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Outcomes of surgically treated distal radial fractures with associated triangular fibrocartilage complex injury

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ABSTRACT

Study Design: Prospective cohort.
Introduction: Clinical studies that evaluate the correlation between associated lesions of the triangular fibrocartilage complex (TFCC) and outcome of distal radial fractures expressed with the patient-rated disability are missing.
Purpose of the Study: To evaluate the outcomes of distal radius fractures associated with or without an injury of the TFCC.
Methods: Patients undergoing operative treatment for distal radial fracture were prospectively enrolled ($n = 70$). The TFCC was examined by wrist arthroscopy, and injuries were classified according to Palmer. Comparative analyses were performed on data from 45 patients with TFCC injury (the injured group) and 25 patients with an intact TFCC (the intact group). The outcome measures included The Patient-Rated Wrist Evaluation (PRWE) and the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaires, 3 and 12 months after injury.
Results: The TFCC was injured in 45 patients (64%). In patients with an intact TFCC, the mean total PRWE score was 27 (at 3 months) and 16 (at 12 months), whereas in patients with TFCC injury, it was 40 (at 3 months) and 24 (at 12 months). Mean DASH scores were 26 and 13 for the intact group and 39 and 27 for the injured group at 3 and 12 months, respectively. PRWE and DASH results showed significant difference at 3 and 12 months when compared using the Mann-Whitney test.
Conclusions: Disability outcomes were worse in patients with distal radial fracture where TFCC was injured. TFCC injuries are an important cofactor affecting the outcome of distal radial fractures.

Introduction

The triangular fibrocartilage complex (TFCC) is a soft-tissue structure frequently injured in distal radial fractures. In 1 cadaveric study where a hyperextension force was applied to cadaveric wrists until a distal radial fracture occurred, an injury to the TFCC occurred in 63% of the specimens.[1] The incidence of TFCC injury associated with distal radial fractures has been reported to range from 35% to 78%.[2]

Cheng et al.[3] reported that healed radial fractures were often complicated by chronic debilitating wrist pain, and one of the important causes was TFCC tears with or without distal radioulnar joint (DRUJ) instability. Ulnar avulsion of the TFCC can result in ulnar-sided wrist pain, decreased grip strength, reduced range of forearm rotation, and clinical signs of DRUJ instability.[4,5] Unrepaired peripheral tears of the TFCC interfere with its important functions related to wrist stability and load bearing.[6] Bohringer et al.[7] concluded that arthroscopic treatment of TFCC tears in acute radial fractures is possible and gives good results. Instability of the DRUJ is a hotbed for research, with new and innovative techniques for TFCC repair appearing daily.[8]

Studies that evaluated distal radial fracture outcomes reported no correlation of the radiographic outcomes with the disability after the injury, suggesting that a well-reduced fracture does not guarantee patient satisfaction.[9,10] Clinical studies that evaluate the

Ethical approval: All procedures performed in this study were in accordance with the ethical standards of our national research committee (Ministry of Health Ethical Board) and with the 1964 Helsinki Declaration and its later amendments.

Informed consent was obtained from all individual participants included in the study.

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correlation between associated lesions of the TFCC and outcomes of distal radial fractures expressed with the patient-rated disability are missing. The objective of this prospective study was to evaluate the outcomes of distal radial fractures with an associated injury of the TFCC. We tested the hypothesis that distal radial fractures have worse outcomes when associated with TFCC injury.

Materials and methods

Patients

After Ministry of Health Ethical Committee's approval was obtained, we conducted a prospective single-center study of patients with distal radial fractures (2012-2014). The inclusion criteria were distal radial fractures in adults aged 16-65 years needing operative treatment for the fracture. Surgical fixation was indicated for distal radial fractures with postreduction radial shortening > 3 mm, dorsal angulation > 10°, or intra-articular displacement > 2 mm.[11] The exclusion criteria were concomitant carpal or hand fracture on initial radiographs; bilateral distal radial fractures; previous wrist injuries or chronic wrist pain on either side; contraindications for wrist arthroscopy (local infection, compartment syndrome, and problems in positioning for vertical traction); arthroscopic findings of intrinsic ligament injury (scapholunate and/or lunotriquetral); and degenerative TFCC lesions. All patients gave their written informed consent.

Operative treatment

Diagnostic wrist arthroscopy preceded fracture fixation. All the operations were performed by the authors of this article. Arthroscopic examination was performed according to standardized protocols.[2,12,13] The patient was positioned supine (after giving general anesthesia), the hand was abducted, and a pneumatic tourniquet was applied. Wrist distraction was achieved using a mechanism for vertical wrist traction with finger traps. A 2.7-mm, 30° arthroscope was used. Initially, the arthroscope was introduced through the dorsal 3-4 portal, and the joint was lavaged to clear it off hematoma and fracture debris. An additional radiocarpal portal, 6R, was then created. A small joint shaver was placed through this portal to help clear all the remaining hematoma and dorsal synovitis and provide a clear view of all joint structures and the fracture site, which were examined using a probe. To examine the integrity of the TFCC, the trampoline and hook tests were used.[2,12,13] The arthroscopic findings of the TFCC were classified according to Palmer's classification system.[14] Dorsal midcarpal radial and midcarpal ulnar portals were created, and the midcarpal joint was inspected. After arthroscopic inspection of the radiocarpal and midcarpal joints (interosseous scapholunate and lunotriquetral ligaments were assessed to identify a tear; the distal radial articular surface was examined for fracture configuration), we performed definitive operative fixation of the distal radial fractures with arthroscopically assisted reduction and internal or external fixation. The injured TFCC was not repaired. Operated wrists were immobilized (those with internal fixation) for 5 weeks postoperatively to make sure the immobilization period is similar to that of the patients with external fixation.

Postoperative interventions

Immediately postoperatively, the patients were instructed by our department's physical therapist (The patients also received a printed instructions.) for at-home digit, elbow, and shoulder exercises. (These home exercises were not monitored.) After immobilization or external fixation was removed, all the patients were referred to physical therapy centers for active and passive interventions supervised by the specialists in physical therapy. All the patients received 12 sessions of a 1-hour supervised program for operatively treated distal radial fractures. Although patients were not blinded to the physical therapists, therapeutic interventions were not modified for patients with associated TFCC injuries.

Ten patients with concomitant carpal ligament injuries and 4 patients with degenerative TFCC tears were excluded as we assessed the association between fractures of the distal radial and TFCC injuries and not other carpal injuries and chronic TFCC wear. To unify the sample, only patients who had satisfactory postoperative fracture reduction according to Fernandez were included in the study.[15] Three patients were lost to follow-up. We analyzed 70 patients who met inclusion criteria and completed the follow-up. Distal radial fractures were classified according to Arbeitsgemeinschaft für Osteosynthesefragen classification, by two trauma surgeons analyzing all the radiographs, as well as arthroscopic findings of the articular fracture configuration.

Groups

Patients were assigned to the injured group ($n = 45$) if arthroscopy identified associated TFCC injury. If no associated lesion was diagnosed (intact TFCC, scapholunate and lunotriquetral

Table 1
Characteristics of the groups of evaluated patients

Patients	Total, *n* (%)	Intact, *n* (%)	TFCC, *n* (%)	*P* value
Gender				
Female	47 (67)	15 (60)	32 (71)	
Male	23 (33)	10 (40)	13 (29)	
Age (y)				.0528
Mean	50.01	45.56	52.49	
SD	14.39	15.36	13.36	
Maximum	65	65	65	
Minimum	16	16	18	
Mechanism of injury				
Fall on outstretched hand	45 (64)	15 (60)	30 (66)	
Fall from a height	20 (29)	8 (32)	12 (27)	
Crush injury	3 (4)	0	3 (7)	
Overdistension	2 (3)	2 (8)	0	
Injured side				
Left	39 (56)	16	23	
Right	31 (44)	9	22	
Dominant side				
Left	1 (1)	0	1	
Right	69 (99)	25	44	
AO classification				.873
A2	3 (4)	0	3 (7)	
A3	20 (29)	9 (36)	11 (24)	
B1	0	0	0	
B2	1 (1)	0	1 (2)	
B3	0	0	0	
C1	11 (16)	4 (4)	7 (16)	
C2	12 (17)	3 (4)	9 (20)	
C3	23 (33)	9 (36)	14 (31)	
Intra-articular fracture				.594
Yes	47 (67)	16 (64)	31 (69)	
No	23 (33)	9 (26)	14 (31)	
Ulnar styloid fracture				.364
Yes	47 (67)	15 (60)	32 (71)	
No	23 (33)	10 (40)	13 (29)	
Fracture fixation type				
AAIF K-wires	10 (14)	4 (16)	6 (13)	
External fixation augmented with K-wires	25 (35)	11 (44)	14 (31)	
ORIF volar conventional plate	18 (27)	5 (20)	13 (29)	
ORIF volar locking plate	16 (23)	5 (20)	11 (25)	
ORIF dorsal locking plate	1 (1)	0	1 (2)	

TFCC = triangular fibrocartilage complex; SD = standard deviation; AO = Arbeitsgemeinschaft für Osteosynthesefragen; AAIF = K-wires = arthroscopy-assisted percutaneous fixation with K-wires; ORIF = open reduction and internal fixation.

Table 2
Baseline PRWE questionnaire results

PRWE baseline	Intact	TFCC	*P* value
Pain			.842
Mean	19.6	21.44	
SD	6.82	7.96	
Specific activities			.455
Mean	54.4	54.2	
SD	8.31	9.08	
Usual activities			.816
Mean	31.56	32.87	
SD	5.28	6.49	
Total			.803
Mean	62.6	64.98	
SD	9.96	12.82	

PRWE = The Patient-Rated Wrist Evaluation; TFCC = triangular fibrocartilage complex; SD = standard deviation.

ligament), patients were assigned to the intact group (control group, $n = 25$).

Outcome measures

Subjective outcome was evaluated using the following patient-reported outcome measures: The Patient-Rated Wrist Evaluation (PRWE)[16] and the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.[17] We selected them because there is extensive evidence for their reliability, validity, and responsiveness in a distal radial fracture population.[17–21] The questionnaires were administered and explained to the patients by their surgeon during their 3- and 12-month follow-up visit. The baseline PRWE measurements were also completed 1 week after surgery; those results were used to determine between-group differences immediately after surgery.

The grip strength measurements were completed by the surgeon with a hydraulic hand dynamometer. The patients were evaluated seated, shoulders in a neutral position, elbow flexed 90°, and the forearm in neutral rotation. The unaffected side was evaluated first, and after that, the injured side was evaluated. Three attempts were made on both sides, and the highest values were recorded. The results are expressed as a percentage of the strength of the uninjured hand, correcting by a factor of 1.07 for the nondominant hand strength.[22] Grip strength was also measured at 3 and 12 months.

Statistical analysis

Power analysis was performed to determine the sample size. Literature data for the incidence of distal radial fractures and their associated injuries were extracted, and the number of patients required for the study according to the age group (16-65 years) was estimated with a statistical power of 95%. During the study, twice as many patients as estimated in each group were recruited for final evaluation.

Data were analyzed using SPSS Statistics for Windows, version 17.0 (SPSS Inc., Chicago, IL) and Minitab 15 Statistical Software (Minitab Inc., State College, PA). Descriptive statistics were computed and are represented as means and percentages as well as minimal and maximal values. A 2-sample *t* test was used to compare between-group differences in characteristics, as well as between-group differences in baseline pain and disability (with 95% confidence intervals). The Mann-Whitney *U* test was used to determine statistically significant differences in outcomes between 2 examined groups. A *P* value of less than .05 was considered statistically significant.

Results

In this study, 45 patients (64%) with arthroscopically diagnosed associated injury of the TFCC were included; in 25 patients (36%), the TFCC was intact. The mean age of the patients in this study was 50 years (range, 16 to 65 years); the majority were women (47 of 70). Table 1 presents patients' characteristics as well as fracture classification and type of fracture fixation.

There was no significant difference in the characteristics of the 2 groups with respect to age of the patients ($P = .0528$); severity of the injury according to Arbeitsgemeinschaft für Osteosynthesefragen classification ($P = .873$); the presence of an intra-articular fracture ($P = .594$); or the presence of an ulnar styloid fracture ($P = .364$). The baseline PRWE scores for the 2 examined groups are shown in Table 2. There were no significant differences in the

Table 3
PRWE scores at 3 and 12 months for the control group of distal radial fractures with intact TFCC

Item	3 mo				12 mo			
	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum
Pain								
At rest	0.4	0.65	0	2	0.36	0.7	0	2
Repeated movement	3.52	2.97	0	10	1.6	0.91	0	3
Lifting heavy object	4.04	2.68	0	10	2.44	1.64	0	5
At its worst	3.8	2.97	0	10	2.88	2.05	0	6
Frequency	2.4	1.12	0	4	2.48	2.42	0	8
Specific activities								
Turn a door knob	1.8	1.91	0	7	1.04	1.17	0	3
Cut meat with knife	2.12	2.20	0	8	1.8	2.57	0	8
Fasten buttons	1.12	1.54	0	5	0.28	0.79	0	3
Push up from a chair	3.44	2.29	0	8	2.12	1.69	0	5
Carry a 5 kg object	4.92	3.26	0	10	2.84	2.76	0	9
Use bathroom tissue	1.8	2.33	0	8	0.8	1	0	3
Usual activities								
Personal care	1	1.12	0	4	0.4	0.76	0	3
Household work	2.56	2.26	0	7	1.04	1.14	0	3
Work	3.56	3.31	0	10	1.6	2.6	0	8
Recreation	2.64	1.87	0	6	1	1.38	0	4
Pain (50)	14.16	8.25	0	29	9.76	6.75	0	23
Specific activities (60)	15.2	10.84	1	42	8.88	7.64	0	24
Usual activities (40)	9.76	6.48	0	21	4.04	5.22	0	16
Total score (100)	26.64	14.18	1	54	16.22	12.7	0	43

PRWE = The Patient-Rated Wrist Evaluation; TFCC = triangular fibrocartilage complex; SD = standard deviation.

Table 4
PRWE scores at 3 and 12 months for the examined group of distal radial fractures with associated TFCC injury

Item	3 mo				12 mo			
	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum
Pain								
At rest	1.67	2.42	0	8	0.98	1.53	0	8
Repeated movement	3.49	2.33	0	10	2.62	2.04	0	9
Lifting heavy object	5.84	2.93	0	10	3.73	2.2	0	8
At its worst	5.64	3.01	1	10	4.24	2.34	0	9
Frequency	4.18	2.69	1	10	2.93	2.4	0	10
Specific activities								
Turn a door knob	3.42	2.85	0	9	1.62	1.89	0	8
Cut meat with knife	4.33	2.98	0	10	2.58	2.14	0	8
Fasten buttons	2.31	2.22	0	8	1.51	1.59	0	8
Push up from a chair	4.84	3.51	0	10	2.38	1.92	0	7
Carry a 5 kg object	6.44	3.35	0	10	3.64	2.31	0	9
Use bathroom tissue	3.44	3.14	0	10	1.58	2.05	0	8
Usual activities								
Personal care	2.8	2.9	0	10	1.31	1.47	0	5
Household work	3.49	2.53	0	9	1.78	1.72	0	6
Work	4.13	3.27	0	10	1.82	1.85	0	7
Recreation	3.62	2.69	0	10	1.64	1.85	0	6
Pain (50)	20.82	10.89	4	48	14.51	8.8	0	39
Specific activities (60)	24.8	14.39	0	56	13.31	9.07	0	36
Usual activities (40)	14.04	10.56	0	38	6.56	6.27	0	22
Total score (100)	40.24	20.78	6.5	95	24.44	15.35	0	63.5

PRWE = The Patient-Rated Wrist Evaluation; TFCC = triangular fibrocartilage complex; SD = standard deviation.

baseline pain and disability characteristics of the 2 groups as well (presented as *P* values in the Table 2).

Based on Palmer's classification, there was a central TFCC perforation (type IA) diagnosed in 6 patients, an ulnar lesion (IB) in 9 patients, a distal lesion of the ulnolunate or ulnotriquetral ligaments (IC) in 4 patients, and radial TFCC tears in 26 patients (ID).

PRWE scores for the intact and injured groups are shown in Tables 3 and 4, respectively, and Figure 1 compares means of both groups. Table 5 and Figure 2 present the DASH questionnaire scores. PRWE scores, as well as DASH scores, for the 2 examined groups were compared using nonparametric Mann-Whitney test (95% CI) (Table 6). The PRWE results showed significant difference in pain, specific activities, and usual activities at 3 and 12 months, as well significant difference in total pain and disability at 3 and 12 months. DASH results also differed significantly at 3 and 12 months.

Grip strength results are shown in Table 7. When compared using the Mann-Whitney test, significant difference was found at 3 months after operation (W = 1131.0, $P = .0029$). At 12 months, the difference in grip strength was not significant (W = 985.0, $P = .2341$).

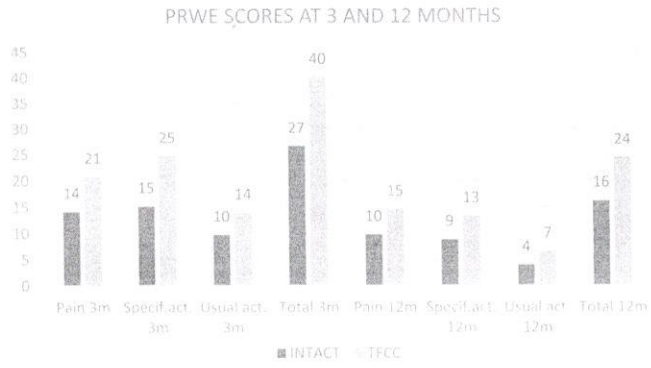

Fig. 1. Mean PRWE scores for the 2 examined groups, 3 and 12 months after injury. INTACT = group of patients with no associated injury; TFCC = group of patients with associated TFCC injury; Spec.act. = specific activities; Usual act. = usual activities.

Discussion

Results of the PRWE pain and disability evaluation showed that patients with a distal radial fracture with an associated lesion of the TFCC have significantly greater pain 3 and 12 months after injury, as well as significantly greater disability at 3 and 12 months, compared with patients with an intact TFCC. DASH results also showed that patients with associated TFCC injury had greater disability at 3 and 12 months after injury. The statistical difference confirms that patients with distal radial fracture with associated TFCC injury had worse disability outcomes than those with an intact TFCC.

Many studies and meta-analyses failed to show advantage of one fixation method over another in distal radial fractures. The functional and subjective outcomes of the treatment of the distal radial fracture are not influenced by the type of the fixation method used. That is why the patients in our study were not divided into groups based on the fixation method used. To make sure there is no difference between the patients with internal and external fixation, the patients with internal fixation were immobilized for 5 weeks postoperatively, similar to those with external fixation. To additionally unify the samples (and minimize the influence of the fixation method on the outcome), we evaluated only the patients with satisfactory postoperative reduction.

Three studies have linked TFCC injury to poorer clinical outcomes after a distal radial fracture.[23-25] Instability of the DRUJ at

Table 5
DASH questionnaire scores at 3 and 12 months

Group	DASH score			
	Mean	SD	Minimum	Maximum
3 mo				
Intact	26.03	11.83	12.5	49.17
TFCC	39.41	19.43	5.83	84.17
12 mo				
Intact	13	11.98	0	35.83
TFCC	27.26	18	0.83	69.17

DASH = Disability of Arm, Shoulder and Hand; SD = standard deviation; TFCC = triangular fibrocartilage complex.

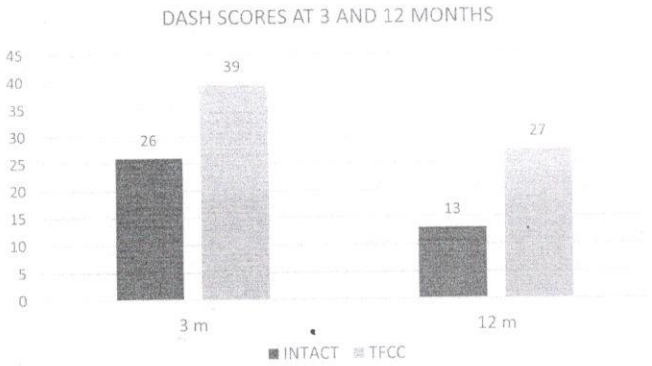

Fig. 2. Mean DASH scores, 3 and 12 months for the 2 examined groups. INTACT = group of patients with no associated injury; TFCC = group of patients with associated TFCC injury.

clinical examination was associated with a worse Gartland and Werley score 1 year after injury[23] and after 6 years,[24] so the destabilizing TFCC injuries are thought to be an important cause of residual problems. Ten of the 11 patients with arthroscopically confirmed complete peripheral TFCC tears had DRUJ instability at 1 year follow-up; they had a worse Gartland and Werley score.[25]

Previous studies that have evaluated outcomes of distal radial fractures with associated TFCC injury used only objective outcome measures (grip strength, forearm and wrist motion, clinical signs of DRUJ instability, and ulnar-sided pain) or functional scoring systems (as Gartland and Werley score). Few studies showed that the deficit in anatomic structures (radiographic abnormalities) or physiology (impairments) as an outcome measure does not reflect the activity limitation (difficulty doing tasks) and participation restriction (difficulty engaging in roles).[22,26] This points out the importance of incorporation of the patient-rated questionnaires in disability evaluation.[26,27] We evaluated the disability of the patients with distal radial fractures with associated TFCC injury using these questionnaires as outcome measures. We found no other studies addressing the quality of life in individuals after distal radial fracture with injured TFCC. However, there are studies that have showed improvement in disability scores after TFCC reconstruction.[28,29]

When treating distal radial fractures, not only bone reduction and fixation but also the effect of associated soft-tissue lesions on postoperative outcomes has to be considered.[30-32] TFCC injuries associated with fractures are frequent and affect distal radial fracture outcomes. TFCC injuries also have to be considered by surgeons and hand therapists as a potential cause for greater pain and disability. Hand therapists have to expect worse results after standard rehabilitation protocols for operatively treated distal radial fractures in patients with associated TFCC injuries.

Table 6
Mann-Whitney test for the PRWE and DASH score results at 3 and 12 months for the 2 examined groups

Results	W	*P*
PRWE pain at 3 mo, intact/TFCC	692.5	.0170[a]
PRWE specific activities at 3 mo, INTACT/TFCC	676.0	.0097[a]
PRWE usual activities at 3 mo, intact/TFCC	771.5	.0156[a]
PRWE total at 3 mo, intact/TFCC	680.5	.0113[a]
PRWE pain at 12 mo, intact/TFCC	692.5	.0169[a]
PRWE specific activities at 12 mo, intact/TFCC	712.0	.0315[a]
PRWE usual activities at 12 mo, intact/TFCC	756.5	.0220[a]
PRWE total at 12 mo, intact/TFCC	692.0	.0167[a]
DASH at 3 mo, intact/TFCC	650.5	.0037[a]
DASH at 12 mo, intact/TFCC	608.5	.0006[a]

PRWE = The Patient-Rated Wrist Evaluation; DASH = Disabilities of Arm, Shoulder and Hand; TFCC = triangular fibrocartilage complex.
[a] Significant difference.

Table 7
Grip strength (percentage of the uninjured side) at 3 and 12 months for the 2 examined groups

Group	Grip strength (%)			
	Mean	SD	Minimum	Maximum
3 mo				
Intact	61.46	25.82	0	87.62
TFCC	43.63	27.28	0	98.08
12 mo				
Intact	78.86	18.06	40.88	128.4
TFCC	72.64	22.49	0	124.61

SD = standard deviation; TFCC = triangular fibrocartilage complex.

Literature suggests debridement for Palmer type IA and ID and suture or reinsertion for type IB TFCC lesions.[2,12,13] Considering this, our study identified 41 patients (59%) with TFCC lesion potentially amenable for operative treatment.

Results presented in this study are part of a larger study of patients with distal radial fracture where effect of all associated soft-tissue lesions was analyzed. Previously, we reported the outcomes of these fractures when associated with intrinsic ligament lesion. A limitation of this study is the follow-up period of only 12 months. Although majority of recovery from a distal radial fracture occurs within 6 months of the fracture,[33-35] healing and rehabilitation process may not be complete 12 months after injury, so studies with a longer follow-up periods are needed.

All patients with arthroscopically diagnosed TFCC injury were considered in a single group for statistical calculations. They were not subgrouped by the Palmer classification type of the TFCC injury because of the total number of patients available for this study (double the number of the minimum sample size that was calculated). Because the results showed worse outcomes in patients with associated TFCC lesion and, in this study, the TFCC was not repaired, we felt it was not appropriate to continue to study larger number of participants. We could not exclude the possibility that if separate TFCC injury types were analyzed, the results would have been different.

This study evaluated only surgically treated distal radial fractures where satisfactory postoperative fracture reduction was achieved. We could not confirm whether our results could be extrapolated to malunited distal radial fractures, so this should be considered as a limitation of this study.

In conclusion, the present study provides evidence that patients with distal radial fracture with associated TFCC injury have worse outcomes than those in whom the TFCC is intact. When treating distal radial fractures, not only bone reduction and fixation but also TFCC injuries have to be considered by surgeons and hand therapists as a potential cause for greater pain and disability. Wrist arthroscopy is useful as a diagnostic, as well as therapeutic, tool for these associated injuries in distal radial fractures.

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