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Original Article

Functional results of arthroscopic triangular fibrocartilage complex reconstruction in chronic distal radioulnar joint instability

Chun-Lang Kuo [a], Hung-Maan Lee [b], Jui-Tien Shih [a,*]

[a] Department of Orthopedic Surgery, Taoyuan Armed Forces General Hospital, Taoyuan County, Taiwan, ROC
[b] Hualien Armed Forces General Hospital, Hualien County, Taiwan, ROC

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ABSTRACT

Purpose: Tears in the triangular fibrocartilage complex (TFCC) often manifest as ulnar wrist pain and limited wrist function. In chronic cases, the treatment of large tears with irreparable TFCC degeneration combined with distal radioulnar joint (DRUJ) instability is difficult. In the current report, we describe the outcomes of a mini-invasive technique for TFCC reconstruction using the palmaris longus (PL) tendon via arthroscopy.

Methods: We examined the cases of 21 adult patients [20 men and 1 woman; age range, 19–24 years (mean age, 22.4 years)] treated for chronic and irreparable TFCC tears from September 1999 to September 2011. We used the arthroscopic TFCC reconstruction method with the PL tendon for all chronic and irreparable TFCC injuries with DRUJ instability in our clinic. Thereafter, the patients underwent a rehabilitation program, which included wrist motion and occupational therapy. The time period from the event causing the tear to the operation ranged from 14 months to 28 months (mean duration, 22.6 months). All the patients had negative, zero, or mildly positive (<2 mm) ulnar variance.

Results: The results were graded using the Mayo modified wrist score. Of the 21 patients, 11 rated their wrists as "excellent," 9 as "good," and 1 as "fair." None of the patients developed wound infections or complications.

Conclusions: The results of this study suggest that arthroscopic TFCC reconstruction using the PL tendon is an effective method for treating chronic and irreparable TFCC tears with DRUJ instability.

1. Introduction

Tears in the triangular fibrocartilage complex (TFCC) are often indicated by ulnar wrist pain and limited wrist function. The TFCC facilitates the rotation of the radius around the ulna, which is the center of forearm rotation.[1–3] Thus, the TFCC is subjected to axial loads and shear forces. The TFCC is composed of the central fibrocartilage, the dorsal and palmar distal radioulnar ligaments, and the sheath of the extensor carpi ulnaris (ECU) tendon. The TFCC functions as a unit rather than as separate ligaments. The vascularity of the TFCC enables surgeons to repair acute peripheral tears, with excellent outcomes. However, in cases of chronic TFCC tears, the outcomes of TFCC repair are controversial.

The TFCC performs three important biomechanical functions.[4] First, it enables the forearm to be loaded or stressed—loading or stress passes from the forearm to the wrist via the TFCC. Second, the TFCC provides primary stability to the distal radioulnar joint (DRUJ). The TFCC is an important stabilizer of the DRUJ when the distal radioulnar ligaments become taut. Third, the TFCC stabilizes the ulnar carpus via the ulnar carpal ligament complex. If the TFCC is traumatized and disrupted, the wrist may become unstable. Thus, tears cause progressive DRUJ instability and subsequent degenerative changes to the TFCC, lunate, ulna, and triquetrum, as well as loss of wrist motion and grip strength. Chronic and irreparable tears, including the degeneration of the TFCC combined with DRUJ instability, are difficult to treat. Therefore, in the current study, we describe the outcomes of a TFCC reconstruction using the palmaris longus (PL) tendon via arthroscopy.

2. Methods

In the current study, we examined 21 adult soldiers (20 men and 1 woman) treated for chronic TFCC tears from September 1996 to September 2011. The ages of the patients ranged from 19 years to 24 years, with a mean age of 22.4 years. All patients had experienced

* Corresponding author. Department of Orthopedic Surgery, Taoyuan Armed Forces General Hospital, Number 168, Zhongxing Road, Longtan Township, Taoyuan County 325, Taiwan, ROC. Tel.: +886 3 4993070; fax: +886 3 4898976.
E-mail addresses: aron0295@yahoo.com.tw (C.-L. Kuo), jui_tien_shih@hotmail.com (J.-T. Shih).

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trauma such as axial loading and hyperextensive injury. The time period from the event causing the tear to surgery ranged from 14 months to 28 months, with a mean duration of 22.6 months. All the patients experienced ulnar wrist pain, reduced grip strength, limited performance ability, tenderness over the ballotable area of the ulna, passive ulnar deviation, and ulna loading-induced pain. The results of the DRUJ stress test and the piano key sign test were positive in all the patients. Reviews of patient medical histories confirmed that all patients had been previously treated elsewhere with oral nonsteroidal anti-inflammatory drugs (NSAIDs) or herbal medicine.

Radiography was performed for all patients to identify any bone fractures or ulnar variance and to assess the presence of degenerative changes. A true lateral radiograph can be used to identify the presence of DRUJ subluxation. All patients underwent a bilateral wrist computed tomography (CT) scan to assess the relationship between the distal radius and ulna, and to assess the presence of DRUJ instability. All patients underwent an arthroscopic wrist examination and TFCC reconstruction using the PL tendon. The lesions of the TFCC tears were identified and classified according to Palmer's classification (Table 1).

2.1. Surgical procedure

The surgery was performed with the patients under general anesthesia. An upper arm tourniquet was applied and the pressure was set between 200 mmHg and 250 mmHg. PL tendon harvesting was performed via the volar approach. An incision was made approximately 2 cm over the palmar crease region. The PL tendon was identified, isolated, and removed using certain instruments (Fig. 1). A tunnel was created just around the DRUJ of the distal radius, which permitted the passage of the tendon through the volar side to the dorsal side. The PL tendon was then passed through the tunnel to the dorsal side of the wrist (Fig. 2). The wrist was elevated and distracted with a traction towel and finger traps applied over the index and middle fingers (Fig. 3A). The 3–4 portal and 6R (or 6U) portal were created. The fovea region of the distal ulnar head was identified (Fig. 3B) and a microvector drill guide (Fig. 3C) was used to create a bony tunnel from the ulnar border to the fovea region of the distal ulnar head. The PL tendon graft was inserted into the wrist joint and pulled out from the ulnar tunnel of the distal ulna. (Figs. 4 and 5). The graft was sutured to itself and to the surrounding tissue.

After surgery, a short arm splint was applied to the patient's wrist for 4 weeks. A rehabilitation and strength exercise program was initiated 6 weeks after the operation. Pre- and postoperative wrist functions were evaluated using Mayo modified wrist scores (Table 2).

All surgeries were performed by a single surgeon and patients were assessed and followed up at the outpatient department. The Mayo modified wrist score, including pain, work status, range of motion, and grip strength, was used to assess wrist function. Moreover, a dynamometer was used to measure grip strength on the injured and contralateral side of the wrist. The results were reported as a percentage of the data on the contralateral side, for normalization.

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

Traumatic lesions	
Class IA	Central rupture
Class IB	Ulnar avulsion with/without disruption of the ulnar styloid process
Class IC	Distal avulsion
Class ID	Radial avulsion with/without osseous lesion of the radius
Degenerative lesions	
Class IIA	Superficial degenerative lesion
Class IIB	Degenerative tear with cartilage lesion of the lunate or ulna
Class IIC	Degenerative disc perforation with cartilage lesion of the lunate or ulna
Class IID	Degenerative disc perforation with cartilage lesion of the lunate or ulna and lunotriquetral instability
Class IIE	Degenerative disc perforation with cartilage lesion of the lunate or ulna, lunotriquetral instability, and ulnocarpal arthrosis

Fig. 1. Palmar longus tendon taken from the volar side of the wrist.

3. Results

Radiographs did not indicate any degenerative changes in the patients. The ulnar variance in all the patients was less than 2 mm. Most patients had dorsal subluxation of the ulna, as observed on true lateral radiographs. Four patients indicated negative results on arthrography, but indicated Palmer type I lesions on arthroscopy. None of the arthrograms revealed carpal interosseous ligament tears, which was confirmed by arthroscopy.

In this series, all patients underwent wrist CT scans to assess subluxation or dislocation of the DRUJ. According to the criteria by Mino et al,[5] the ulnar head of a normal DRUJ lies between two traced lines that define the dorsal and palmar borders of the radius. All preoperative transverse CT scans indicated DRUJ subluxation

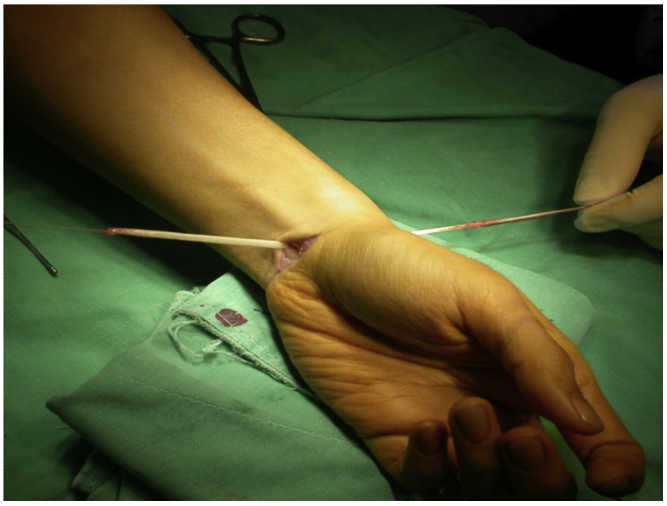
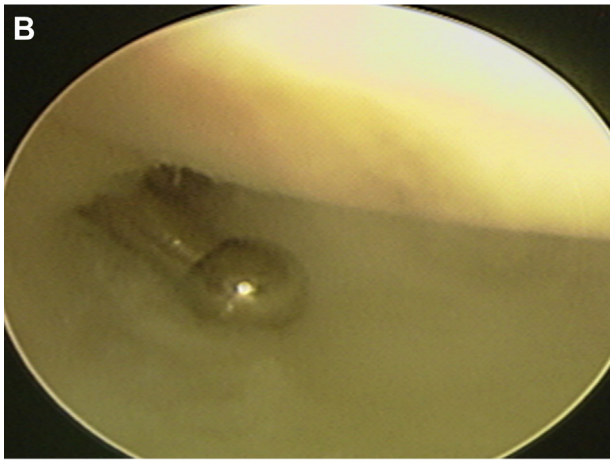


Fig. 2. A tunnel was created just around the distal radioulnar joint (DRUJ) of the distal radius, which permitted the tendon graft to pass from the volar to the dorsal side of the wrist.



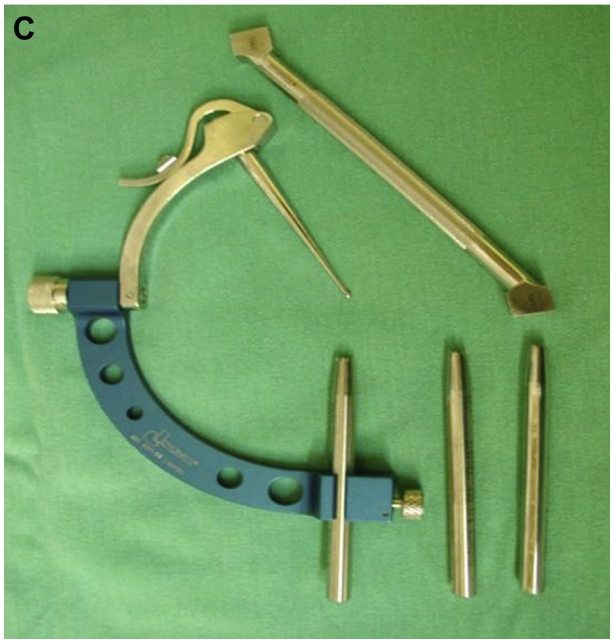


Fig. 3. (A) The wrist was elevated and distracted with a traction towel and finger traps applied over the index and middle fingers. (B) The fovea region of the distal ulna was identified under arthroscopy, and (C) a microvector drill guide was used to create an ulnar tunnel for anatomic insertion of the tendon graft.

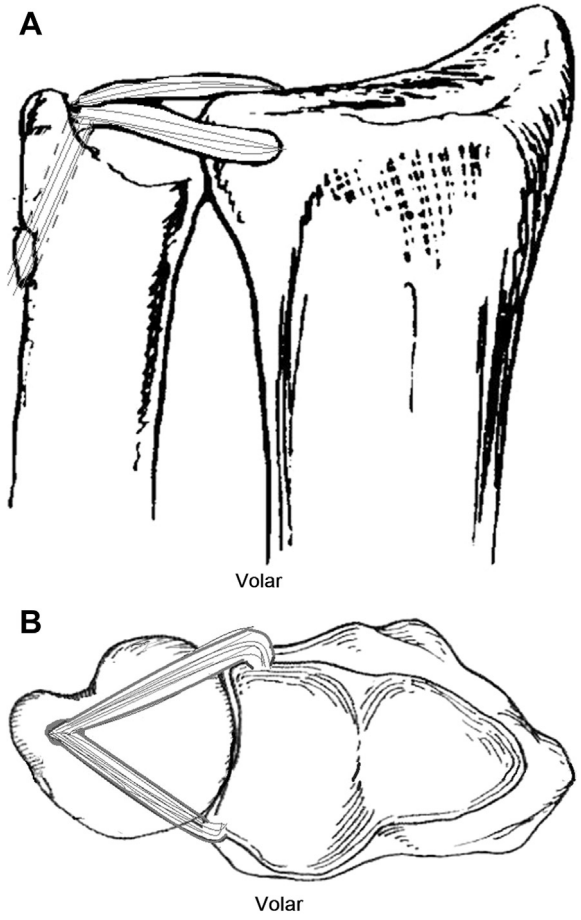


Fig. 4. Anatomic triangular fibrocartilage complex reconstruction using the palmaris longus (PL) tendon. (A) Reconstruction as viewed from the volar side and (B) the joint surface.

(Fig. 6A). Wrist CT scans were repeated for all patients at 12–24 months after surgery. Notably, all ulnar heads were located between the two tracing lines, according to the criteria of Mino et al (Fig. 6B). Three patients underwent wrist magnetic resonance

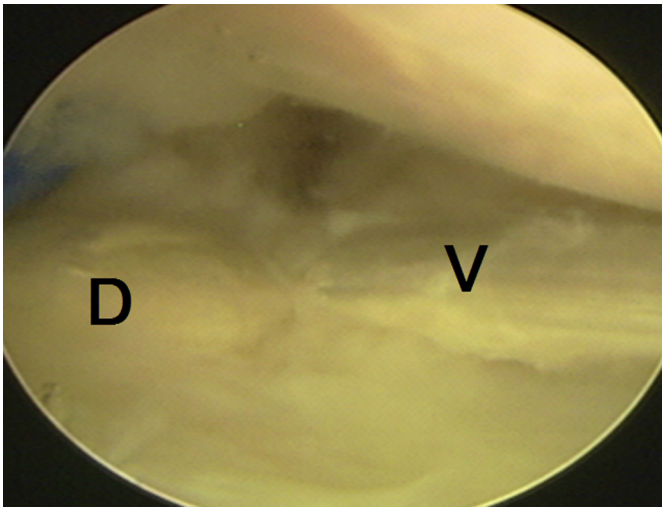


Fig. 5. This image indicates that both limbs of the graft were pushed back into the ulnar tunnel around the fovea region of the ulna. D = dorsal limb of the graft; V = volar limb of the graft.

Table 2
Mayo modified wrist score.

Pain point	
No pain	25
Mild occasional	20
Moderate	15
Severe	0
Work status	
Regular job	25
Restricted job	20
Able to work but unemployed	15
Unable to work due to pain	0
Range of motion	
>120°	25
100–119°	20
90–99°	15
60–89°	10
30–59°	5
0–29°	0
Grip strength (% of normal)	
90–100	25
75–89	15
50–74	10
25–49	5
0–24	0

Total point scores: excellent (91–100), good (80–90), fair (65–79), and poor (<64).

imaging (MRI) that indicated a TFCC tear, which was then confirmed by wrist arthroscopy. All 21 patients underwent wrist arthroscopy, which indicated TFCC tears with mild degenerative changes (Palmer type IIA or B). The tears and inflammatory synovium were debrided using a small joint power shaver. None of the patients developed interosseous ligament lesions. The function of the injured wrist was evaluated before surgery. Most patients had moderate ulnar wrist pain, could not work or tolerate military training, and had decreased grip strength (35–40% of that of the uninjured hand). Their Mayo modified wrist scores ranged from 30 to 55. After surgery, all 21 patients were followed up at the outpatient department for 25–48 months, with a mean follow-up duration of 36.2 months. None of the patients complained of persistent wrist pain during daily activities. Grip strength improved to approximately 65–90% of that of the other hand. Of the 21 patients, 11 (52.0%) achieved “excellent” results, 9 (43%) had “good” results, and 1 (5%) had “fair” results (Table 3). None of the patients had superficial wound infections.

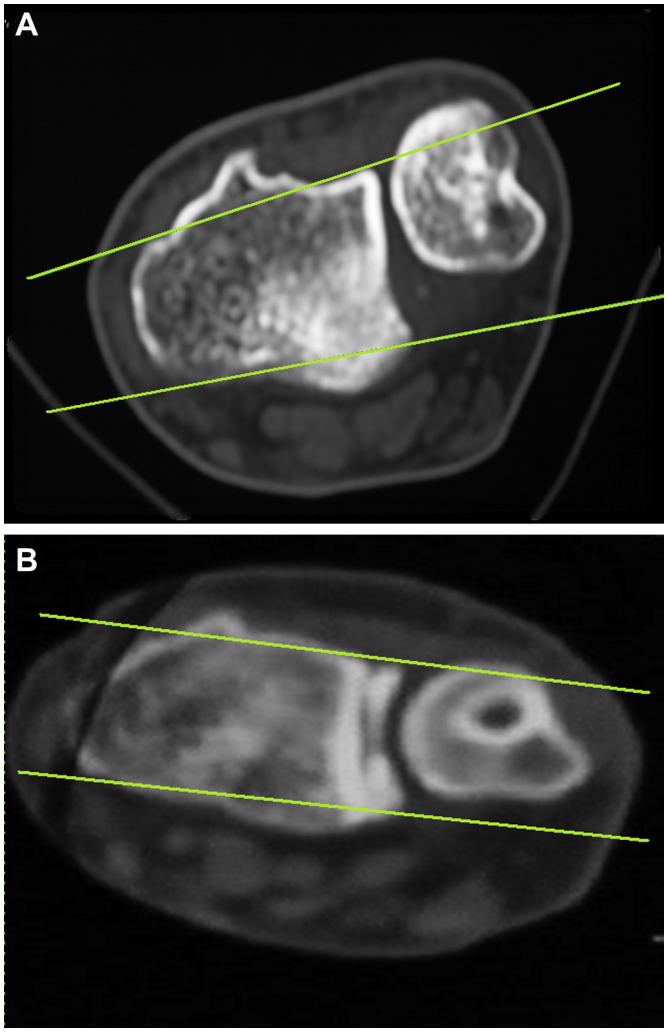


Fig. 6. (A) Preoperative computed tomography (CT) scan shows distal radioulnar joint (DRUJ) subluxation. (B) Postoperative CT scan shows the ulnar head located between the two tracing lines that define the dorsal and palmar borders of the radius.

4. Discussion

Restoration of stability and a full, painless range of motion are the goals of treatment for chronic, posttraumatic, unstable DRUJ. When surgical management is indicated and the TFCC is irreparable, preserving the distal ulna and reconstructing both the radioulnar ligaments provides the best possibility for achieving these goals. In 1991, Hermansdorfer and Kleinman[6] first reported a series of treatments for chronic TFCC tears. Eight of 11 patients resumed painless normal activity. However, it is difficult to treat patients with chronic TFCC tears and DRUJ instability. Several TFCC reconstruction procedures have been suggested to stabilize the DRUJ.[7–9] However, most of these methods only tighten the joint and reduce the pronation and supination capacity of the DRUJ. Hui and Linscheid[10] were the first to describe the anatomic reconstruction of dorsal DRUJ subluxation; this procedure involved TFCC reconstruction with a partial ECU tendon, and not only stabilized the DRUJ but also maintained pronation and supination. Thus, it significantly improved wrist function, and all the patients showed improved functional activity. In 1985, Darrow et al[11] reported the results of ulnar shortening in patients with ulnar wrist pain due to DRUJ instability, chronic TFCC tears, and Madelung deformity. They reported good or excellent results in 77% of cases. Biomechanical studies have demonstrated that shortening the ulna by just 2.0 mm significantly reduced the force transmitted to the ulna from the carpus.[12,13] In the current study, most patients underwent ulnar shortening following TFCC reconstruction due to the presence of a positive or zero ulnar variance. Ulnar shortening can reduce TFCC loading, thus preventing further degeneration. Moreover, ulnar shortening can also tighten the TFCC, thus increasing the stability of the DRUJ and the ulnocarpal joint.[14] Three patients in the current study had MRI scans that indicated the presence of TFCC tears. A previous study indicated that MRI had an accuracy rate of 95% in the detection of TFCC tears,[15] and therefore, MRI is highly sensitive for the diagnosis of TFCC tears. In our clinic, MRI scans revealed positive results in certain cases where arthroscopy had yielded negative findings. The current study demonstrated that the noninvasive technique is not sufficiently reliable for routine use, consistent with the findings of other studies.[16–18] Thus, arthroscopy appears to be the most accurate method for the diagnosis of TFCC tears. Several studies[19,20] have obtained satisfactory results after the immediate repair of acute TFCC tears. For chronic cases, short-term studies have demonstrated good results for partial TFCC excision, although some long-term studies have reported a failure

Table 3
Patient list.

Cases	Sex/age (y)	Ulnar variance (mm)	Fractures	Wrist scores	
				Preoperative	Postoperative
1	M/19	0	–	60	91
2	M/21	2	+	58	92
3	M/22	1	–	55	90
4	M/21	2	+	57	94
5	M/22	0	–	61	92
6	M/24	0	–	55	92
7	M/23	0	–	54	91
8	M/20	2	+	59	92
9	M/23	1	–	61	95
10	M/23	0	–	51	88
11	M/23	0	–	53	89
12	M/21	−1	–	50	83
13	M/20	0	–	55	80
14	M/21	−1	–	54	86
15	M/24	0	–	56	88
16	M/24	2	+	61	87
17	M/24	2	+	60	86
18	M/22	2	+	59	84
19	M/21	1	+	57	82
20	M/24	2	+	56	78
21	F/21	2	+	61	88
Mean	22.4	0.76		($p < 0.01$)	

rate of >30% when TFCC excision is performed without ulnar shortening.[21,22] In 1991, Osterman and Terrill[23] reported that the debridement of the redundant cartilage remnant was highly successful, with an overall improvement rate ranging from 75% to 85%. The study demonstrated that the debridement of the degenerative TFCC and inflammatory synovium via arthroscopy could successfully alleviate symptoms. However, ulna surgery remained an option for the remaining 15–25% of patients who still exhibited symptoms.

Only one patient in this study had "fair" scores after TFCC reconstruction. Although the symptoms of all the patients improved, they still reported mild pain during work or sport, and slight limitation of wrist supination. Possible causes of this condition are the adhesion of the grafts and degenerative changes in the wrist joints. The grip strength of these patients improved to at least 65% of that of the other hand. In addition, the wrist scores were better than those before surgery (Table 3). Three patients in this study developed superficial wound infections and were treated with antibiotics. These patients showed good results 2 years after surgery. TFCC reconstruction using the PL tendon under arthroscopy is an effective procedure. This procedure does not disturb the ECU sheath and surrounding tissues, thus preserving ulnocarpal stability.

This procedure enables intra-articular and anatomic reconstruction of both the dorsal and volar radioulnar ligaments (Fig. 5) via wrist arthroscopy. Compared to open reconstructions,[24,25] this mini-invasive procedure (not involving arthrotomy or creation of a large wound) facilitated early initiation of the rehabilitation program and shorter hospital stay. Arthroscopy enabled clear identification of the fovea region of the distal ulnar head, which allowed precise creation of the tunnel using a microvector drill guide. The tendon graft was passed from the dorsal and volar sides of the distal radius to the fovea region of the distal ulnar head, which was in close proximity to the rotation center of the ulnar long axis. From a biomechanical point of view, this insertion site is not only anatomic but also more isometric for the tendon graft during forearm supination and pronation. Therefore, the graft was able to prevent DRUJ diastasis and subluxation without impairing the range of motion (Fig. 7). After the tendon graft was removed from the ulnar tunnel, we sutured the tendon graft to itself and to the surrounding tissue.

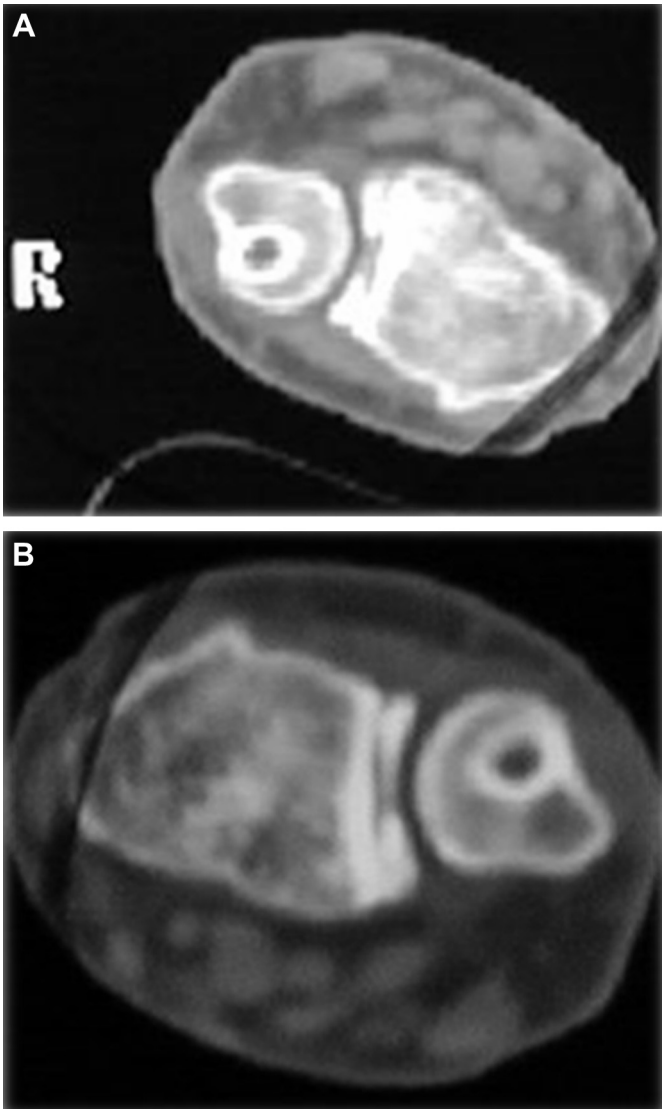


Fig. 7. (A, B) Postoperative computed tomography (CT) of the wrist in supination and pronation positions demonstrate good distal radioulnar joint (DRUJ) congruency and no motion limitation.

We did not loop the tendon graft limbs around the ulnar neck[24] because this more invasive method has not been proven to improve graft tension or DRUJ stability. In the current study, the tendon graft was fixed via a small incision over the ulnar neck without extensive dissection of the soft tissue, including the dorsal DRUJ capsule and extensor retinaculum.

For more chronic cases with preexisting DRUJ arthritis, the current procedure is contraindicated, and other techniques such as the Darrach and Sauvé-Kapandji procedures are recommended for pain relief. However, the results of the Darrach procedure are generally poor in patients with greater activity demands.[26,27] The Sauvé-Kapandji procedure yielded good results for patients who were young or those with greater activity demands.[28,29] However, the potential complications included nonunion or delayed union of the arthrodesis, fibrous or osseous union at the pseudoarthrosis, and painful instability at the proximal ulna stump.[30] In the current study, the patients were relatively young (age range, 19–24 years; mean age, 22.4 years) and the period from the event causing the tear to surgery was short (range, 14–28 months; mean, 22.6 months). All patients underwent early TFCC reconstruction prior to

degeneration. At the postoperative follow-up examination, 52% of patients achieved “excellent” results and 43% of patients had “good” results. We suggest that surgery should be performed at an early stage, immediately once reconstruction is indicated, and before the development of degenerative changes secondary to DRUJ instability or ulnocarpal impaction.

This procedure establishes a potentially satisfactory head-notch relationship, restores TFCC integrity and stability, maintains DRUJ supination and pronation motion, and reduces the force transmitted to the ulna. This would consequently reduce symptoms, improve wrist function, and enable patients to perform work, sport, and military training activities.

Therefore, TFCC reconstruction using the PL tendon under arthroscopy is an effective method for treating irreparable TFCC with chronic posttraumatic DRUJ instability.

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