Outcomes after Arthroscopic Debridement of the Triangular Fibrocartilage Complex in Adolescents

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Abstract

Background To the best of our knowledge, we are not aware of any reports focusing on results of arthroscopic debridement of triangular fibrocartilage complex (TFCC) tears in immature patients.

Purpose The purpose of this study was to evaluate our results after arthroscopic debridement of TFCC tears in adolescents.

Materials and Methods We retrospectively identified all patients of 18 years or less, who received an arthroscopic TFCC debridement due to a traumatic or degenerative tear according to Palmer. These cases were clinically re-evaluated after a mean period of 6.7 years (SD $\pm$ 3.9 years). All patients completed the Modified Mayo Wrist Score (MMWS), Disabilities of the Arm, Shoulder and Hand (DASH) inventory, and Patient-Rated Wrist Evaluation (PRWE).

Results Thirteen adolescent patients (mean age: 15.6 ± 2.2 years at surgery) were included. The mean MMWS increased significantly from 70 ± 13.6 to 90 ± 6.5 after the TFCC debridement; mean postoperative DASH and PRWE scores of 17 ± 15.2 and 21 ± 18.5 , respectively, indicated good and excellent outcomes for the majority of the cohort. The mean pain level decreased significantly from a mean of 5.7 ± 2.0 to 1.8 ± 2.0 at follow-up. Six patients needed a reoperation to achieve a successful outcome.

Conclusion Arthroscopic debridement of TFCC tears, performed as a concomitant wrist surgery in adolescents, efficiently reduced wrist pain and yielded good to excellent results in the long term. However, under certain circumstances, its results are unpredictable and further surgery may be necessary to eventually achieve the satisfying outcomes. Further studies are needed to confirm these findings.

Level of Evidence Level IV, therapeutic case series.

Keywords

- adolescents
- children
- debridement
- triangular fibrocartilage complex
- resection
- DRUJ

Triangular fibrocartilage complex (TFCC) tears are common findings in the painful ulnocarpal wrist joint.^{1,2} In general, injuries of this particular structure are more frequently seen with increasing age.³ However, immature patients are also prone to such lesions, which often occur concomitantly with fractures of the distal radius.⁴ While avulsions of the TFCC from its radial or ulnar styloid insertion can be repaired reliably using a host of different techniques (e.g., all-inside, inside-out, and

outside-in sutures), central perforations and flap-like tears cannot be repaired due to a lack of vascularized tissue. Eighteen of 32 biopsy specimens of centrally located TFCC tissue did not reveal any blood vessels in a cadaver study.⁵ Hence, debridement/partial resection of the TFCC to a stable rim was indicated to restore joint integrity by elimination of mechanical and thus inflammatory stimuli. Common devices to accomplish such procedures include shavers, punches, and laser-assisted devices

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such as holmium-YAG laser instruments.⁶ Therefore, several studies investigated the clinical outcomes after TFCC debridement in adult populations with the majority reporting good to excellent results.^{7–14} Only a few studies questioned whether this procedure had a positive impact on patient outcomes.^{15,16}

While all these procedures have been performed almost exclusively in adult patients, literature on arthroscopic TFCC surgery in children and adolescents is scarce. To date, only a few reports in the literature mentioned arthroscopic wrist surgery in children, and even fewer studies investigated results after TFCC surgery in this age group.^{2,17–19} Farr et al, for example, reported good short-term clinical outcomes after TFCC repair. They showed significant pain reduction and improvement in both Modified Mayo Wrist Scores (MMWS) and physiologic grip strength when compared with the contralateral side in 12 adolescents.¹⁸ Similarly, Terry and Waters observed complete pain relief in four cases undergoing arthroscopic TFCC repair.¹⁹ However, we are—to the best of our knowledge—not aware of any such reports on TFCC debridement in pediatric patients.

Thus, the purpose of this study was to evaluate our long-term results after arthroscopic debridement of TFCC tears in children and adolescents. We asked whether this procedure would be a reliable means of reducing wrist pain and improving function, as shown by dedicated functional outcome scores, in this young population.

Materials and Methods

Institutional review board approval was obtained prior to this retrospective study. Thereafter, all patients who underwent wrist arthroscopy and received arthroscopic debridement (partial resection) of an injured TFCC tear between 2002 and 2015 were identified by our hospital data registration system. Patients who fulfilled the inclusion criteria were invited for a single clinical follow-up examination. Informed consent was obtained from all patients (or their legal guardians) prior to the examination. The following inclusion criteria were defined: patients of 18 years of age or less at surgery; minimum follow-

up of one year; wrist arthroscopy revealing a traumatic (type 1) or degenerative (type 2) TFCC tear according to Palmer²⁰; and arthroscopic debridement or partial resection of the TFCC with or without concomitant hand/forearm surgery. All patients more than 18 years of age and those with incomplete pre- or postoperative data were excluded.

Thirteen adolescent patients (1 male, 12 females) fulfilled the inclusion criteria and were clinically re-evaluated after a mean follow-up of 6.7 years (SD $\pm$ 3.9; range, 1.2–14.0). Eight left and five right wrist joints were evaluated. The mean age at the time of initial surgery was 15.6 years (SD $\pm$ 2.2; range, 11.2–18.5 years) and at the final follow-up was 22.4 years (SD $\pm$ 3.6; range, 16.9–28.4 years). The mean duration between the first examination at our tertiary referral center and wrist surgery was 0.5 year (SD $\pm$ 0.5; range, 0.0–1.8 years). Seven patients stated that they initially sustained an injury prior to developing pain.

Surgical Technique

The wrist arthroscopy was performed in a standardized manner with the patient in the supine position.¹⁷ The forearm was positioned over an arm table, fixed in an elevated position using a wrist traction device (Maquet; Rastatt, Germany), and extended using 2 to 3 kg bags. Standard 3/4 and 6R ports were installed. First, the wrist joint was inspected with a 2.3-mm 30 degree arthroscope and a probe. The integrity and stability of the TFCC and the intercarpal ligaments were assessed with the probe, and standardized tests (hook test, trampoline test) were performed to rule out a peripheral, repairable TFCC tear. Generally, a positive hook test and/or a loss of trampoline effect are established methods to confirm a peripheral TFCC tear. Any TFCC tears present were then classified according to Palmer's classification.²⁰ Whenever a TFCC tear, located either centrally (type 1A, 2A, 2C), radial sided with intact palmar and dorsal insertions (type 1D), or even ulnar sided (1B)—which we would nowadays repair—was confirmed by arthroscopy, debridement of the TFCC, and resection of any flaps to a stable rim were performed (→ Figs. 1 and 2). Different arthroscopy punches and a shaver were used to provide

Fig. 1 Arthroscopic view from the 3/4 portal showing a central, flap-like TFCC tear before (A) and after resection to a stable rim (B). TFCC, triangular fibrocartilage complex.

Fig. 2 Arthroscopic view from the 3/4 portal showing a small, central, slit-like TFCC tear before (A) and after debridement (B). The ulnar head is eventually visible below the resected TFCC. TFCC, triangular fibrocartilage complex.

smooth TFCC edges. Whenever possible, we usually intended to keep any deep fibers of the foveal TFCC insertion intact. Chondroplasty of the ulnar head was not performed routinely in children or adolescents to retain as much viable tissue as possible. Concomitant operative procedures were performed in the same session as needed (► **Table 1**). We usually add an ulnar shortening osteotomy only in cases of ulnar positive variance and carpal edema in magnetic resonance imaging (MRI) sequences. In cases with no concomitant bone procedure, the operated wrist was then immobilized in a well-padded dressing with elastic bandage for 2 weeks. Thereafter, occupational therapy (active and passive motion exercises) was started. Full load bearing and sports participation were allowed after substantial pain relief was achieved but usually not before 3 months postoperatively.

Follow-Up and Outcome Measures

Children and adolescents who were included in this investigation originally reported persistent ulnar-sided wrist pain for at least 3 months despite conservative treatment (e.g., NSAIDs, activity modification, occupational therapy, splinting). Standardized anteroposterior (AP) and lateral wrist radiographs as well as MRI studies were obtained for all patients prior to wrist arthroscopy. We routinely do not obtain MRI arthrography in children due to its increased invasiveness. We followed a previously established treatment algorithm for children and adolescents with chronic wrist pain.² Since 3 months of conservative treatment may be brief for some patients, we usually follow conservative treatment for up to 6 months if imaging is unremarkable. Certain preoperative clinical findings including wrist and forearm range-of-motion (ROM), intraoperative findings (including the type of TFCC tear according to Palmer²⁰), concomitant surgical procedures, preoperative wrist pain level according to a visual analog scale (VAS; 0–10 point scale), and the MMWS (91–100 points, excellent; 81–90 points, good; 71–80 points, fair; ≤ 70 points, poor)^{21,22} were determined by a formal chart review. We then collected the following clinical data from both the operated and contralateral wrists and patient-reported outcome measures during the invited follow-up examination: wrist ROM (sagittal, frontal plane), forearm pro-/supination, stability of the distal radio-ulnar joint (in pro-/supination/neutral position), intra- and postoperative complications, VAS, MMWS, the Disabilities of the Arm, Shoulder and Hand (DASH) inventory (0–100 point scale; low scores indicate better outcomes, high scores indicate worse outcomes),^{23,24} and the Patient-Rated Wrist Evaluation (PRWE; 0–100 point scale, low scores indicate better outcomes and high scores indicate worse outcomes).²⁵ Ulnar variance was measured on AP wrist radiographs using the method of perpendiculars. Finally, grip strength of both hands was assessed using the Jamar dynamometer (Biometrics Ltd., United Kingdom). Each grip measurement was recorded in triplicate in a standardized manner and an average value was calculated. Absolute values in kilograms (kg) and the percentage of grip strength compared with the healthy contralateral side were reported. Moreover, surgery-related complications were graded according to Goslings and Gouma²⁶ as follows: 0 (no harm), 1 (temporary disadvantage, no reoperation), 2 (recovery after reoperation), 3 (probably permanent damage/disability), 4 (death), and 5 (unclear due to untimely death, not applicable in this study).

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Statistical Analysis

All pre- and postoperative MMWS and VAS scores, as well as the postoperative MMWS, VAS, and grip measurements of the operated wrist and the contralateral unoperated side, were compared using Wilcoxon signed-rank test. All continuous data were reported using means, standard deviations (SDs), and ranges. The significance level was set at $p < 0.05$.

Results

The initial pathological findings and the concomitant procedures that were performed are listed in ► **Table 1**. The main TFCC tear patterns according to Palmer were traumatic central tears such as type 1A ($n = 3$; 23%) and combined type 1A/D

Table 1 Overview of case cohort undergoing arthroscopic TFCC debridement

Case no.	Sex	Age at surgery (y)	Follow-up (y)	Injury	Surgery		
					Additional findings	Concomitant procedures	Further surgery
1	F	16.3	9.9	Yes	Synovitis	Synovectomy	DRUJ stabilization
2	F	13.3	12.1	No	Synovitis	Synovectomy	Ulnar shortening Osteotomy
3	F	16.6	6.5	Yes	Synovitis, Madelung's deformity	Synovectomy	
4	F	13.0	14.0	Yes	Scapholunate ligament tear (Geissler grade 1)		
5	F	17.8	1.2	No			DRUJ stabilization, ECU rerouting, partial wrist denervation
6	M	17.0	6.2	Yes	Synovitis, ligamentous hyperlaxity	Arthroscopic ligament shrinking	
7	F	15.0	7.0	Yes	Mild ulna hypoplasia		Corrective osteotomy radius/ulna, Partial wrist denervation
8	F	16.9	1.2	Unknown	Mild ulna hypoplasia, Radioulnar impingement	Ulna corrective osteotomy	
9	F	18.5	9.9	No	Chondromalacia lunate fossa	Biopsy (synovia)	
10	F	15.5	4.9	No	Madelung's deformity		Ulnar shortening osteotomy
11	F	18.3	2.7	No	Ligamentous hyperlaxity	Arthroscopic ligament shrinking	
12	F	11.2	5.7	Yes	Ligamentous hyperlaxity	Arthroscopic ligament shrinking	Distal ulna epiphysiodesis
13	F	14.1	5.9	Yes	Ganglion cyst	Ganglion excision	

Abbreviations: DRUJ, distal radioulnar joint; ECU, extensor carpi ulnaris tendon; F, female; M, male; TFCC, triangular fibrocartilage complex.

($n = 3$; 23%) tears. Moreover, other tear locations such as type 1B ($n = 2$; 15%), type 1D ($n = 1$; 8%), and combined types 1B/D ($n = 2$; 15%) were also found and debrided. Only two cases with degenerative TFCC tears were treated (type 2A [$n = 1$; 8%], type 2C [$n = 1$; 8%]).

Clinical Results

The patients' pain level on VAS decreased significantly from a mean of 5.7 (SD $\pm$ 2.0; range, 3–9) to a mean of 1.8 (SD $\pm$ 2.0; range, 0–6) postoperatively ($p = 0.007$). Thereafter, the postoperative VAS did not differ significantly from the unoperated contralateral side (mean 0.5 [SD $\pm$ 1.7; range, 0–6], $p = 0.074$).

We observed a significant increase in the MMWS from a mean of 70 (SD $\pm$ 13.6; range, 50–85) to a mean of 90 (SD $\pm$ 6.5; range, 80–100) after surgery ($p < 0.002$, **Fig. 3A**). The difference in the postoperative MMWS between the operated and contralateral sides at the final follow-up was not statistically significant ($p = 0.081$). No preoperative DASH or PRWE scores were available for this analysis. The

mean postoperative DASH score of 17 (SD $\pm$ 15.2; range, 0–47) indicated an excellent outcome after the TFCC debridement procedure for the overall cohort (**Fig. 3B**). In cases where the DASH Sports and Work Modules were completed, mean scores of 41 (SD $\pm$ 33.8; range, 0–75) and 21 (SD $\pm$ 30.4; range, 0–78) points were reported, respectively (**Table 2**). Hence, these results suggested good (work module) and fair (sports module) outcomes for these two subscales, respectively. The mean postoperative total PRWE of 21 (SD $\pm$ 18.5; range 0–62) confirmed the overall good clinical outcome for the cohort (**Fig. 3C**).

The mean postoperative ROM arc was 98° for wrist flexion–extension (SD $\pm$ 16.8; range, 85–150°), 93° for wrist radial deviation–ulnar deviation (SD $\pm$ 26.8; range, 67–171°), and 100° for forearm pro-/supination (SD $\pm$ 9.0; range, 83–113°) of the contralateral side (**Table 2**). The postoperative grip strength averaged 87% (SD $\pm$ 32.5; range, 35–153%) of the contralateral side at final follow-up. No significant difference in grip strength between the operated wrist and the unaffected side was observed ($p = 0.064$).

Fig. 3 Postoperative MMWS (A), DASH scores (B), and PRWE scores (C) of the study group and contralateral side (only for the MMWS) are presented. DASH, Disabilities of the Arm, Shoulder and Hand; MMWS, modified Mayo wrist scores; PRWE, patient-rated wrist evaluation.

Complications

Two adolescents reported recurrence of pain after a short period of decreased pain due to a clinically diagnosed distal radioulnar joint (DRUJ) instability (grade 2). Two patients needed to undergo an ulnar shortening procedure, and one required a distal ulnar epiphysiodesis due to the eventual development of an ulnar-sided impaction syndrome (grade 2). The latter one was the only case necessitating a shortening osteotomy, which had an ulnar positive variance prior to arthroscopy. Another patient later underwent staged distal radius and ulnar correction osteotomies due to an associated mild ulna hypoplasia, which was not initially addressed because of a lack of DRUJ symptoms (grade 2).

Discussion

The current study investigated the clinical long-term results after TFCC debridement procedures in children and adolescents. We obtained standardized outcome scores and grip measurements to find out whether TFCC debridement was beneficial for this immature age group.

Despite the long follow-up period and rigorous inclusion criteria, this study has several limitations. First, it is limited by its relatively small sample size. Second, our cohort comprised patients with mainly, but not only, central tears because formerly we used to debride peripheral TFCC tears as well in accordance with the previous literature.^{13,27} Moreover, several concomitant procedures were performed. Although most of the concomitant procedures were of mild nature, it remains unclear, if TFCC debridement was the only factor that led to the clinical improvements. Nevertheless, predominant preoperative symptoms such as a positive fovea sign disappeared in all cases after surgery, making it likely that TFCC surgery was a main factor for improvements. Moreover, the accounted variable copathologies represent the broad spectrum of pediatric wrist pathologies associated with traumatic TFCC injuries. However, further studies with cases without copathologies should be performed to confirm our findings.

Several other studies have reviewed the results following TFCC debridement procedures including both central and peripheral tears in adults.^{7-14,27} Minami et al investigated the results of 16 cases after a mean follow-up of 35 months.⁹ The overall results were excellent in 13 of 16 patients but slight pain remained in eight wrists, and 3 patients were dissatisfied due to moderate to severe residual pain. Darlis et al reported good and excellent outcomes according to the MMWS in 85% of the cases.⁷ TFCC lesions, however, are often accompanied by other interosseous ligament tears as shown by Tan et al.⁸ Nevertheless, improvement of symptoms can be obtained even in these cases in as many as 85% of patients.⁸ Similarly, Husby and Haugstvedt debrided 26 central and 6 radial tears with 18 cases having an associated chondral injury.¹⁰ In addition, they reported good and excellent results in 27 of 35 cases, including almost full restoration of both wrist motion (94%) and grip strength (94%).¹⁰

Some authors also presented less convincing findings. De Smet et al stated that only 18 of 42 adult patients were satisfied with their interventions after a mean follow-up of 29 months.¹⁵ In another study, the procedure failed in a total of 12% of cases.¹¹ Nishizuka et al, who compared results after ulnar shortening osteotomy versus TFCC repair, TFCC debridement, or conservative treatment, reported that TFCC debridement yielded inferior results with regard to function and pain relief.¹⁶

We observed a clinically significant reduction in pain and definitive functional improvements in dedicated wrist outcome scores and ROM. However, a high percentage of patients needed subsequent surgical procedures to achieve these good results. As mentioned by Jang et al,²⁸ both DRUJ instability and ulnar impaction are among the most common reasons for repeat wrist arthroscopy. Therefore, these are thoroughly assessed routinely before and after arthroscopy in our

Table 2 Functional outcomes after TFCC debridement

Case no.	VAS preop	VAS postop	VAS control	MMWS preop	MMWS postop	MMWS control	DASH postop	PRWE postop	Grip strength (kg)	Grip strength control (kg)	Grip strength (%)	ROM (S) (degrees)	ROM (F) (degrees)	ROM (P/S) (degrees)	DRUJ instability (at final follow-up)	Ulnar variance
1	6	1	0	50	95	100	8	7	28.5	33.4	85	97	86	100	None	Negative
2	N/A	0	0	80	100	100	0	0	35.2	31.7	111	91	79	94	Mild	Neutral
3	N/A	2	1	N/A	85	90	19	21	30.0	22.9	131	100	100	93	Moderate	Neutral
4	8	4	0	70	80	100	47	62	16.1	36.0	45	88	69	100	Mild	Unknown
5	7	0	0	65	95	100	30	19	19.6	12.8	153	100	89	100	Moderate	Positive
6	4	2	0	85	90	100	10	20	28.9	37.8	76	91	109	106	None	Neutral
7	8	0	0	50	95	80	12	9	20.1	24.8	81	85	81	100	None	Negative
8	4	2	0	85	85	100	17	16	17.7	21.4	83	93	83	83	None	Negative
9	3	5	0	75	80	100	21	35	13.0	21.1	62	87	67	88	None	Neutral
10	4	1	6	65	90	80	4	15	18.6	18.4	101	150	171	109	Mild	Neutral
11	5	1	0	80	95	95	5	10	19.2	20.3	95	103	109	113	Moderate	Negative
12	5	0	0	80	95	100	8	5	19.3	26.8	72	87	88	106	Severe	Positive
13	9	6	0	50	85	100	46	53	10.2	29.4	35	100	82	113	None	Negative
Mean (±SD)	5.7 (2.0)	1.8 (2.0)	0.5 (1.7)	70 (13.6)	90 (6.5)	96 (7.6)	17 (15.2)	21 (18.5)	21 (7.3)	26 (7.4)	87 (32.5)	98 (16.8)	93 (26.8)	100 (9.0)		

Abbreviations: Control, contralateral wrist; DASH, Disabilities of the Shoulder, Arm and Hand; DRUJ, distal radioulnar joint; F, frontal; MMWS, Modified Mayo Wrist Score; N/A, not available; P/S, pro-/supination; postop, postoperative; preop, preoperative; PRWE, Patient-Rated Wrist Evaluation; ROM, range-of-motion; S, sagittal; SD, standard deviation; TFCC, triangular fibrocartilage complex; VAS, visual analog scale.

institution. Accordingly, two patients eventually needed a DRUJ stabilization, two an ulnar shortening osteotomy, and one patient, who had a huge growth potential in the distal ulna, required temporary distal ulnar epiphysiodesis.²⁹ These repeat interventions were performed 6 months (DRUJ) to more than 2 years (ulnar shortening) after index surgery. Both cases with DRUJ instability were apparently stable before the intervention and became unstable thereafter owing to an extensive, unrepairable TFCC tear and thus thorough TFCC debridement. However, the instability became evident 2 to 3 months postoperatively after patients resumed heavier daily life activities. The other revision cases exhibited dynamic ulnar positive variance in wrist radiographs (one case) and ulnar impaction syndromes visible on MRI sequences (two cases) over time. Prior to the index intervention, only one of them presented with a static ulnar positive variance on plain films but without any evidence of ulnar impaction on MRI; the other two cases eventually shortened were ulnar neutral at index surgery. According to many reports in the literature, we decided to wait and observe the postoperative course until it was clear that TFCC debridement had not been successful for the ulnar positive patient.^{10,14}

In the literature on adult patients, there is an ongoing debate on whether the ulna should be shortened either concomitantly with a TFCC debridement procedure or only in the case of recalcitrant ulnocarpal pain. It has therefore been shown that a radiologically evident ulnar positive variance may lead to high failure rates in "TFCC debridement only" procedures.⁹ De Smet et al compared 34 cases with debridement only versus 12 cases undergoing concomitant distal ulnar shortening.³⁰ DASH scores were superior in those without wafer surgery. Other studies showed high patient satisfaction rates after such wafer procedures for the treatment of traumatic and degenerative tears.³¹ Van Sanden evaluated 11 cases with impaction syndrome after failed TFCC debridement.³² Although postoperative pain scores were good in 10 of 11 cases, patient satisfaction was relatively low due to many complications observed such as nonunions. Some other authors, who experienced much better postoperative outcomes, emphasized that ulnar shortening should be reserved for those with persistent pain after arthroscopic debridement.^{33,34} A static ulnar positive variance of + 1.8 mm has been identified as a predictive factor for both the necessity and success of an early shortening procedure after failed TFCC debridement.¹⁴ However, these results were only observed for cases with degenerative tears of Palmer type 2C.¹⁴

Our clinical results compared favorably with the limited literature on adolescent TFCC surgery. Compared with the short-term outcomes after TFCC repair in adolescents,¹⁸ the current long-term results after debridement were quite similar, although a higher revision rate has been noted. Nevertheless, we believe that TFCC debridement should be performed in children who reveal stable central or radial TFCC tears during wrist arthroscopy, do not respond to conservative treatment beforehand, and do not show clinical and/or radiographic evidence of instability or ulnar impaction. As suggested previously, we aimed to resect less than two-thirds of the TFCC area.^{35,36} Whenever either DRUJ

instability or an ulnocarpal impaction syndrome is evident before arthroscopy, both further diagnostic steps and concomitant surgical interventions should be considered. Otherwise, we suggest monitoring the patients closely after TFCC debridement to document their clinical progress.

Note

This work was performed at the Orthopedic Hospital Speising, Vienna, Austria.

Ethical Review Committee Statement

This study has been approved by the local institutional review board/ethical committee.

Conflict of Interest

None.

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