6R portal; L, lunate; R, radius; UH, ulnar head; VDRU, volar distal radioulnar portal.

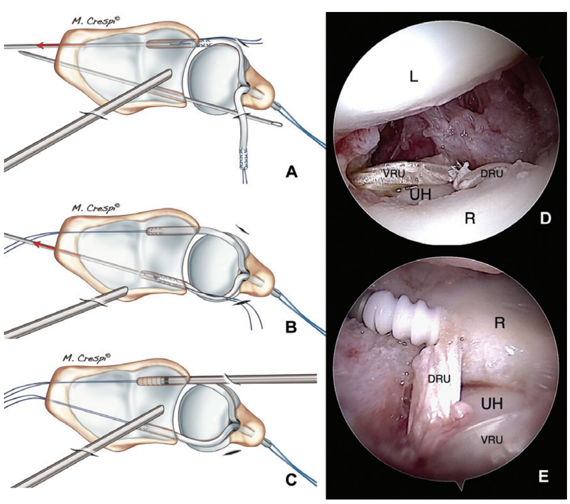

Fig. 5 With a view from 3 to 4 portal, the two ends of the tendon graft are introduced in the corresponding volar (**A**) and dorsal (**B**) radial tunnels using a Suture Passer needle (Arthrex, *Naples,* FL). (**C**) Maintaining the tension of the sutures exiting at the radial edge of the wrist, the graft is fixed from the 6R and volar distal radioulnar portal using 3-mm interference screws. (**D**) View from 3 to 4 portal, both ends of the graft have been fixed in the radial tunnels. (**E**) View from the VDRU portal, fixing the graft in the dorsal radial tunnel using 3-mm interference screw. DRU, dorsal radioulnar ligament; L, lunate; R, radius; UH, ulnar head; VRU, volar radioulnar ligament.

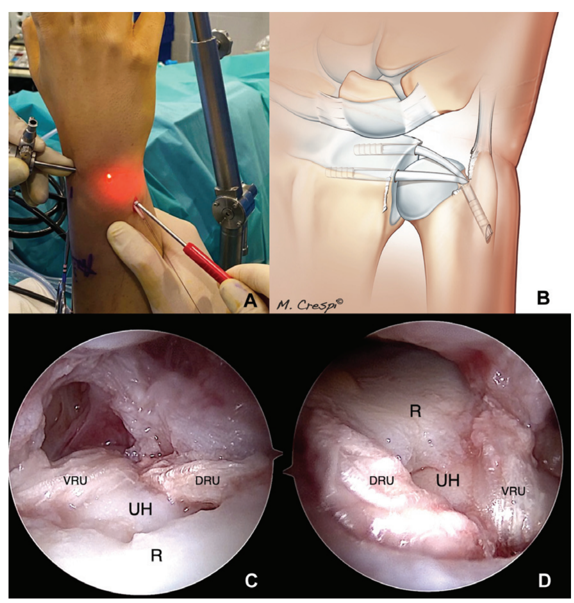

Fig. 6 (**A**) Finishing the reconstruction of the proximal portion of the TFCC after ulnar tunnel fixation using 4-mm interference screw. (**B**) Completed TFCC reconstruction. (**C**) Completed TFCC ligamentoplasty, view from 3 to 4 portal. (**D**) View from 6R portal. DRU, dorsal radioulnar ligament; R, radius; TFCC, triangular fibrocartilage complex; UH, ulnar head; VRU, volar radioulnar ligament.

Table 1 Postsurgical rehabilitation protocol

	Immobilization	Exercises
<2 wk	Münster Splint or brachial splint	Active elbow flexion/extension exercises; Active thumb abduction and flexion exercises; Shoulder and cervical mobilization
3 wk	Splint removal; wear at night	ROM: active and self-assisted wrist flexion/extension; active pronation/supination. MUSCLE (stabilize distal radioulnar joint): Isometrics PQ (supination), ECU (pronation). Elbow isometrics Br, B, T Thumb isometrics: APL, EPB PROPIOCEPTION: Mirror Therapy; Tenodesic exercises; PNF
6 wk	No type of immobilization	ROM: Assisted pronation/supination is allowed. MUSCLE: Elastic bands (PQ, ECU, B, Br, T, APL, EPB, FCR, ECRL, FDS) PROPIOCEPTION: Ball rollers; conscious, and unconscious neuromuscular control
12 wk		Assisted pronation/supination with ketellbell Progressive re-education of support palm Add Powerball^{R}; pliometrics with ball ; E-Link Biometrics ^{R}

Abbreviations: APL, abductor pollicis longus; B, brachial; Br, brachio radialis; ECRL extensor carpi radialis longus; ECU, extensor carpi ulnaris; FCR, flexor carpi radialis; FDS, flexor digitorum superficialis; FPB, flexor pollicis brevis; PNF, proprioceptive neuromuscular facilitation; PQ, pronator quadratus; T, tríceps

Note: Fort the first 2 wk immobilization with a brachial or Münster splint. After removing it, we work on the distal radioulnar joint stabilizers with isometric exercises. From the 6th week we introduce resistance exercises . Progressive proprioception is worked from the start. Powerball^{R} will be introduced at 12th week.

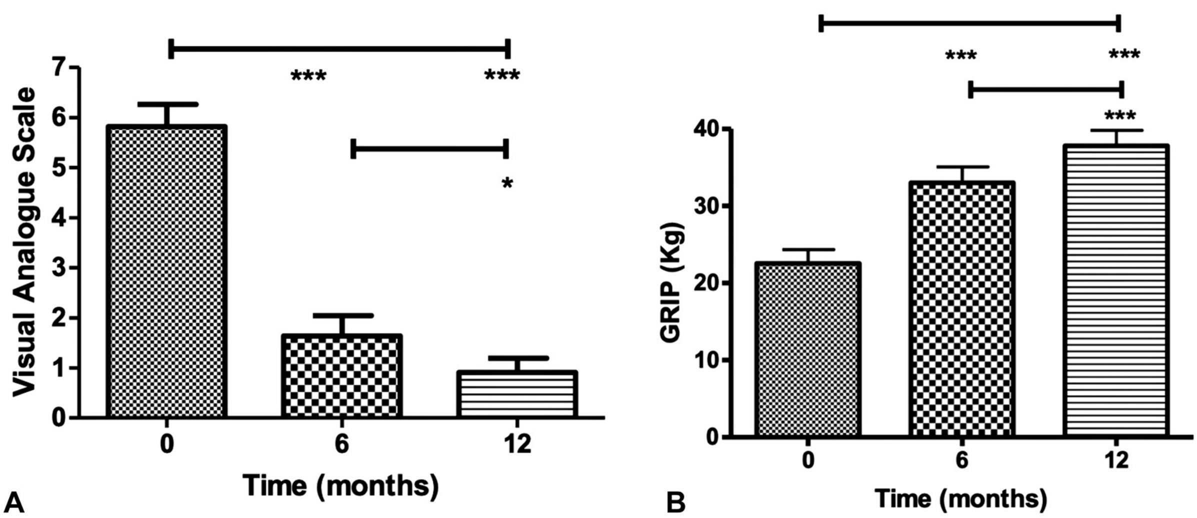

Fig. 7 (**A**) Assessment of pain by visual analog scale (VAS) preoperatively (0 months) and during the postoperative period (6 and 12 months). Data are expressed as mean ± SEM. Significantly different, $^{*}p < 0.05$, $^{***}p < 0.001$. (**B**) Assessment of grip strength (in kg) preoperatively (0 months) and during the postoperative period (6 and 12 months). Significantly different, $^{***}p < 0.001$.

Discussion

Peripheral tears of the TFCC with involvement of the radioulnar ligaments (pc-TFCC) can cause pain and DRUJ instability. Ligament reconstruction with tendon graft is the treatment of choice in chronic non-repairable TFCC tears with clinical DRUJ instability if the cartilage surface is in good condition. Wrist arthroscopy is the most reliable technique for accurate diagnosis and guidance in cases of TFCC injuries, and often for application of the appropriate treatment in a given case.[13–16] Superior intra-articular visualization, potentially greater accuracy, and reduced morbidity are the major advantages of arthroscopy over open procedures. Moreover, it also allows a more anatomical reconstruction to be performed, placing the insertion of the radioulnar ligaments at their anatomical attachments.

Several open and arthroscopically assisted techniques have been described that attempt to restore DRUJ stability. DRUJ ligamentoplasty using open surgery has yielded satisfactory outcomes in terms of DRUJ stability and pain relief,[17,18] but the treatment has been associated with greater joint stiffness and restricted ROM, probably due to the surgical approach, soft tissue damage, the arthrotomy and scarring.

The Adams Technique,[7] although more anatomical than others described, does not reconstruct the radial insertions of the radioulnar ligaments, creating a transosseous tunnel from dorsal to volar in the radius. Studies using this

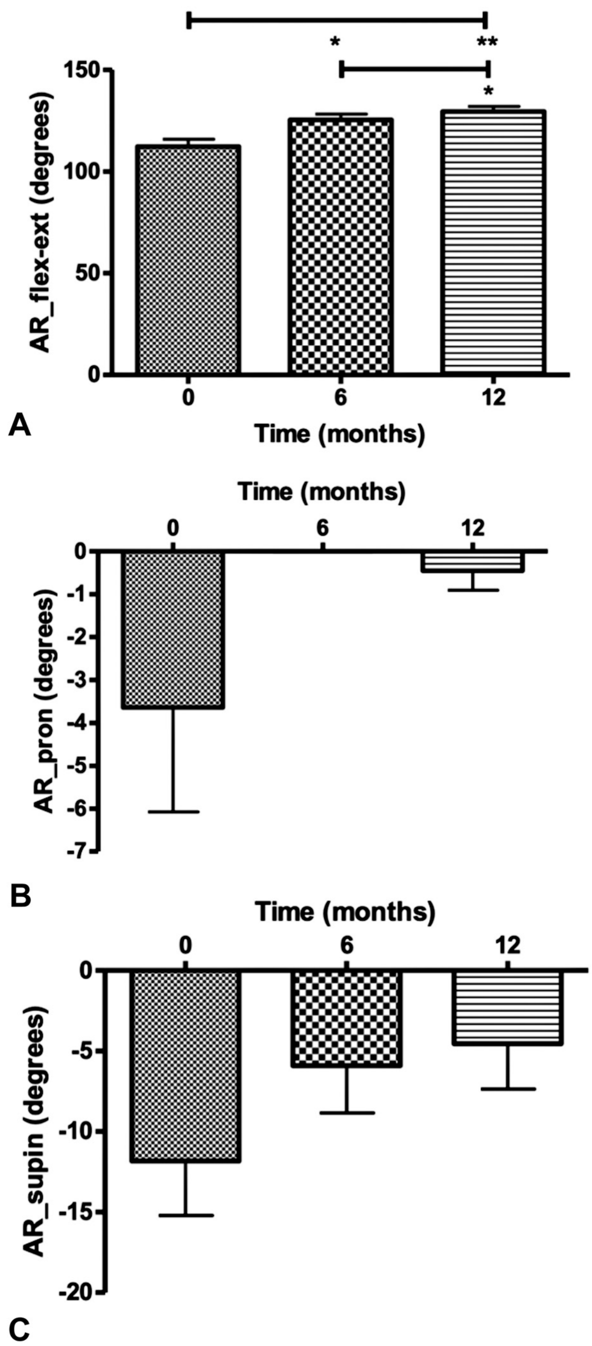

Fig. 8 Assessment of range of joint motion range in flexion-extension (**A**), pronation (**B**), and supination (**C**) (in degrees) preoperatively (0 months) and during the postoperative period (6 and 12 months). Significantly different, $^{*}p < 0.05$; $^{**}p < 0.01$.

technique[18–21] have shown positive results, with recovery of joint stability in 75 to 100% of cases, improvement of pain in 76 to 89%, and good functional outcomes.

In all series, however, the pronosupination ROM, although improved, remained limited. Adams[18] reported pronation and supination results of 72 and 70 degrees, respectively; Seo et al[19] published a pronation ROM of 76.3 degrees and supination ROM of 82.5 degrees; in the study by Kootstra,[20] pronation was 73 degrees and supination was 71.4 degrees; while Gillis et al[21] reported pronation of 71.39 degrees and supination of 62.7 degrees.

Henry[22] performed previous arthroscopy to confirm the diagnosis, and in the same procedure performed open reconstruction by creating two tunnels in the radius in an attempt to replicate the insertion of radioulnar ligaments. Although the results were good, with joint stability and functional improvement in all patients, mobility was again affected, with flexion-extension of 123 degrees, pronation of 71 degrees, and supination of 74 degrees.

Good functional outcomes were also achieved using the arthroscopy-assisted technique described by Atzei[9,10]; outcomes for ROM were superior, with pronation of 80 degrees and supination of 81 degrees. Similar results were reported by Mak et al,[23] with mobility results superior to those obtained in open surgery techniques.

Performing all-arthroscopic reconstruction relieves postoperative pain and reduces scar tissue. Furthermore, the proposed arthroscopy-assisted reconstruction accurately and anatomically reconstructs the radioulnar ligament insertions. The use of strong fixation with Bio-Tenodesis screws allows a shorter period of immobilization and early mobilization, as noted in the biomechanical study by Rigó et al[24] This, together with less insult to soft tissue, may explain the improved mobility in our series, presenting a mean total flexion-extension at 12 months of 129.54 degrees (115–140), with pronation of 89.54 degrees (85–90), and supination of 85.45 degrees (60–90).

The technique presented herein achieved DRUJ stability in 100% of cases at 12 months, comparable to other published series. The improvement in pain and functionality seen in other studies is significant, as was the case using our technique, achieving a reduction in pain using the VAS scale from a preoperative score of 5.81 (4–8) to 0.9 (0–3) at 12 months. The MWS improved from 58.63 (35–70) prior to surgery to 88.18 (70–100) at 12 months, with 81.81% of cases having good or excellent results. Atzei[9] and Mak and Ho[23] published comparable MWSs of 82 and 79, respectively.

Functional outcomes assessed using the QuickDASH score showed a significant improvement, from 49.36 (36.25–56.81) preoperatively to a score of 7.84 (0–22.72) 12 months post-surgery.

Joint stability and pain reduction enabled significant recovery of grip strength, from a mean of 22.5 kg (19–32) preoperatively to a mean of 37.8 kg (29–49) at 12 months, achieving 92% of the strength of the contralateral hand. This finding is comparable to the grip strength achieved in the series by Atzei,[9,10] which was 96%, and higher than the results obtained by open reconstruction.[17,18,20–22]

We have found no severe complications in our series to date. One case of paresthesia in the ulnar scar area was recorded that resolved at 4 months. Only one case presented a notable restriction in supination, approximately 30 degrees, but maintained a good overall function with significant improvement in previous pain.

Precision in creating bone tunnels and arthroscopic confirmation are essential to avoid intraoperative fractures. Minimizing soft tissue insult can reduce the appearance of

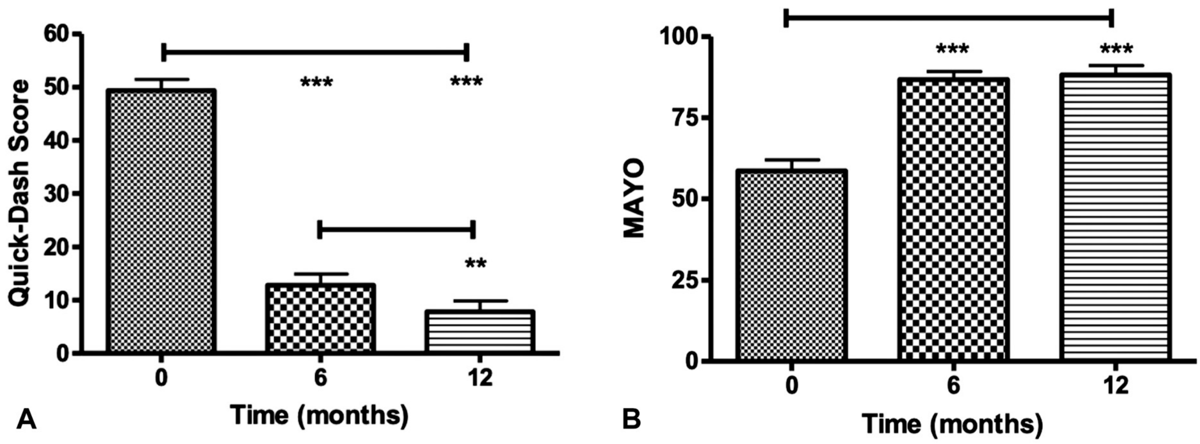

Fig. 9 (A) Results of the functional assessment with the QuickDASH score preoperatively (0 months) and during the postoperative period (6 and 12 months). Significantly different, $^{**}p < 0.01$, $^{***}p < 0.001$. (B) Results of the functional assessment with the MSW preoperatively (0 months) and during the postoperative period (6 and 12 months). Significantly different, $^{***}p < 0.001$.

complications such as scar tissue pain, neuropraxia of the sensory branches of the ulnar nerve, or infections, as have been reported in other series.[10,17,21,23]

Conclusion

The all-arthroscopic technique for the reconstruction of irreparable peripheral TFCC tears is a reliable technique, intended not only to minimize the surgical trauma to reduce postoperative pain and to facilitate rehabilitation, but also to allow greater precision and thus improve both the quality of the reconstruction and the functional outcome.

The good results in our series are comparable to those obtained using other techniques in terms of DRUJ stability and pain relief, but superior with regard to mobility and function.

Ethics Committee
This study was approved by the Ethics Committee of the Hospital Quirónsalud Valencia.
This study was performed in Unidad de Cirugía de Mano y Miembro Superior. Hospital Quirónsalud Valencia. Valencia, Spain.

Conflict of Interest
None declared.

References

1 Nakamura T, Makita A. The proximal ligamentous component of the triangular fibrocartilage complex. J Hand Surg [Br] 2000;25 (05):479–486
2 Atzei A, Luchetti R. Foveal TFCC tear classification and treatment. Hand Clin 2011;27(03):263–272
3 Johnson RK, Shrewsbury MM. The pronator quadratus in motions and in stabilization of the radius and ulna at the distal radioulnar joint. J Hand Surg Am 1976;1(03):205–209
4 Breen TF, Jupiter JB. Extensor carpi ulnaris and flexor carpi ulnaris tenodesis of the unstable distal ulna. J Hand Surg Am 1989;14 (04):612–617
5 Eliason EL. An operation for recurrent inferior radioulnar dislocation. Ann Surg 1932;96(01):27–35
6 Hui FC, Linscheid RL. Ulnotriquetral augmentation tenodesis: a reconstructive procedure for dorsal subluxation of the distal radioulnar joint. J Hand Surg Am 1982;7(03):230–236
7 Adams BD. Anatomic Reconstruction of the distal radioulnar ligaments for DRUJ instability. Tech Hand Up Extrem Surg 2000;4(03):154–160
8 Mansat M, Mansat Ch, Martinez Ch. L'articulation radio-ulnare inférieur. Pathologie traumatique. Le poignet 1983;1:187–195
9 Atzei A. DRUJ instability: arthroscopic ligament reconstruction. In: del Piñal F, Mathoulin C, Luchetti R, eds. Arthroscopic Management of Ulnar Pain. Berlin: Springer Verlag; 2012: 147–160
10 Atzei A, Luchetti R, Borelli PP, et al. Arthroscopic TFCC reconstruction by tendon graft. Rivista di Chirurgia della Mano. 2006b; 43:370–376
11 Carratalá Baixauli V, Lucas García FJ, Martínez Andrade C, Carratalá Baixauli R, Guisasola Lerma E, Corella Montoya F. All-arthroscopic triangular fibrocartilage complex ligamentoplasty for chronic DRUJ instability. Tech Hand Up Extrem Surg 2019;23 (01):44–51
12 Lucas FJ, Carratalá V, Miranda I, Martinez C. The volar distal radioulnar portal in wrist arthroscopy: an anatomical study. J Wrist Surg 2021 Apr; 10(02):176–182
13 Park JH, Ahn KS, Chang A, Kwon YW, Choi IC, Park JW. Changes in the morphology of the triangular fibrocartilage complex (TFCC) on magnetic resonance arthrography related to disruption of ulnar foveal attachment. Skeletal Radiol 2020;49(02):249–256
14 Mutimer J, Green J, Field J. Comparison of MRI and wrist arthroscopy for assessment of wrist cartilage. J Hand Surg Eur Vol 2008; 33(03):380–382
15 Boer BC, Vestering M, van Raak SM, van Kooten EO, Huis In 't Veld R, Vochteloo AJH. MR arthrography is slightly more accurate than conventional MRI in detecting TFCC lesions of the wrist. Eur J Orthop Surg Traumatol 2018;28(08):1549–1553
16 Andersson JK, Andernord D, Karlsson J, Fridén J. Efficacy of magnetic resonance imaging and clinical tests in diagnostics of wrist ligament injuries: a systematic review. Arthroscopy 2015; 31(10):2014–20.e2
17 Scheker LR, Belliappa PP, Acosta R, German DS. Reconstruction of the dorsal ligament of the triangular fibrocartilage complex. J Hand Surg [Br] 1994;19(03):310–318
18 Adams BD, Berger RA. An anatomic reconstruction of the distal radioulnar ligaments for posttraumatic distal radioulnar joint instability. J Hand Surg Am 2002;27(02):243–251

19 Seo KN, Park MJ, Kang HJ. Anatomic reconstruction of the distal radioulnar ligament for posttraumatic distal radioulnar joint instability. Clin Orthop Surg 2009;1(03):138–145
20 Kootstra TJM, van Doesburg MH, Schuurman AH. Functional effects of the Adams procedure: a retrospective intervention study. J Wrist Surg 2018;7(04):331–335
21 Gillis JA, Soreide E, Khouri JS, Kadar A, Berger RA, Moran SL. Outcomes of the Adams-Berger ligament reconstruction for the distal radioulnar joint instability in 95 consecutive cases. J Wrist Surg 2019;8(04):268–275
22 Henry M. Anatomic reconstruction of the radioulnar ligament. Hand (N Y) 2012;7(04):413–419
23 Chu-Kay Mak M, Ho PC. Arthroscopic-assisted triangular fibrocartilage complex reconstruction. Hand Clin 2017;33(04):625–637
24 Rigó IZ, Riano F, Kalapos R, Haugstvedt JR. Biomechanical comparison of modified Adams-Berger and DX technique in DRUJ reconstruction. J Wrist Surg 2021;10(06):516–522

