Clinical and Radiographic Correlates for the Treatment of Ulnocarpal Impaction

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Abstract

Keywords

- ulnocarpal impaction
- ulnar variance
- pronation and grip
- ulnar shortening osteotomy
- wafer procedures
- patient-rated outcome scores
- radiographs
- wrist arthroscopy

Background Ulnocarpal impaction (UCI) is a described cause of ulnar side wrist pain.

Questions Does absolute ulnar variance (UV) or change in UV with grip affect patient-rated outcome scores (PROS) in patients with symptomatic UCI undergoing surgery? Does UV differ between symptomatic and contralateral wrists? Does arthroscopic grade of triangular fibrocartilaginous complex (TFCC) tears and lunotriquetral (LT) ligament tears influence PROS? Do PROS improve following ulnar shortening osteotomy (USO) or wafer procedures and does improvement depend on the amount of shortening or achievement of negative UV?

Patients and Methods We analyzed information on patients undergoing USO or wafer procedures for UCI as recorded in a database of prospectively collected information on individuals with ulnar side wrist pain. This included (1) patient-rated wrist evaluation and QuickDASH scores on enrolment, 3 and 12 months postoperatively; (2) standardized bilateral posteroanterior (PA) wrist radiographs, including PA grip views of the symptomatic wrist; and (3) arthroscopic findings.

Results Larger changes in UV between PA neutral and grip views prior to surgery were associated with smaller improvements in PROS, 12 months after surgery. Actual UV value before and after surgery did not affect PROS. There was no difference in UV between symptomatic and contralateral wrists. The presence of TFCC or LT ligament tears did not influence PROS. Mean PROS improved postoperatively.

Conclusions Ulnar shortening procedures result in improvement in PROS in patients with UCI. Variation in UV with rotation and grip results in variable outcomes.

Level of Evidence This is a Level II, cohort study.

Ulnar side wrist pain has been referred to as the “black box” of the wrist, reflecting the diagnostic and therapeutic challenge that it presents. There are multiple potential sources of pain in a small physical space. Ulnocarpal impaction (UCI) is one of the causes of ulnar side wrist pain. Compression between the ulnar head and the lunate and triquetrum results in injury to the triangular fibrocartilaginous complex (TFCC) and cartilage surfaces. Such contact occurs with

activities involving ulnar deviation of the wrist and grip and rotation. Pronation and grip may result in relative lengthening of the ulna compared with the radius.¹ Diaphyseal ulnar shortening osteotomy (USO) and wafer resection are well-established treatment options for individuals with UCI. While surgeons have been able to demonstrate changes in ulnar variance (UV) following such intervention, few studies have formally evaluated patients' perception of the

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benefits derived from surgical treatment. The objectives of this study were to answer the following questions:

- Does absolute UV or change in UV with grip affect patient-rated outcome scores (PROS) in patients with symptomatic UCI undergoing surgery?
- Does UV differ between symptomatic and contralateral wrists?
- Does arthroscopic grade of TFCC tears and lunotriquetral (LT) ligament tears influence PROS?
- Do PROS improve following USO or wafer procedures and does improvement depend on the amount of shortening or achievement of negative UV?

Patients and Methods

We conducted an analysis of prospectively collected data. After obtaining approval from our institutional review board in 2014, we collected data from patients presenting to our institution with ulnar sided wrist pain. Patients that can communicate effectively in English and can provide informed consent for inclusion in the database are enrolled on their first visit. Data collected included demographics, symptoms, and, where indicated, the effect of a diagnostic injection of local anesthetic and steroid. Standardized radiographs included neutral posteroanterior (PA) projections of symptomatic and contralateral wrists and pronated grip PA and lateral projections of affected wrists. When surgery was performed, arthroscopic findings and the details of the surgery performed were recorded. Standardized radiographs were performed postoperatively and a standardized examination repeated 2-to-3 and 12 months postoperatively. Patient-rated wrist evaluation (PRWE), QuickDASH, Short Form 12 (SF-12), and Centre for Epidemiological Studies Depression Scale (CES-D) scores were also recorded on enrolment, 2-to-3 and 12 months postoperatively.

Additionally, subjects were asked to complete a patient satisfaction survey 2-to-3 and 12 months after surgery. This consisted of six questions relating to satisfaction with the result of treatment, improvement in pain, ability to perform light activity, heavy activity, wash hair, and put a shirt on. For each of these questions, subjects selected from the options “very satisfied,” “somewhat satisfied,” “somewhat dissatisfied,” and “very dissatisfied,” scoring one, two, three, and four points for each response, respectively. The total score was divided by 24 and multiplied by 100 to give the final score each time the questionnaire was completed. The best score possible was 25 and the worst, 100.

From this database, we identified patients with 1-year follow-up after USO and wafer procedures performed for UCI. A combination of findings strong enough to convince investigators that UCI was the cause of ulnar wrist pain was used to make the diagnosis of UCI. These findings included at least two of the following:

- Ulnar wrist pain with loaded grip and/or rotation
- Ablation of such pain by a diagnostic injection of local anesthetic and steroid administered into the TFCC
- Plain radiographic findings of lunate impaction lesions and/or corresponding changes on the ulnar head

- Importantly, evidence of cartilage and ligament injury on the ulnar aspect of the wrist on arthroscopy of the wrist joint and damage of the articular cartilage of the ulnar head and undersurface of the TFCC on sub-TFCC arthroscopy, where this was possible.

Magnetic resonance imaging was not used as part of the standard diagnostic process. Radiographic analysis of PA views included measurement of UV, the shortest ulnar head-lunate distance, lunate facet inclination, sigmoid notch angle (oblique/flat/reverse oblique), distal radioulnar joint height, lunate type based on both the classification described by Veigas² and that by Antuna-Zapico,³ ulnar styloid shape, ulnar styloid index, ulnar styloid length, the presence or absence of nonunion of the ulnar styloid, and the presence or absence of an os triangulare. These features on the symptomatic side were compared with those on the contralateral side. Changes in UV and ulnar head-lunate distance and carpal translocation based on PA neutral and grip views were also noted. Analysis of lateral radiographs included assessment of UV and radial tilt. ▶ **Table 1** provides a description of the methods that were used to assess some radiographic features.

We also examined the change in PROS 2-to-3 and 12 months after surgery. We compared the changes in outcomes to published data on minimally important clinical difference (MCID). A difference in the PRWE of 17 or more was reported by Kim and Park in 2013 as an MCID for UCI treated by USO.⁹ No published data on the MCID for the QuickDASH score could be identified. However, in the same paper relating to the PRWE Kim and Park⁹ published an MCID of 13.5 for the DASH score. We elected to use this figure for changes in QuickDASH scores based on the paper by Gummesson et al,¹⁰ which affirmed that the QuickDASH can be used with similar precision as the DASH. We also tested for an association between CES-D (with a threshold value of 16 for major depression¹¹), and the other PROS.

Surgical Techniques

Procedures were performed by three hand fellowship-trained surgeons. Wrist arthroscopy was performed using 10 to 15 lb of traction. Three-four, five-six or 6R, midcarpal ulnar, midcarpal radial, and sub-TFCC portals (when possible) were established and the state of articular surfaces and ligaments noted.

USO was performed through a direct approach to the ulna, between the extensor carpi ulnaris and flexor carpi ulnaris under loupe magnification. Two oblique parallel osteotomies were performed under copious irrigation, excising a small segment of the ulna to achieve the desired amount of shortening based on preoperative plans. The osteotomy was compressed and fixed using a 3.5 dynamic compression plate, with or without a lag screw based on surgeon preference, or a specific USO plate. A bulky dressing was applied postoperatively. Patients were reviewed 2 weeks later and given instructions to perform gentle range of motion exercises.

Wafer resections were performed either arthroscopically or open.

Table 1 Methods used to assess radiographic features

Radiographic feature	Assessment technique
PA ulnar variance	Lines perpendicular to the long axis of the radius are drawn at the level of the volar ulnar aspect of the distal radius and the distal-most aspect of the ulnar head. ⁴ The ulnar variance is the perpendicular distance between these two lines, positive values representing an ulnar head that lies distal to the radius
PA ulnar head–lunate distance	The shortest distance between the distal aspect of the ulnar head and the proximal aspect of the lunate
Lunate facet inclination	A line perpendicular to the long axis of the radius is drawn at the level of the volar ulnar aspect of the distal radius. Lunate facet inclination is the angle between this line and a line connecting the distal ulnar corner of the radius and the prominence between the lunate and scaphoid facets on the distal radial articular surface ⁵
Ulnar styloid length	Lines perpendicular to the long axis of the radius are drawn at the level of the distal ulnar head and the tip of the ulnar styloid process. Ulnar styloid length is the perpendicular distance between these two lines
Ulnar styloid process index	A line perpendicular to the long axis of the radius is drawn at the widest part of the ulnar head, measuring ulnar head width. Ulnar styloid process index is calculated as (ulnar styloid length – ulnar variance) ÷ ulnar head width ⁶
Lunate uncovering index (carpal translocation)	A line tangential to the radial aspect of the DRUJ is drawn through the lunate. Lunate uncovering index is calculated as the widest part of the lunate ulnar to the reference line ÷ the widest part of the whole lunate along a line perpendicular to the reference line ⁷
Sigmoid notch angle (oblique/flat/reverse oblique)	A line tangential to the radial aspect of the sigmoid notch is drawn. Where this line extends ulnarly distally the sigmoid notch is denoted as oblique. If the line extends radially distally, the sigmoid notch is denoted as reverse oblique. If the line is parallel to the long axis of the radius the notch is denoted as flat
Lateral ulnar variance	On a lateral wrist radiograph, lines perpendicular to the long axis of the radius are drawn at the most distal aspect of the ulnar head and the most proximal part of the articular aspect of the lunate facet. Lateral ulnar variance is the perpendicular distance between these two lines ⁸
Radial tilt	The angle subtended between a line parallel to the long axis of the radius and a line joining the dorsal and volar articular aspects of the distal radius on a lateral radiograph

Abbreviations: DRUJ, distal radioulnar joint; PA, posteroanterior.

Statistical Methods

Two-tailed *t*-tests were used to analyze paired and nonpaired mean values and Spearman's correlation test was utilized to assess the relationship between continuous data such as that between radiographic features and PROS. The Kruskal–Wallis test was used to compare mean values between three or more groups. Cohen's Kappa statistic was utilized to compare categorical data between paired observations and the Fisher's exact test used to compare categorical data between unpaired observations, with the Freeman–Halton extension used for contingency tables with two rows and three columns. The significance level was set at a *p* value of 0.05.

Results

Forty-four patients had surgery between October 2014 and December 2016. One withdrew consent for inclusion after surgery and thirteen did not respond to requests to attend follow-up appointments. Thirty had 1-year follow-up and were included in the analysis. Some PROS were not completed by up to four people 3 months postoperatively, and up to seven people 12 months postoperatively. Five individuals did not undergo wrist arthroscopy and data for one person who did have an arthroscopy was missing. Initially the imaging protocol was not followed, decreasing the number of standardized

radiographs. The mean age was 48.6 years [standard deviation (SD) 14.6 years]. Fifty percent were male, and the dominant limb was involved in 47% of cases. Twenty-five USO and five wafer procedures were performed. Concurrently performed procedures included five foveal TFCC repairs.

The average UV of symptomatic wrists was +1.9 mm (SD, 2.3 mm), with four patients having negative UV. The mean change was –3.2 mm (SD, 2.5 mm) postoperatively, with four patients still having positive UV. Neither the initial UV nor the change in UV as a result of surgery was associated with enrolment or postoperative PROS. An average increase in PA UV of +0.4 mm (SD, 0.9 mm) was noted on pronated grip views compared with neutral views. Expressed as a percentage of the variance on nongrip radiographs, this change (median 7% increase, interquartile range 39% increase to 24% decrease) was associated with the percentage change in the PRWE and QuickDASH scores 12 months after surgery (*p* values 0.03 and 0.01, respectively), greater change in variance with pronation, and grip being associated with smaller improvements. PA lunate–ulnar head distance [mean 2.4 mm (SD, 1.1 mm)] and lateral UV (mean 0.7 mm [SD, 2.3 mm]) were not related to PROS.

Paired analysis revealed no statistical difference in UV, and other radiographic features, between symptomatic and contralateral wrists.

Fig. 1 Mean patient-rated outcome scores on enrolment, 3 and 12-months postoperatively.

All individuals who had arthroscopy had an abnormal TFCC, 47% of them being characterized by type IIA and IIB lesions. The enrolment PRWE, QuickDASH, and CES-D scores were not related to the condition of the TFCC based on the Palmer classification¹² (p values 0.54, 0.32, and 0.32, respectively). Twelve-month post-surgical patient satisfaction scores, changes in PRWE, QuickDASH, and CES-D scores were not related to the condition of the TFCC (p values 0.40, 0.45, 0.45, and 0.41, respectively). The condition of the LT ligament on arthroscopy (normal vs abnormal) was not related to pre-operative PROS ($p > 0.05$). Of those with 12-month follow-up, 43% had a normal LT ligament on arthroscopy. Based on the Geissler classification,¹³ 100% of the abnormal LT ligaments had grade I or grade II changes. Changes in PRWE and QuickDASH scores 12 months postoperatively were not related to the condition of the LT ligament ($p = 0.66$).

The PRWE, QuickDASH, and CES-D scores improved after shortening procedures (see ►Fig. 1). However, only 55% of patients exceeded the MCID for the PRWE and 60% for the QuickDASH score. The SF-12 physical and mental component scores did not improve.

Discussion

Surgical treatment of UCI primarily involves decompression of the ulnar side of the wrist either with USO or wafer resection. This study primarily assessed the relationship between UV and PROS in individuals undergoing surgical treatment.

Limitations included a smaller dataset than anticipated because of loss to follow-up, noncompletion of some PROS, noncompliance with the imaging protocol early on and the absence of arthroscopic data in some cases. Follow-up extended only for 1 year postoperatively. It was felt that follow-up longer than 1 year would result in significant loss to follow-up. As well, the test retest validity of the PRWE has been demonstrated to be excellent for an interval of up to 1 year.¹⁴

There was no association between initial UV and PROS. While the average UV on PA radiographs of symptomatic wrists was positive, four individuals had negative UV. The finding that individuals with negative UV can have UCI has

been reported before.¹⁵ UCI cannot be excluded based on negative UV. Despite having positive UV postoperatively PROS can still improve, suggesting that appropriately planned USO or wafer procedures do not have to result in negative UV. The only radiographic feature that was associated with PROS 1 year postoperatively was the change in PA UV between neutral and pronated grip views on enrolment. There was a negative correlation between change in variance with pronated grip view and PRWE and QuickDASH scores. This suggests that assessment of dynamic change of UV¹⁶ may identify patients requiring greater amounts of shortening to achieve clinical improvement. Variability in dynamic UV may be due to an interplay of factors affecting longitudinal stability of the forearm. The axis of rotation lies in an oblique plane relative to the long axis of the ulna resulting in increased UV in pronation.¹⁷ Gemmill described the importance of the central band of the interosseous membrane in maintaining longitudinal stability by transferring distal-to-proximal forces from the radius to the ulna and the role of the distal oblique ligament and TFCC in transferring proximal-to-distal forces from the ulna to the radius, supported by the action of muscles originating on the humerus and inserting onto the wrist and hand.¹⁷ Cadaveric investigation of acute longitudinal instability after radial head excision has shown more instability in men who had been involved in heavy manual work or athletics entailing the use of hands, possibly from wrist flexors, extensors, and the biceps chronically pulling the radius proximally and resulting in more laxity of the interosseous membrane and inferior capsule.¹⁸

Symptomatic and contralateral wrists had similar features, echoing publications by Tsuge and Nakamura.¹⁹ This provides evidence against routinely obtaining contralateral radiographs in the management of patients with idiopathic UCI because the contralateral radiograph is unlikely to provide information that is not already present on the radiograph of the symptomatic wrist.

Arthroscopically, all TFCCs were found to be abnormal. The Palmer grade of the TFCC tear did not correlate with PROS at enrolment or changes in PROS 1 year after surgery.

This conclusion cannot extend to foveal detachments (Palmer type 1B) as all five patients with foveal detachments identified at the time of surgery were repaired to bone.

Having arthroscopically confirmed LT ligament abnormality was not associated with worse PROS on enrolment than those of individuals with normal LT ligaments. LT ligament abnormalities were not correlated with changes in PROS 1 year postoperatively. Mirza et al²⁰ described success in treating isolated LT tears with USO. Their diagnostic criteria for LT tears were primarily based on arthroscopic findings. Our results suggest that the presence or absence of LT pathology has no influence on PROS. However, it should be noted that all of the LT tears that we identified were grade I or grade II tears.

PROS focusing on the upper extremity (PRWE and QuickDASH) improved significantly 1 year post-shortening procedure. The improvement in the PRWE surpassed the MCID of 17 1 year postoperatively in 55% of patients. The improvement in the QuickDASH surpassed the adopted MCID of 13.5 in 60% of patients 1 year postoperatively. These findings rely on assessment of MCID performed by Kim and Park.⁹ Improvements in the PRWE and QuickDASH scores in the first 3 months postoperatively were significantly correlated with improvements in CES-D scores. This relationship between PROS and the CES-D has also been described by Lozano Calderón et al in patients undergoing open carpal tunnel release.²¹ Our study was not designed to determine a cause and effect relationship between the scores. The association between changes in the CES-D and PRWE and QuickDASH scores had lost significance a year postoperatively. We hypothesize that this may have been due to a ceiling effect in the CES-D; While the PRWE and QuickDASH scores continued to improve between 3 and 12 months postoperatively, the CES-D score was already good 3 months postoperatively and there was not much room for improvement.

The CES-D score at enrolment was not related to the patient satisfaction score 12 months after surgery. This echoes the findings between the CES-D, PRWE, and QuickDASH scores. The finding that SF-12 physical and mental component scores were not related to changes in the other patient-rated scores is not unique to our study. Maia et al²² also noted this in relation to upper extremity conditions and suggested that the SF-12 is too broad in its assessment of individuals to pick up changes where region or disease-specific changes are being assessed.

In conclusion, shortening procedures for UCI appear to be successful in improving PROS in the majority of patients. Larger changes in UV with grip and pronation appear to correlate with smaller improvements in PROS. In the absence of features suggestive of trauma or developmental abnormality, contralateral radiographs are unlikely to change management. Severity of TFCC abnormalities and LT ligament abnormalities does not appear to be related to PROS, albeit noting that foveal detachments were repaired in our patients. Appropriately planned surgery does not have to result in negative UV to achieve improved PROS.

Ethical Review Committee Statement

Approval for this work was provided by the University of British Columbia Providence Health Care Research Ethics Board.

Conflict of Interest

None declared.

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