Patient-Related Factors Influencing Ulnar-Shortening Osteotomy Outcomes Using the Trimed Dynamic Compression Plate

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abstract

Ulnocarpal impingement can be surgically managed with various shortening osteotomy techniques. The purpose of this study was to retrospectively examine the outcomes of the ulnar-shortening osteotomy technique using the Trimed dynamic compression plate (Valencia, California) and to determine whether results vary among patient-related factors, including smoking status, occupation, preoperative diagnosis, and workers’ compensation status. Twenty-seven patients (28 wrists) operated by a single surgeon underwent ulnar shortening over a 4-year span. Radiographic analysis was obtained preoperatively and at an average 24-month follow-up. A subset of 12 patients completed the Disabilities of the Arm, Shoulder and Hand (DASH) inventory; the Patient-Rated Wrist Evaluation (PRWE); and the visual analog scale for pain and underwent clinical evaluation for range of motion and strength. Ulnar variance improved in all cases between pre- and postoperative imaging (P<.05). Grip strength and range of motion were found to be 79% and 90% of the contralateral extremity, respectively. Among the examined patient-related factors, patients involved in a workers’ compensation claim demonstrated significantly different DASH (average, 56.8 claim vs 26.8 no claim; P=.037) and PRWE (average, 66.0 claim vs 32.8 no claim; P=.008) scores while also showing a trend toward nonunion (3/10 claim vs 1/18 no claim; P=.105). Results of ulnar-shortening osteotomy using the Trimed system at 2-year follow-up show consistent objective improvements in radiographic ulnar variance. Workers’ compensation claims may negatively influence outcomes of ulnar shortening, and this factor should be considered in preoperative patient selection and counseling. [Orthopedics. 2015; 38(2):e106-e111.]

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Ulnocarpal impingement or ulnocarpal impaction occurs when relative positive ulnar variance exists. This results in an increased force per unit of contact area between the lunate and the distal ulna. Patients with as little as 2.5 mm of positive ulnar variance may experience increases in ulnocarpal loading up to 42%. Clinically, patients present with signs and symptoms similar to triangular fibrocartilage complex (TFCC) tears, such as ulnar-sided wrist pain aggravated by ulnar deviation of the wrist.

Etiologies of ulnocarpal impaction syndrome vary. Ulnar-positive variance may be idiopathic or may be the result of disturbances of distal radius growth, as seen in Madelung’s deformity. Upper-extremity trauma, including Essex-Lopresti injuries, which are associated with fracture of the radial head, can lead to proximal radius migration and subsequent ulnocarpal impaction. Surgical correction of this condition has included resection of the distal ulna or ulnar-shortening osteotomy. Feldon et al described the wafer procedure, in which only the distal 2 to 4 mm of the distal ulna is removed, leaving intact the foveal attachment of the TFCC. Although originally described as an open procedure, it is now routinely performed arthroscopically, with care taken not to disrupt the distal radial ulnar joint (DRUJ).

Numerous osteotomy procedures have been described. These techniques share the common goal of unloading the carpus on the ulnar side, by correcting ulnar-positive variance. A reduction in ulnar variance has been shown to decrease ulnocarpal loading down to 4%. Among the various operative techniques, ulnar-shortening osteotomy has evolved over time to produce reliable subjective and objective results.

Initially, the ulnar-shortening osteotomy was described as a freehand technique. Rayhack introduced an oblique osteotomy cutting jig, and Labosky and Waggy advocated stacking multiple saw blades during a single cut to create more reproducible parallel cuts and improve on the nonunion results reported with use of the freehand technique. Additional clinical improvements were demonstrated when examining range of motion, pain, grip strength, and function after the use of a standardized Trimed cutting jig (Valencia, California). The Trimed system was compared with the use of a freehand technique using Synthes dynamic compression plates (DCPs) (Paoli, Pennsylvania) and was found to be equivalent in several surgical aspects, with an added benefit of shortened operative times.

The current study examined the results of the use of the ulnar-shortening osteotomy technique using the Trimed DCP over a 4-year span (2008-2011) at a single institution. The primary objective of this study was to determine whether patient-related factors influence bony union assessed with radiographic data.

**MATERIALS AND METHODS**

Patients undergoing ulnar-shortening osteotomy by the senior author (J.D.L.) between January 1, 2008, and December 31, 2011, were evaluated for study enrollment. Institutional review board approval was obtained. Included in the study were patients treated with Trimed DCP for ulnar-shortening osteotomy, without prior ipsilateral extremity surgery. The surgical technique involved use of a 3.2-mm lag screw through a volar plate construct as previously described by Laufer et al. All patients were immobilized with a volar splint until suture removal at 1 week postoperatively, followed by short-arm casting for 4 weeks.

Twenty-eight wrists in 27 patients met inclusion criteria. Mean patient age was 33 years (range, 15 to 60 years) at the time of the index procedure. There were 9 males and 18 females. The dominant hand was involved in 15 patients. Seven procedures were performed for posttraumatic causes and 21 for chronic conditions. Specifically, traumatic preoperative diagnoses included distal radius malunion (n=4), ulnar styloid fracture (n=2), and Essex-Lopresti injury (n=1). Atraumatic surgical indications included ulnocarpal impaction (n=11), chronic TFCC tears (n=9), and Madelung’s deformity (n=1). Correction of symptomatic ulnar variance greater than 3 mm via shortening osteotomy took precedence over consideration for arthroscopic debridement of TFCC injuries. Eight patients smoked perioperatively. Ten cases involved a workers’ compensation claim. Patients who routinely lifted objects at work were considered to have a laboring occupational status, and 10 laborers were included in this series, ranging from heavy construction workers to foundry workers.

The primary outcome measurement was radiographic evidence of union at most recent follow-up. The primary author (P.V.) reviewed all images. Radiographic union was defined as the absence of any linear density at the osteotomy site or complete bony remodeling and absence of gap along 2 cortices at the proximal and distal aspect of the osteotomy site on orthogonal images. Measurements of ulnar variance were performed on posteroanterior radiographs with the shoulder abducted to 90° and the wrist in neutral rotation against the cassette.

Formal clinical follow-up evaluation was also performed on a subset of 12 patients at an average of 28 months postoperatively. Attempts to contact every patient were made multiple times, but 1 patient refused travel and the remaining patients were unable to be reached. Objective range of motion, grip strength, pinch strength, and radiographic alignment analysis combined with subjective Disabilities of the Arm, Shoulder and Hand (DASH) score; Patient-Rated Wrist Evaluation (PRWE) score; and visual analog scale (VAS) pain scores from 0 to 10 were recorded. Values were reported as a percentage result of the contralateral extremity as a control. The DASH and PRWE scores are validated questionnaires scaled from 0 to 100, ranging from least to most disability.

Power analysis using t test for outcome variables was used. With follow-up data for 22 patients, a 10% difference in time to radiographic union would be detected.
with 86% power. Potential detrimental preoperative risk factors affecting union rates and outcome scores were analyzed using Student’s t test and chi-square analysis. Risk factors considered in analysis included smoking status, hand dominance, workers’ compensation claim involvement, occupational categorization, and preoperative diagnosis (posttraumatic vs atraumatic). In all instances, a P value of .05 was significant.

**RESULTS**

**Ulnar Variance**

Preoperatively, ulnar-positive variance was observed in all but 1 patient, with an average of +3.0 mm (range, -0.6 to 7.3 mm). Postoperatively, all 27 patients were noted to have radiographic shortening of the involved ulna, with an average correction of 3.9 mm (range, 0.7 to 8.3 mm). Radiographic imaging also demonstrated that the preoperatively observed ulnar-positive variance changed to an average of 0.9 mm (range, -3.7 to 3.8 mm) ulnar-negative variance postoperatively. The change in ulnar variance among pre- and postoperative imaging was statistically significant (P<.05).

**Radiographic Union**

Bony union was achieved in 24 (86%) patients at 18 months postoperatively. Time to radiographic union in these patients averaged 5.2 months (range, 2.1 to 12.5 months). Three of the 4 nonunited wrists involved a nondominant extremity. Union rates were differentiated based on a select set of epidemiologic patient variables, including preoperative diagnosis, smoking status, laboring job status, and workers’ compensation status. Overall, no patient-related factors appeared to affect the union rate with statistical significance (Figure 1). All 7 cases of ulnar shortening performed for posttraumatic conditions went on to bony union, whereas only 17 (80%) patients undergoing shortening for chronic conditions united.

Of the 4 nonunited cases, 2 patients self-identified with a laboring job status and 2 did not. Thus, 2 (20%) of 10 laborers went on to nonunion, whereas only 2 (11%) of 18 nonlaborers went on to nonunion. Three (30%) of the 10 workers’ compensation cases went on to nonunion, whereas only 1 (6%) of the 18 non–workers’ compensation cases ended in nonunion. Although not statistically significant, a trend toward nonunion was observed in patients involved in a workers’ compensation claim (P<.105). Finally, among the 4 cases of nonunion, 2 patients smoked and 2 did not. The difference in nonunion among smokers (2/8 [25%]) was not statistically different (P=.3) from the nonunion rate among nonsmokers (2/20 [10%]).

**Objective Outcomes**

A subset of 12 patients returned for objective and subjective clinical evaluation. Of these patients, 3 were involved in a workers’ compensation claim, 4 smoked, and 4 were considered laborers. Pinch and grip strength averaged 88% and 79%, respectively, when compared with the uninvolved extremity (Table 1). Range of motion measured flexion, extension, pronation, supination, and radial and ulnar deviation. Flexion was decreased when compared with the contralateral extremity postoperatively in three-fourths (9/12) of the evaluated patients. Extension arc was decreased in two-thirds (8/12) of patients. Supination and pronation arc were decreased in all but 2 patients and 1 patient, respectively. Average postoperative arc range of motion measurements are shown in Table 2.

**Subjective Outcomes**

Subjective data considered VAS, DASH, and PWRE scores. On average, patients rated postoperative pain at most recent follow-up to be 3.3±2.80. Ten of the 12 patients rated pain less than 5. Patient-Rated Wrist Evaluation scores...
averaged 41.1±20.68, and DASH scores averaged 34.3±22.47 (Table 3).

**Patient Factors and Subjective Outcomes**

Comparisons were made between subjective scores based on patient-related factors. Of note, patients with workers’ compensation claims demonstrated significantly higher disability and pain scores (Figure 2). Average DASH score was 56.8±23.95 in patients with claims and 26.8±17.23 (P=.037) in patients without claims. Similarly, average PRWE score was 66.0±6.25 in patients with claims and 32.8±16.39 (P=.008) in patients without claims. Finally, average VAS scores were 5.00±2.646 and 2.63±2.722 (P=.227) in patients with and without workers’ compensation claims, respectively.

Patients who smoked also demonstrated higher average DASH and PRWE scores than nonsmokers. Average DASH score was 56.8±23.95 in smokers and 24.4±16.82 (P=.98) in nonsmokers. Average PRWE score was 66.0±6.24 in smokers and 29.6±14.03 (P=.85) in nonsmokers. Average VAS score was 1.50±1.915 in smokers, which was lower than the 3.17±2.927 (P=.34) average in nonsmokers. However, despite these observed trends, none of the average differences reached statistical significance.

Subjective pain averages did not appear to vary based on preoperative working status. Average DASH score was 45.5±28.81 in manual laborers and 25.4±19.78 (P=.20) in non-laborers. Average PRWE score was 45.8±27.50 in manual laborers and 32.1±15.61 (P=.48) in non-laborers. Average VAS score was 2.25±1.708 in manual laborers and 2.67±3.204 in non-laborers (P=.55). Similar to smoking status, manual laborers demonstrated a trend of higher pain scores that did not reach statistical significance.

Patients with preoperative posttraumatic diagnoses demonstrated average DASH and PRWE scores of 28.3±19.52 and 36.7±20.15, respectively, at most recent follow-up. In contrast, average DASH and PRWE scores in atraumatic patients were 55.7±33.75 (P=.45) and 52.0±26.87 (P=.5), respectively. Pain also appeared to show an increasing

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**Table 2**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Current Study</th>
<th>Luria et al*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrist flexion</td>
<td>67°</td>
<td>10.4</td>
</tr>
<tr>
<td>Wrist extension</td>
<td>64°</td>
<td>N/A</td>
</tr>
<tr>
<td>Flexion/extension arc</td>
<td>131°</td>
<td>116°</td>
</tr>
<tr>
<td>Radial/ulnar deviation arc</td>
<td>51°</td>
<td>44°</td>
</tr>
<tr>
<td>Pronation/supination arc</td>
<td>157°</td>
<td>137°</td>
</tr>
</tbody>
</table>

*a Valencia, California.*

**Table 3**

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Current Study</th>
<th>Luria et al*</th>
</tr>
</thead>
<tbody>
<tr>
<td>DASH</td>
<td>34.3±22.47</td>
<td>10.4</td>
</tr>
<tr>
<td>PRWE</td>
<td>41.1±20.68</td>
<td>N/A</td>
</tr>
<tr>
<td>VAS</td>
<td>3.3±2.80</td>
<td>0.71</td>
</tr>
</tbody>
</table>

*Abbreviations: DASH, Disabilities of the Arm, Shoulder and Hand; VAS, visual analog scale.*

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**Figure 2:** Subjective outcome scores at 28-month follow-up of patients treated with ulnar-shortening osteotomy using the Trimed dynamic compression plate (Valencia, California) were differentiated on patient variables: smoking status, preoperative laboring status, and workers’ compensation status. Among the examined patient variables, significant differences were observed in the Patient-Rated Wrist Evaluation (PRWE) scores of patients with workers’ compensation claims. Abbreviations: DASH, Disabilities of the Arm, Shoulder and Hand; VAS, visual analog scale.
trend in patients with atraumatic diagnoses based on VAS score, which averaged 3.3±3.12 vs 1.5±2.12 (P=.42) in patients with posttraumatic diagnoses.

**Complications**

In this series, the reoperation rate was 14% (4/28). There were no instances of infection. Hardware remained in place for all but 4 patients at most recent follow-up. In the 4 cases of nonunion, all underwent a revision procedure and subsequently went on to union.

**DISCUSSION**

Several studies have shown that patients with workers’ compensation claims tend to have less favorable subjective surgical outcomes. However, the underlying mechanism for this finding remains elusive. Workers’ compensation patients are typically less likely to be married, are younger, have achieved lower levels of education, have more strenuous working environments, and have low expectations following treatment. It has been suggested that these factors may all play a role in leading to the disparate outcomes in this patient population.

The findings of the current study seem to corroborate results previously cited in the literature. Indeed, workers’ compensation status may portend a poor prognosis for patients undergoing ulnar-shortening osteotomy because average PRWE scores were significantly higher in this patient population (P<.008). Bernstein et al examined the results of 16 patients treated with arthroscopic TFCC debridement and ulnar-shortening osteotomy for an average of 26 months. That study demonstrated lower postoperative subjective modified Mayo wrist scores (68 vs 89) in the 10 patients involved in workers’ compensation claims. Consequently, in combination with the current literature, the results of the current study suggest that surgeons should consider workers’ compensation status when planning for ulnar-shortening osteotomy procedures.

In this series, there was a trend toward lower radiographic union rates in patients with workers’ compensation claims, as well as a significant decrease in the functional outcomes of these patients. The aforementioned characteristics of workers’ compensation patients may be related to the observations made in this study, and the relationship between these findings serves as an opportunity for future investigations.

The corrective change noted with the current technique mirrors the consistent ulnar variance improvement among several other ulnar-shortening osteotomy techniques. Baek et al examined the results of 36 wrists treated with ulnar-shortening osteotomy at an average 79-month follow-up. These patients were managed with a transverse shortening osteotomy and plating. Ulnar variance correction averaged 5 mm with an average ulnar-negative variance of 0.6 mm postoperatively, compared with 4 mm and 0.9 mm, respectively, in the current study. Similarly, Lee et al reported 39 patients managed with arthroscopic TFCC debridement and ulnar-shortening osteotomy. In their series, patients averaged 2.9 mm of ulnar-positive variance preoperatively and were corrected to 0.3 mm of ulnar-negative variance postoperatively. Darlis et al described a step-cut osteotomy, which yielded a 2.5-mm improvement in average pre- and postoperative ulnar variance measurements in 29 patients. The current study’s results indicate that use of the Trimed DCP can reliably result in consistent surgical correction of maligned ulnar variance, similar to other described methods.

Complication rates after ulnar-shortening osteotomy are varied in the literature. Studies by Luria et al, Baek et al, and Darlis et al reported a 0% infection and nonunion rate. When the step-cut osteotomy with the palmar plate technique was reviewed, 3 reoperations were encountered in 29 patients for symptomatic hardware. However, nonunion and delayed union rates of up to 15% have been demonstrated when patients were followed beyond 6 years. Four cases of nonunion occurred among the 28 cases reviewed in the current study. Explanations for the discrepancy among trials include variations among study selection criteria, surgeon technique, and perioperative protocol. Future randomized studies with longer follow-up may demonstrate more accurate and precise reporting of true complication rates with this procedure.

A modifiable surgical parameter that may contribute to the higher than previously reported rates of nonunion is the use of an oscillating saw for bony osteotomy. Excess heat generation from the cutting blade could potentially lead to irreversible damage to osseous organic material, thermal necrosis, and consequently higher nonunion rates. One study using a turkey femur model demonstrated significant increases in bone temperature directly related to blade size and inversely proportional to the speed of the cut after osteotomy with a microsagittal saw. Minimizing ulnar contact time with the saw blade and frequent use of irrigation during osteotomy are 2 techniques that can limit heat formation.

An advance to the current technique of ulnar shortening may be found in alternatives to the use of an oscillating saw. Ultrasonic bone scalpels have been used in spinal and oral surgery to perform precise osteotomies. When used in specific frequencies, these devices have been shown to cut only mineralized tissues. As a result, the use of a bone scalpel over a saw blade has an added benefit of limiting damage to neurovascular structures resting in close proximity to osteotomy sites. The Piezosurgery device (Mec-
tron, Carasco, Italy) has been used in a successful metacarpal osteotomy, and similar instruments may have benefit in the future.

There are several limitations to this study. Many are related to its retrospective design. There was a small patient sample size, reflecting the relatively uncommon occurrence of patients indicated for use of this technique. Non-responder bias is present because several of the patients were lost to follow-up, and the observed subjective and objective clinical outcomes are based on a small subset of 12 patients. In addition, the use of the contralateral extremity as a control group serves as a possible source of observational bias. Despite these limitations, one major strength of the study is that the radiographic measurements were collected on all 27 patients at an average follow-up of 24 months. In addition, the study was adequately powered to detect radiographic differences in union as previously described. Moreover, the authors are unaware of other studies that demonstrate trends to lower union based on an epidemiologic factor.

**Conclusion**

Results of ulnar-shortening osteotomy using the Trimed DCP at 2-year follow-up produce consistent improvements in radiographic ulnar variance. Although no differences were seen in union rates based on patient-related factors such as smoking status, laboring status, and preoperative diagnosis, union rates trended down with patients involved in workers’ compensation claims. Consideration should be given to these factors when selecting patients for the ulnar-shortening osteotomy using the Trimed DCP. Future prospective studies are needed to determine long-term outcomes associated with the use of this technique.

**References**