Changes in Ulnar Variance after a Triangular Fibrocartilage Complex Tear

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Abstract

Purpose The relationship between triangular fibrocartilage complex (TFCC) tear and ulnar impaction syndrome has not been fully understood. We hypothesized that a TFCC tear could change the ulnar variance, which may be the cause of ulnar impaction syndrome.

Patients and Methods A total of 72 patients who underwent TFCC foveal repair between January 2011 and June 2016 were included in this retrospective study. Among them, 44 patients diagnosed with TFCC foveal tear with distal radioulnar joint instability and no ulnar impaction syndrome underwent TFCC foveal repair only (group A) and 28 patients diagnosed with TFCC foveal tear with ulnar impaction syndrome underwent TFCC foveal repair and ulnar shortening osteotomy simultaneously (group B). We measured their ulnar variances in preoperative, postoperative, and last follow-up plain radiography. We also compared them with the ulnar variance of the contralateral (uninjured) wrist. Postoperative clinical outcomes, such as range of motions of the wrist, the visual analog scale (VAS) for pain, grip strength, and Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) score, were assessed.

Results Ulnar variance increased after TFCC tears compared with that on the uninjured side in both groups (group A: 0.98 vs. 0.52 mm, $p = 0.013$; group B: 2.71 vs. 2.13 mm, $p = 0.001$). Once the TFCC was repaired, ulnar variance decreased (group A: 0.98 to 0.01 mm, $p < 0.01$; group B: 2.71 to 0.64 mm, $p < 0.01$). However, it was increased on the last follow-up radiograph (group A: 0.01 to 0.81 mm, $p < 0.01$; group B: 0.64 to 1.05 mm, $p = 0.004$). There were no significant improvement of range of motion, except for pronation–supination motion ($p = 0.04$). Mean grip strength increased from 56.8 to 70.8% of the contralateral unaffected hand at the last assessment ($p = 0.01$). Mean VAS for pain decreased from 7.4 ± 2.5 preoperatively to 2.7 ± 2 postoperatively ($p = 0.001$). The QuickDASH score significantly improved from 45 to 9 ($p = 0.001$).

Conclusion Ulnar variance may be changed after a TFCC tear. In our study, it decreased after TFCC foveal repair. However, as time went on, the ulnar variance increased again, which could be one of the causes of ulnar impaction syndrome and ulnar-sided wrist pain.

Level of Evidence This is a therapeutic Level IV study.

Keywords

- ▶ distal radioulnar joint
- ▶ triangular fibrocartilage complex
- ▶ ulnar impaction syndrome
- ▶ ulnar shortening osteotomy
- ▶ ulnar variance

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The triangular fibrocartilage complex (TFCC) is assumed to be the primary stabilizing structure of the distal radioulnar joint (DRUJ). Foveal disruption of the TFCC could cause DRUJ instability.¹ Additionally, chronic lesions in the TFCC (i.e., from wear) have been considered to be results of ulnar impaction syndrome (UIS). Palmer and Werner showed that positive ulnar variance resulted in an increase in ulnocarpal load, and this phenomenon has been implicated in the etiology of degenerative TFCC tears.^{2,3} A biomechanical study on the influence of TFCC on dorsopalmar direction stability used the “ballotement test.”⁴ Moreover, a cadaveric study has been conducted to determine the influence of TFCC tears on the DRUJ “vertical” or longitudinal stability.^{5,6} Smith et al⁶ documented that isolated disruption of the TFCC could result in 0.5 to 3 mm (median: 1.3 mm) of proximal radial migration. However, they did not provide accumulated clinical data, and therefore the influence of TFCC tears on the DRUJ “vertical” stability remains poorly understood. We hypothesized that a TFCC tear could change the ulnar variance, which may be the cause of UIS.

Patients and Methods

The Institutional Review Board approved the protocol for this retrospective study and granted a waiver of informed consent. Between January 2011 and June 2016, 77 patients (82 cases) underwent surgical procedures performed by a single surgeon to treat TFCC foveal tears at our hospital. Five cases that involved bilateral operation were excluded because the uninjured contralateral side served as the comparison group. Seventy-two patients (72 cases) were thus included in this study, and the radiographs of 72 wrists were reviewed retrospectively. Of the 72 patients, 42 men and 30 women (mean age: 34 years [range: 13–79 years]) were followed for a mean of 26.8 weeks (range: 12–155 weeks). Among them, 44 patients diagnosed as TFCC foveal tear with the DRUJ instability and no UIS underwent TFCC foveal repair only (group A), and 28 patients diagnosed as TFCC foveal tear with UIS underwent TFCC foveal repair and ulnar shortening osteotomy simultaneously (group B). Patients who did not undergo TFCC repair after the improvement of the DRUJ instability after ulnar shortening osteotomy were not included in this study. We diagnosed TFCC foveal tear in cases of sustained ulnar-sided wrist pain by inspection for a prominent ulnar head, a positive “ulnar fovea sign,” and DRUJ instability. The DRUJ instability was checked by “the ballotement test,” in which the radius and carpal bones were grasped by the examiner with the forearm in a neutral position, and the distal ulna, which was fixed between the examiner’s thumb and index finger, was moved in the dorsal and palmar directions with respect to the radius. The result of the test was positive if the ulna was conspicuously displaced relative to that on the contralateral side with the presence of pain or apprehension.⁷ Patients in group B also had sustained symptoms of ulnar impaction in addition to the DRUJ instability. Physical examination maneuvers described for UIS include the ulnocarpal stress test (i.e., pain with an axial load applied to an ulnar-deviated wrist

passively rotated through pronation and supination).^{8,9} Surely, the ulnocarpal stress test can show positive results even in other pathological conditions such as lunotriquetral ligament injury, TFCC injury without impaction, and isolated arthritis. Therefore, the author did not determine the diagnosis of UIS by ulnocarpal stress test only. The UIS was diagnosed by combining the positive ulnocarpal stress test, tenderness of the dorsal area of the lunotriquetral joint or ulnar head, and radiological findings. Group B had 11 patients with lunate malacia on X-ray, 9 patients with high signal intensity at the ulnar side of the lunate on T2-weighted image of magnetic resonance imaging (MRI), and 8 patients with fibrillation and chondromalacia on the ulnar side of the lunate and wear of the central area of TFCC by arthroscopic examination. By combining the two groups, 64 (89%) of the 72 patients had trauma (group A: 39; group B: 25) and 8 had none (group A: 5; group B: 3).

In the first 12 patients, only TFCC repair was performed when the patient had TFCC foveal tear without positive physical examinations of UIS. However, around one year after the surgery, 3 of the 12 patients newly complained of symptoms and signs of UIS and eventually underwent revision surgery (ulnar shortening osteotomy).

In group B, the author performed ulnar shortening osteotomy first and checked the DRUJ instability again by performing an intraoperative physical examination (the ballotement test). TFCC repair was performed when the DRUJ instability remained, and TFCC repair was required for all patients in group B. We compared them with contralateral (uninjured) wrist ulnar variance and then compared changes by group. Fourteen cases underwent arthroscopic repair (group A: 6; group B: 8), and the others underwent open repair in a foveal repair fashion. Suture anchor was used to reinsert the deep limb of TFCC to the fovea. Nonabsorbable suture anchors (Mitek Mini QUICKANCHOR Suture Anchor, DePuySynthes) were used in 24 cases, whereas absorbable suture anchors (Bio-PushLock, Arthrex) were used in the other cases. In all ulnar shortening cases, we used an LCP Distal Ulna Plate (Synthes GmbH). The author performed ulnar shortening osteotomy in the metaphysis rather than the diaphysis of the ulna, and it is possible to perform two procedures (open TFCC repair and distal metaphyseal ulnar shortening osteotomy) with only single incision (→ Fig. 1).

We measured ulnar variance on pre- and postoperative radiographs, as well as on the last follow-up radiograph. We obtained a posteroanterior radiograph of the wrist with the shoulder at 90-degree abduction, the elbow at 90-degree flexion, the forearm in a neutral rotation, and the wrist in neutral alignment. We measured ulnar variance using the method of perpendiculars.¹⁰ In this method, a line was first drawn along the longitudinal axis of the radius. Then, a line was drawn at the apex of the cortical rim of the distal ulnar aspect of the radius, and another line was drawn at the apex of the distal cortical rim of the ulna, both of which were perpendicular to the first line. The distance between these two lines was then measured. First, we compared preoperative and contralateral side films to determine the influence of TFCC on vertical stability. Then, we also compared pre- and postoperative radiographs to clarify the longitudinal traction

Fig. 1 Open triangular fibrocartilage complex repair and distal metaphyseal ulnar shortening osteotomy were performed with single incision.

effect of TFCC. Finally, postoperative and final follow-up radiographs were compared (► **Figs. 2 and 3**). Measurements were performed with the m-view 5.4 (Marosis) program and reviewed independently by two investigators.

After the measurements were performed, data were recorded and analyzed using SPSS version 20.0. A descriptive analysis was performed, and we analyzed differences in

radiological assessments (ulnar variance) using the paired Student *t*-test, Wilcoxon signed-rank test, and Mann-Whitney *U* test. We used a normality test to determine whether a dataset displayed a normal distribution. If the dataset could not be modeled by a normal distribution, we used the data after square-root transformation or log transformation.

All variables are reported as means and standard deviations. The level of significance was set at $p < 0.05$. We also used a two-way mixed effects model with absolute agreement to determine the intraclass correlation coefficients (ICCs) for each individual type of measurement.

Results

The interrater agreement was substantial for the overall data (ICC: 0.93; 95% confidence interval: 0.907–0.947).¹¹ The average preoperative ulnar variance of the injured side in group A was 0.98 mm and that of the uninjured side was 0.52 mm, showing a mean difference of 0.44 mm ($p = 0.013$). The average preoperative ulnar variance of the injured side in group B was 2.71 mm and that of the uninjured side was 2.13 mm, showing a mean difference of 0.79 mm ($p = 0.001$). Differences of ulnar variance between the preoperative injured side and contralateral uninjured side within each group were statistically significant.

In group A, the average ulnar variance on postoperative radiographs was 0.01 mm, and the mean difference between the preoperative and postoperative ulnar variance was 0.97 mm ($p < 0.01$). There was an increase of ulnar variance of 0.72 mm at the last follow-up ($p < 0.01$). Similarly, in group B, the average ulnar variance on the postoperative radiographs was 0.64 mm, and the mean difference between the preoperative and postoperative ulnar variance was 2.07 mm ($p < 0.01$). And then, there was an increase of ulnar variance of 0.41 mm at the last follow-up. All differences between measurements in the same group were statistically significant (► **Tables 1 and 2**) (► **Figs. 4 and 5**). However, in comparison by group, postoperative ulnar variance ($p = 0.059$), final follow-up ($p = 0.972$), and the difference between contralateral ulnar variance and preoperative variance ($p = 0.223$), there were no significant differences.

Fig. 2 A 37-year-old male patient presented with right wrist pain. (A) Compared with the contralateral side (left wrist), preoperative image of the injured (right) side showed a discrepancy in ulnar variance. (B) Triangular fibrocartilage complex repair was performed with suture anchors, and the ulnar variance decreased to neutral (left side). But, at the last follow-up, positive ulnar variance is noted (right side).

Fig. 3 A 21-year-old male patient presented with right wrist pain. (A) Compared with the contralateral side (left wrist), preoperative image of the injured (right) side showed a discrepancy in ulnar variance. (B) Triangular fibrocartilage complex repair was performed with absorbable suture, and ulnar shortening osteotomy was also performed (left side). At the last follow-up, the ulnar showed complete union, but ulnar variance increased (right side).

The portion or contribution of the degenerative change could not be totally excluded, but all the cases in our study had Palmer's classification 1b foveal tear. Fourteen cases were confirmed by arthroscopic examination such as the hook test and trampoline test (group A: 6; group B: 8), and the others were confirmed through a direct incision of the 6U portal area as a foveal tear of TFCC. There were two cases of revision TFCC repair due to recurrent instability. In group B, 28 patients who underwent TFCC repair and ulnar shortening osteotomy improved the symptoms of UIS after surgery.

Postoperatively, mean ranges of flexion–extension motion, radioulnar deviation, and pronation–supination motion were 139 degrees (range 113–163 degrees), 57 degrees (range 49–66 degrees), and 164 degrees (range 127–173 degrees), respectively. There was no significant improvement of range of motion, except for pronation–supination motion ($p = 0.04$). Mean grip strength increased from 56.8 to 70.8% of the contralateral unaffected hand at the last assessment ($p = 0.01$). Mean visual analog score (VAS) for pain decreased from 7.4 ± 2.5 preoperatively to 2.7 ± 2 postoperatively ($p = 0.001$). The Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) score significantly

improved from 45 to 9 ($p = 0.001$). The purpose of this study is to show the relationship between TFCC tear and change of the ulnar variance. Therefore, we did not analyze the relationship between extent of ulnar variance and clinical result. And, there were no significant differences in ulnar variance at final follow-up between two groups.

Discussion

The ulnar shortening procedure is frequently indicated in UIS because this procedure decreases compressive stress across the ulnocarpal joint.^{2,12,13} Several studies have indicated that the ulnar shortening procedure increases ulnocarpal stability, as the ulnocarpal ligament (complex) is tightened by elongation.^{12,14–17} The actual effect of ulnar shortening on the DRUJ stability is uncertain.¹⁸ Tomaino and Elfar¹⁹ showed that as many as 25% of wrists with TFCC tears have residual symptoms following arthroscopic debridement alone, and it is likely that static or dynamic ulnar positive variance plays a role.

Table 2 Comparative radiological outcomes ($n = 72$)

	Group A (<i>n</i> = 44)	Group B (<i>n</i> = 28)	<i>p</i> -Value ^a
	Mean		
Contralateral UV	0.52	2.13	0.001
Preoperative UV	0.98	2.71	0.000
Postoperative UV	0.01	0.64	0.059
Final F/U UV	0.81	1.05	0.972
Difference 1	0.44	0.79	0.223
Difference 2	0.97	2.07	0.000
Difference 3	0.72	0.41	0.009

Abbreviations: F/U, follow-up; UV, ulnar variance.

Note: Difference 1, preoperative UV minus contralateral UV; difference 2, preoperative UV minus postoperative UV; difference 3: final F/U UV minus postoperative UV.

^aMann–Whitney U -test.

Table 1 Overall radiological outcomes ($n = 72$)

	Group A ($n = 44$)		Group B ($n = 28$)	
	Mean	p -Value ^a	Mean	p -Value ^b
Contralateral UV	0.52	0.013	2.13	0.001
Preoperative UV	0.98		2.71	
Preoperative UV	0.98	0.000	2.71	0.000
Postoperative UV	0.01		0.64	
Postoperative UV	0.01	0.000	0.64	0.004
Final F/U UV	0.81		1.05	

Abbreviations: F/U, follow-up; UV, ulnar variance.

^aPaired t -test.

^bWilcoxon signed-rank test.

Fig. 4 Overall radiologic outcomes of group A. *Statistically significant.

Fig. 5 Overall radiologic outcomes of group B. *Statistically significant.

Although Palmer's classification of TFCC lesions differentiates posttraumatic central perforations (IA tears) from degenerative tears secondary to ulnocarpal impaction (IIC),²⁰ the distinction is not always clinically clear.¹⁹ In our study, a small but constant difference in ulnar variance was present between the injured or affected wrist and that on the contralateral side, suggesting that TFCC tears cannot only be the result of UIS but could also cause it. Also, there were some cases in which central perforation and foveal tear of TFCC were found simultaneously (► Fig. 6).

The surgical procedure of TFCC repair combined with ulnar shortening osteotomy was introduced in 2013, which is also the year we began using the LCP Distal Ulna Plate for ulnar shortening osteotomy. When conducting conventional

Fig. 6 Coronal proton-density fat-suppressed magnetic resonance image of a 48-year-old male with central perforation (arrowhead) and foveal tear (arrow) of the triangular fibrocartilage complex.

diaphyseal ulnar shortening, an additional or elongated incision is needed for TFCC repair. However, by using a distal ulna plate, TFCC repair and ulnar shortening osteotomy can be easily performed by a single incision.

Boulas and Milek substantiated the use of ulnar shortening to relieve ulnolunate impingement in patients with ulnar-positive or ulnar-neutral wrists in whom ulnar wrist pain developed and who demonstrate TFCC tears after acute trauma and/or overuse syndromes.²¹ Minami et al²² and others^{23–25} have reported a lower success rate with ulnar-positive variance and have suggested that ulnar shortening may provide better outcomes for these patients, even following traumatic peripheral avulsion. The results of Shen et al's study suggested that for traumatic wrist injuries, radiographic findings of ulnar-positive variance may actually represent a more severe injury than that seen in an ulnar-neutral or ulnar-negative wrist. Moreover, they provided an explanation for the observation that patients with ulnar-positive variance and a traumatic TFCC injury have a worse clinical outcome.⁵ In patients who had combined lesion of TFCC tear and UIS, it is possible that TFCC repair could relieve some symptoms of UIS by stabilizing DRUJ.^{12,14–18} However, if only TFCC repair is performed in such cases, the symptoms of UIS may remain, and revision surgery may be needed eventually. In addition to the medical aspects, it would be a burden to the socioeconomic costs of individual patients to perform an additional operation. Therefore, if the symptoms of TFCC tear and UIS are mixed, and radiological evidence is supported, the combined procedure could solve both problems at once and prevent revision surgery.

After reattachment of TFCC to the ulnar fovea, ulnar variance would decrease because of reduction of the dorsal subluxation of the ulnar head in the DRUJ. But, we checked all the lateral X-rays of wrists in our study, and there is no constant pattern of change of the DRUJ subluxation after TFCC repair (► Fig. 7). Reduction of the DRUJ subluxation in the sagittal plane could change ulnar variance on plain X-ray, but Kawanishi et al²⁶ also suggested that beam incident angle, distance between the cassette and ulnar head, should

Fig. 7 A 27-year-old female presented with left wrist pain. Lateral view of preoperative (A), postoperative (B), and final follow-up (C) wrist radiographs. There was no significant change of dorsal subluxation of the ulnar head in spite of repair of the triangular fibrocartilage complex tear.

affect ulnar variance. Therefore, we thought that without the stability of the DRUJ, ulna head should migrate distally in the vertical direction and not only in the sagittal direction.

This study had several limitations. First, the subjective element of radiographic measurement created the potential for error and observer bias. Furthermore, differences are minute in some views. For that reason, a subset of measurements was performed independently by two investigators, which confirmed substantial agreement. Second, the wrist radiographs were obtained for usual care rather than for study purposes, and therefore a standardized study protocol was not used. Third, at the time of surgery, the indication for whether to perform ulnar shortening was determined by a physical examination, which also has a subjective element. Fourth, we did not classify patients by specific surgical procedure, such as arthroscopic versus open repair, or by whether absorbable or nonabsorbable sutures were used. We thought that the influence of such factors would be minimal, however. Finally, follow-up periods were not standardized, and they may not be long enough to notice radiological changes.

In conclusion, ulnar variance may be changed after a TFCC tear. In our study, it decreased after TFCC foveal repair. However, as time went on, the ulnar variance increased again, which could be one of the causes of UIS and ulnar-sided wrist pain.

Note

This work was performed at the Department of Orthopaedic Surgery, St. Vincent's Hospital, Catholic University of Korea, Seoul, South Korea.

Conflict of Interest

None.

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