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Arthroscopic assisted tendon reconstruction for triangular fibrocartilage complex irreparable tears

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Abstract

We report our 11-year experience of performing arthroscopically assisted triangular fibrocartilage complex reconstruction in the treatment of chronic distal radio-ulnar joint instability resulting from irreparable triangular fibrocartilage complex injuries. Eleven patients were treated. Three skin incisions were made in order to create radial and ulna tunnels for passage of the tendon graft, which is used to reconstruct the dorsal and palmar radio-ulnar ligaments, under fluoroscopic and arthroscopic guidance. At a mean follow-up of 68 months all but one had a stable distal radio-ulnar joint. Pain and grip strength, Mayo wrist score, Disability of the Arm Hand and Shoulder and patient-rated wrist and hand evaluation scores improved. The ranges of forearm rotation remained largely unchanged. Complications included an early tendon graft tear, two late-onset graft ruptures, one ulna styloid fracture during surgery and persistent wrist discomfort during forearm rotation requiring tendon graft revision in one case. An arthroscopic assisted approach for triangular fibrocartilage complex reconstruction appears safe and produces comparable results with the open technique.

Keywords

Irreparable triangular fibrocartilage complex tears, TFCC reconstruction, arthroscopic TFCC reconstruction, TFCC tendon graft, anatomical TFCC reconstruction, arthroscopic anatomical TFCC reconstruction

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Introduction

Conventional treatment of traumatic peripheral tears of the triangular fibrocartilage complex (TFCC) can be by open or arthroscopic repair. Recently proposed algorithms for the treatment of TFCC peripheral tears (Atzei, 2009; Atzei and Luchetti, 2011; Atzei et al., 2008) question whether a satisfactory repair can be achieved either by simple capsular suture or by fixation to the distal ulna, following arthroscopic demonstration of either the integrity (Class 1) or rupture (Classes 2 and 3) of the foveal insertions of the TFCC. However, there are other conditions that are not amenable to repair. Conditions such as extensive tears or broad gaps, resulting from debridement or after failed suture, and chronic neglected tears with nonviable margins (Class 4), are not suitable for simple repair and require reconstruction using a tendon graft. TFCC reinforcement or augmentation using a tendon graft has been proposed by Nakamura (Nakamura, 2015; Nakamura and Obara, 2015) and Bain et al. (2014). Both techniques are indicated for incomplete, ulnar-sided, irreparable TFCC tears, with some residual vital and competent ligament tissue. Conversely, reconstruction is indicated for complete TFCC tears with wide retraction or degeneration of the ligamentous tissue.

In the early 1980s, Mansat et al. (1983) in France proposed a technique of 'anatomical' reconstruction of the palmar and dorsal branches of the distal radio-ulnar ligament to restore distal radio-ulnar

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Table 1. Patient charateristics.

Gender (total numbers)	11
Male	5
Female	6
Mean age (years)	37 (16–57)
Affected side	
Right	6
Left	5
Time from injury (months)	16 months (6–28)

joint (DRUJ) stability in chronic TFCC tears, using a palmaris longus tendon graft. In the 1990s, other reconstruction techniques were proposed that focused mainly on the reconstruction of the dorsal branch of the distal radio-ulnar ligament (Shecker et al., 1994; Shih and Lee, 2005; Teoh and Yam, 2005; Tsai and Stilwell, 1984), the volar branch or both branches depending on unidirectional or multidirectional DRUJ instability (Johnston Jones and Sanders, 1995–1996). Recently, Adams et al. (Adams, 2000; Adams and Berger, 2002; Adams and Divelbiss, 2001) refined and popularized the technique suggested by Mansat et al.; it has become the standard open procedure for reconstruction of irreparable TFCC tears. Recently this technique has been modified to be performed arthroscopically in order to reduce surgical morbidity (Tse et al., 2013) and also to improve the quality of reconstruction, especially concerning the stability of the ulnocarpal joint (Atzei, 2012; Atzei et al., 2006b).

The aim of this study was to present the technique of arthroscopically assisted reconstruction of the TFCC, as described by Atzei (2012), and its clinical outcome.

Materials and methods

Eleven wrists in 11 patients (five men and six women) had arthroscopically assisted TFCC reconstruction between 2005 and 2012 (Table 1). The mean age at the time of surgery was 37 years (range 18 to 57). The dominant wrist was involved in eight patients. All patients, but one (suffering from calcium deposits on the ulnar TFCC), had a history of injury: three patients had an associated distal radius fracture and seven patients had a wrist sprain mainly involving the DRUJ. All patients had persistent ulnar-sided wrist pain, weakness and symptomatic instability of the DRUJ. DRUJ stability was measured with the ballottement test (Atzei et al., 2007; Poehling et al., 1994); all patients had increased translation compared with the contra-lateral uninjured wrist and no definite endpoint clinically. Nine of them had had previous surgery: arthroscopic TFCC debridement in four; open TFCC repair in one; and arthroscopic TFCC to bone repair in four. Of these patients, two had a history of gouty arthritis and one patient had well controlled rheumatoid arthritis.

We assessed the patients pre- and post-operatively both objectively and subjectively. Objectively we measured forearm and wrist ranges of motion (ROM) with a manual goniometer. Mean grip strength was evaluated using a hand-held dynamometer (Jamar, Preston Corp, Jackson, MI) in grip positions 1 to 5, both in kgf and as a percentage compared with the contra-lateral unaffected side. Work status was assessed using the Italian-validated versions of the Disability of the Arm Hand and Shoulder (DASH) questionnaire (Padua et al., 2003) and patient-rated wrist and hand evaluation (PRWHE) score (Fairplay et al., 2012), both pre- and post-operatively. Subjectively we measured pain with a visual analogue score and recorded the DASH, PRWHE and the Mayo wrist score (0–100 points) (Cooney and Bussey, 1987).

Postero-anterior and lateral radiographs were performed in all cases pre-operatively and at follow up. CT and magnetic resonance imaging scans were also performed pre-operatively in selected cases.

The inclusion criteria for treatment were: symptomatic unstable DRUJ with arthroscopic finding of Atzei Class 4 irreparable peripheral TFCC tear and healthy DRUJ cartilage. The exclusion criteria were: arthritic or stiff DRUJ; malunion of the distal radius; and previous or active wrist (or DRUJ) septic arthritis.

Surgical technique

The surgical technique is well described by Atzei (2012). The author's technique of TFCC reconstruction is a modification of the open procedure described by Adams (2000). All the arthroscopic steps were performed using the dry arthroscopy technique (Atzei et al., 2006a; del Piñal et al., 2007). The most significant technical modifications in comparison with the Adams technique are: (1) the extremity of the palmar limb of the graft is pulled inside the ulnocarpal joint through the interval between the palmar ulnocarpal ligaments (Figures 1 and 2); and (2) both extremities of the graft are fixed inside the ulnar tunnel with a 4-mm interference screw (Biotenodesis System Screw® -ref. AR-1540B, Arthrex Inc., Naples, FL) (Figures 3 and 4).

Postoperative treatment

The wrist is immobilized in a neutral to slightly supinated position in an above-elbow plaster cast for 3–4

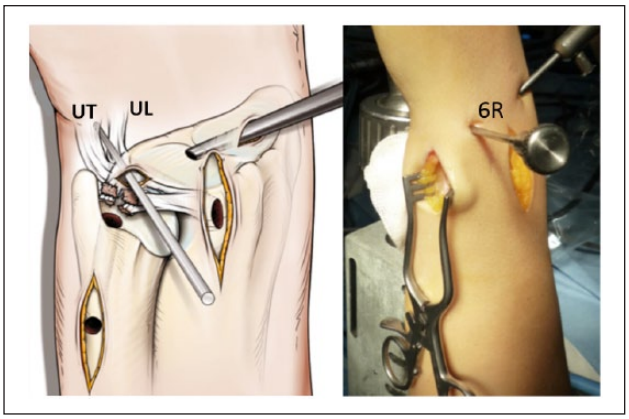

Figure 1. Drawing and intraop picture showing trocar positioned between the ulno-triquetral and ulno-lunate volar ligament, introduced through the 6R portal under arthroscopic control.
UT: ulno-triquetral; UL: ulno-lunate; 6R: portal.

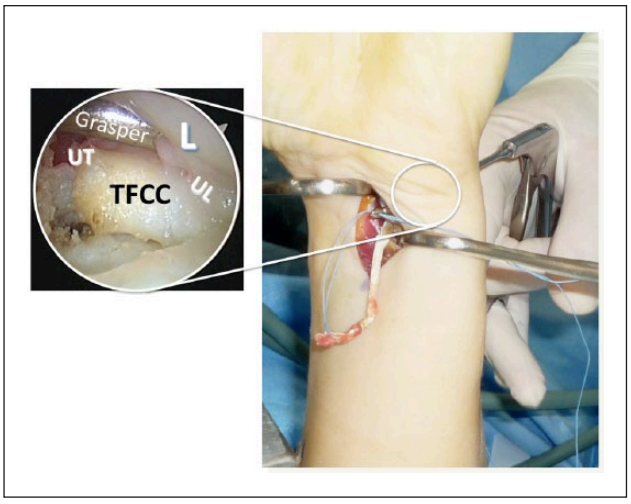

Figure 2. Grasper, introduced into the ulnocarpal joint by the 6R portal, exits volarly passing through the ulno-triquetral and ulno-lunate grasps the suture attached to the volar branch of the tendon graft. The aim is to temporary pull the extremity of the graft inside the ulnocarpal joint through the interval between two ulnocarpal ligaments and over the palmar branch of the TFCC and successively into the ulna bone tunnel.
TFCC: triangular fibrocartilage complex; UT: ulno-triquetral; UL: ulno-lunate; 6R: portal.

weeks and then in a Münster-type splint for a further 3 weeks. Subsequently, gradual recovery of wrist pronation and supination is obtained during physical therapy sessions but, when not in therapy, the patient continues to wear a wrist splint for the following 2 weeks. Progressive resisted wrist and hand-strengthening exercises are started after the 8th post-operative week. Complete use of the wrist is delayed until after 4 months, but heavy loading is avoided for 6 months.

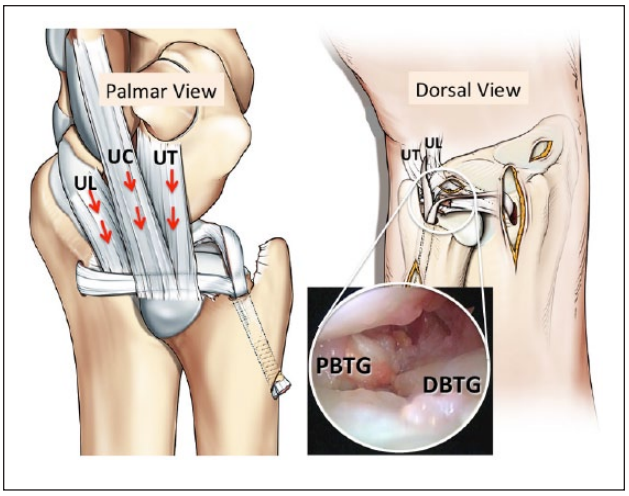

Figure 3. Drawings and arthroscopic pictures showing the correct position of the two branches (palmar and dorsal branch of tendon graft) in order to obtain an anatomical reconstruction of the TFCC. Observe the position of the palmar branch of the tendon graft that passes over the palmar branch of the TFCC, between the ulno-triquetral and ulno-capitate + ulno-lunate ligament, determines a re-tensioning (red arrows) of the ulnocarpal ligaments stabilizing the ulno-carpal joint.
PBTG: palmar branch of tendon graft; DBTG: dorsal branch of tendon graft; UT: ulno-triquetral; UC: ulno-capitate; UL: ulno-lunate.

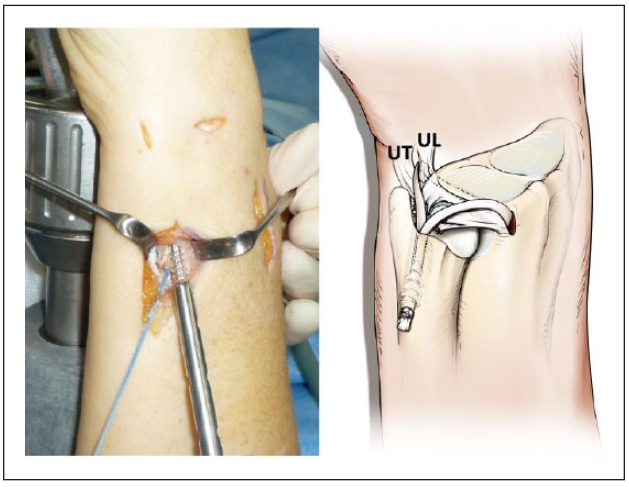

Figure 4. Drawing and picture showing the tendons graft fixation into the ulnar bone tunnel by using an interference screw according to the technique of the Biotenodesis System Screw®. Proper tension of the graft restores stability of the ulno-carpal and the DRUJ.
UT: ulno-triquetral; UL: ulno-lunate.

Results

All patients (six females and five male) with mean age of 37 years, were evaluated at a mean follow-up of 68 months (range from 9 to 120 months).

Table 2. Clinical results at a mean follow-up of 68 months (9–120).

		Pre-op	Post-op
Pain at rest	(VAS)	4	2
Pain at stress	(VAS)	9	4
Pronation	(°)	85	80
Supination	(°)	81	81
Prono-supination	(°)	166	161
Flexion	(°)	64	60
Extension	(°)	70	67
Flexion–extension	(°)	135	127
Grip strength	Kg	13	20
Mayo wrist score	points	52	82
DASH	points	48	25
PRWE	points	70	33

DASH: Disability of the Arm Hand and Shoulder; PRWE: patient-rated wrist and hand evaluation; VAS: visual analogue scale.

Pre-operative evaluation demonstrated that all patients had obvious painful DRUJ instability. Grip strength was half of the contralateral side; forearm rotation was almost complete in all but one patient (Table 2).

All patients were classified arthroscopically as Palmer Type 1B, Atzei class 4 (Atzei, 2009); in two cases the avulsion was not reducible and in the other cases the patients had poor TFCC quality and poor healing potential. Two cases had recurrent instability after TFCC repair to bone (Atzei, 2009; Atzei and Luchetti, 2011; Atzei et al., 2007, 2008). One patient had an associated luno-triquetral instability.

At follow-up, DRUJ stability was clinically restored in all but one patient, who was re-operated on using the Moritomo technique (Moritomo and Kataoka, 2014) of open palmar tendon graft reconstruction. Pain decreased from 4 to 2 at rest and from 9 to 4 under stress on with visual analogue scale. Wrist ROM and forearm rotation did not change significantly. Grip strength increased from 54% to 96% of the contra-lateral uninjured wrist. The Modified Mayo Wrist Score was excellent in four patients and good in five. Eight patients were satisfied with the results of the procedure: DASH and PRWHE scores improved (Table 2). All patients resumed their previous manual activities (one was a student); three patients changed work due to unrelated reasons.

Pre-operative radiographs did not demonstrate subluxation or evidence of DRUJ degeneration. The ulnar styloid was un-united in two patients. At final follow-up at a mean of 68 months (range 9 to 120), radiographs showed the correct position of the bone tunnels in the distal radius and ulna head with no evidence of DRUJ arthritis.

Complications and failures

Peri-operatively a minimally displaced ulnar styloid fracture occurred in one patient when the interference screw was inserted in the ulnar tunnel. The fracture healed during the standard post-operative immobilization period. Post-operatively, paraesthesia was present in the distribution of the dorsal sensory branch of ulnar nerve for 3 months. Five patients complained of painful scarring around the ulna neck, that resolved by rehabilitation and deep connective tissue massage. In one patient the graft was sutured around the ulnar neck. During the first post-operative year, the patient complained of persistent discomfort during forearm rotation due to irritation caused by the tendon graft loop and requested surgical treatment. At revision surgery, almost 1 year later, the tendon graft loop was divided and the graft extremities were secured with an interference screw into a transversal bone tunnel in the distal ulna. Complete tendon rupture occurred in one case due to a fall 1 month post-operatively. The TFCC reconstruction was revised using a strip of the FCR tendon through the previous radial and ulnar tunnels. One patient had a secondary late recurrence of DRUJ instability; at arthroscopy there was fraying of the palmar branch of the TFCC reconstruction. This patient had an open palmar tendon graft reconstruction (Moritomo and Kataoka, 2014) with good clinical restoration of DRUJ stability.

Discussion

In this study, all patients obtained an improvement in wrist pain and grip strength while wrist range of motion remained almost unchanged, since they had an almost full ROM pre-operatively. A slight reduction in wrist pronation was reported in two cases; one patient had 60° reduction in pronation.

Clinical stability of the DRUJ was restored in all but one case. However, no objective measures were made of DRUJ stability, using the recently introduced methods either mechanical (Pickering et al., 2016) or by ultrasound (Oldfield et al., 2016), so the degree of improvement and absolute measurement of stability is unknown.

Atzei et al. (2006b) reported results at a mean follow-up of 6 months (range 3 to 10); three patients recovered 91% of forearm rotation and 81% of grip strength, without signs or symptoms of DRUJ instability. These results were further confirmed at midterm follow-up of a mean of 22 months (range 12 to 34) (Atzei, 2012). Clinical results of Tse's arthroscopic cases (Tse et al., 2013) demonstrated an improvement in wrist pain and grip strength and

particularly in range of motion. We believe this is related to the restricted ROM recorded pre-operatively in Tse's series (Tse et al., 2013), compared with our series. Compared with published series' treated with open surgery (Adams and Berger, 2002; Hess et al., 2016), arthroscopic assisted techniques (Atzei, 2012; Tse et al., 2013) and the present study showed overall better results in wrist range of motion, pain and grip strength. However, one also must take into consideration the greater complexity of the series published by Hess, in which the patients underwent multiple operations at the same time: ulna shortening (six cases), scaphoid reconstruction (one case); luno-triquetral ligament reconstruction (three cases); and scapho-lunate ligament reconstruction (one case) (Hess et al., 2016).

Compared with the open technique of tendon graft reconstruction of DRUJ ligaments, arthroscopic assistance has some potential benefits: (1) the capsule of the ulnar wrist and the surrounding tissues are preserved; (2) the most ulnar part of the TFCC is debrided exposing the fovea; (3) the volar and the dorsal remnants of the radial TFCC are preserved; (4) the palmar tendon graft is passed through the palmar ulno-carpal ligaments and over the remnants of the palmar branch of the TFCC; (5) the fixation of the tendon graft is not done as a loop around the ulnar neck but into the bone tunnel with an interference screw.

The palmar tendon graft, passed through the palmar ulno-carpal ligaments (point 4), is the key difference in this technique (Atzei, 2012; Atzei et al., 2006b) from both the open techniques and the arthroscopic assisted technique of Tse et al. (2013). Tensioning of the palmar ulno-carpal ligaments in association with DRUJ stabilization should provide the advantage of restoring proper biomechanics of the TFCC. Actually, owing to the limitations of the clinical methods currently used to assess TFCC reconstruction, particularly concerning the relevance of ulno-carpal instability, we cannot demonstrate any advantages compared with the open techniques and to the technique of Tse et al. (2013). We hope that the introduction of improved methods of objective assessment of the stability of ulnar side of the wrist (including DRUJ and ulno-carpal joint) will clarify this issue.

In our series, we reported four complications that deserve a comment: (1) the ulnar tunnel fracture did not alter patient recovery because the fracture healed during the same time of the planned post-surgical wrist immobilization; (2) the tendon graft ruptured after a fall on the outstretched wrist, just 1 month post-surgery, and was revised using a different tendon graft (strip of flexor carpi radialis tendon (FCR)) through the same bone tunnels; (3) the late recurrence of palmar DRUJ instability was revised successfully using the technique proposed by Moritomo and Kataoka (2014); (4) the persistent discomfort, caused by the tendon looped around the ulnar neck, was relieved by revising fixation and using an interference screw technique. Based on these observations it appears that the endo-osseous fixation of the graft with the interference screw is a valuable modification from the open technique.

Arthroscopic assisted TFCC reconstruction is a complex procedure that demands a specific learning curve. However, once the technique is mastered, the numerous advantages over open surgery, such as being minimally invasive and providing greater surgical accuracy, are potential major benefits.

We acknowledge several limitations in this study, mainly related to the small number of patients, to the lack of objective assessment of DRUJ instability and, as already discussed, to the lack of direct comparison with open techniques.

Overall this technique appears to give reliable long-term results but with appreciable early complications. It also demands considerable arthroscopic skills and an appreciable learning curve.

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