Ulnar Shortening Osteotomy for Ulnar Impaction Syndrome

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Abstract

Background Ulnar impaction syndrome is a condition in which the ulna impacts on the ulnar carpus. This most commonly occurs when the ulna is longer than the radius, but it can also occur in wrists with ulnar neutral and ulnar negative variance.

Materials and Methods In this paper we outline our surgical technique for ulnar shortening osteotomy. A previously published retrospective case series of 28 patients treated at our center is presented. Fifty consecutive patients who underwent ulnar shortening osteotomy (USO) for ulnar impaction syndrome were approached for study, and 28 consented to review. Mean preoperative ulnar variance was +2.3 mm, and mean postoperative ulnar variance was –0.8 mm. Mean follow-up time was 21.2 months (8 to 41 months) and ten of 28 were receiving workers' compensation. Mean preoperative pain score (visual analog scale; VAS) was 7.9. Univariate analysis was performed to assess clinical and demographic data. In addition, subgroup analysis of workers' compensation patients and smokers was performed.

Description of Technique A longitudinal incision over the subcutaneous border of the ulna is used to expose the ulna between the distal and middle third of the ulna from the ulna styloid. Preoperative posteroanterior (PA) X-rays are reviewed to determine the amount of shortening required, with a goal of creating –2 mm variance postoperatively. A 6-hole dynamic compression plate is predrilled distally prior to performing two oblique osteotomies separated by the desired shortening length. The fragments are reduced, controlling for rotation, and plated using compression. In some cases, a lag screw is employed across the oblique osteotomy site.

Results Mean pain scores were significantly reduced postoperatively (VAS 7.9 versus 3.1, $P < 0.0001$). The mean Disabilities of the Arm, Shoulder, and Hand (DASH) score was 37.2 postoperatively. Flexion, extension, and supination were reduced compared with the contralateral unaffected extremity (84.6%, 85.3%, and 86.9% of normal). Patients receiving workers' compensation and smokers had significantly more pain postoperatively (VAS 5.2 vs. 2.0, $P = 0.0002$ and VAS 4.4 vs 2.4, $P < 0.05$, respectively). Eleven of 28 patients required hardware removal for plate irritation, and five of 28 patients had a nonunion.

Conclusion We present our surgical technique for ulnar shortening osteotomy. Pain was significantly improved in our population; however, patients receiving workers' compensation and smokers had less improvement in pain and higher disability scores.

Keywords

- ulnar shortening osteotomy
- ulnar impaction syndrome

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Ulnar impaction syndrome is a degenerative condition characterized by a constellation of clinical and radiographic findings that result from the abutment of the distal ulna against the lunate and triquetrum. This abutment results in compromise of the triangular fibrocartilage complex (TFCC), chondromalacia of the lunate and triquetrum, abnormal wear on the distal ulna, and sometimes disruption of the lunotriquetral ligament.[1,2] The etiology of this condition is related to a relatively longer ulnar height compared with the radius at the wrist. This is seen with either an abnormally long ulna (i.e., idiopathic positive ulnar variance) or a shortened radius (i.e., fracture malunion, Essex-Lopresti, or premature physis closure).[2]

The diagnosis of the condition is based on symptoms, signs, and radiographic findings. Patients often present with progressive ulnar-sided wrist pain that worsens with ulnar deviation, pronation, and power grip.[1,2] Signs of ulnar impaction syndrome include occasional swelling and pain with palpation over the ulnar side of the wrist. Depending on the underlying etiology, patients may demonstrate decreased wrist flexion–extension and/or pronation–supination. Physical exam maneuvers described for ulnar impaction syndrome include the ulnocarpal stress test (pain with axial load applied to an ulnar-deviated wrist passively rotating through pronation and supination).[2,3]

X-ray and magnetic resonance imaging (MRI) are the most common imaging modalities used to investigate ulnar impaction syndrome. Computed tomography (CT) is also an available imaging modality. X-ray findings may include a positive ulnar variance, arthritic changes such as subchondral sclerosis or cystic formation of the lunate, triquetrum, or ulna, and on occasion a widened lunotriquetral interval in the case of lunotriquetral ligament instability.[4] A pronated-grip view is helpful to accentuate the ulnar variance and determine whether there is dynamic ulnar impaction.[5] MRI can detect early changes associated with ulnar impaction syndrome, including a TFCC tear or fibrillation, chondromalacia, and bone edema of the affected carpal bones.[4]

The management of ulnar impaction syndrome includes nonoperative and operative measures. Nonoperative measures such as activity modification, splinting, and nonsteroidal anti-inflammatory drugs (NSAIDs) may provide symptomatic relief; however, they will not alter the underlying pathophysiology. Operative management of ulnar impaction syndrome depends on the underlying etiology; however, the most common procedures used to address ulnar impaction syndrome are an ulnar shortening osteotomy or an open or arthroscopic distal wafer resection with or without TFCC débridement.[2,6,7,] An osteochondral shortening of the ulna that preserves the distal cartilage is another option.[8–10] Advantages of an ulnar shortening osteotomy (USO) include unloading the ulnar carpus, precise shortening, tightening the ulnocarpal ligament complex, and avoiding damage to the distal articular surface of the ulna.[2] Complications include nonunion or delayed union, which can take up to 8 months, or incongruity of the distal radioulnar joint, which may limit the amount of ulnar shortening. In addition, Tolat et al described different morphologies of the sigmoid notch.[11] A distally facing notch is a relative contraindication.

The purpose of this paper is to describe the author's preferred surgical technique of USO to address ulnar impaction syndrome, to provide results reflecting our experience with this technique, and to summarize the literature describing the management of ulnar impaction syndrome.

Methods

Study Design

We performed a retrospective analysis of 28 consecutive patients over 18 years old who were treated with a USO for ulnar impaction syndrome between 2007 and 2009.[12] There were 50 patients eligible for study, and 28 of these consented to participate. There were nineteen female patients and nine male. The average age was 48.1 (18 to 74) with a mean follow-up time of 21.2 months (8 to 41 months). Previous trauma to the affected extremity was reported in 23 of 28 patients (82%), with 10 of 28 (36%) receiving workers' compensation and 10 of 27 patients (37%) being smokers (smoking data was missing on one patient). The dominant hand was affected in the majority of cases (17/28, 60.7%).[12]

The mean pre- and postoperative ulnar variance and osteotomy union was evaluated radiographically. The clinical outcomes were measured using a patient-rated visual analogue scale (VAS) for pain and the DASH (Disabilities of the Arm, Shoulder, and Hand) questionnaire. The wrist range of motion (ROM) and grip strength were also recorded and compared with the contralateral extremity by an independent observer. Complete data on preoperative wrist ROM, grip strength, and DASH questionnaire were not available and therefore not included for analysis. Wrist range of motion and grip strength were compared with the contralateral unaffected extremity postoperatively. The data was evaluated using paired and unpaired Student's *t*-tests for continuous variables and Fisher's exact test for binomial variables.[12]

Surgical Technique

Operative planning begins with evaluation of the X-ray images preoperatively. The amount of ulnar shortening is calculated by evaluating the PA view of the wrist with the shoulder 90° abducted, elbow 90° flexed, and wrist in 0° pronosupination and flexion–extension. In general, we aim to achieve a postoperative ulnar variance of –2 mm (►**Fig. 1**). In addition, the distal radioulnar joint (DRUJ) is carefully assessed for obliquity of the sigmoid notch. As described by Tolat,[11] a type III DRUJ has a reverse oblique angle of the distal radius at the sigmoid notch, in contrast to a type I DRUJ (vertical) and type II DRUJ (oblique). The obliquity is measured by assessing the angle of the sigmoid notch in comparison to the longitudinal axis of the radius. A type I (vertical) DRUJ is one where the sigmoid notch is parallel to the longitudinal axis of the radius, a type II (oblique) is one where the sigmoid notch is angled toward the ulna, and a type III (reverse oblique) is angled away from the ulna.[11] A type III DRUJ (►**Fig. 2**) can lead to excessive contact pressures of the

Fig. 1 Pre-operative PA X-ray.

Fig. 2 Type III DRUJ.

joint in the setting of a USO and is considered a relative contraindication to USO.[11,13]

Our technique is performed following administration of an upper-extremity block and using an upper-arm tourniquet. In cases with an associated symptomatic TFCC tear, wrist arthroscopy with a TFCC débridement is performed. USO then immediately follows in cases when wrist arthroscopy is performed. A longitudinal incision is planned over the subcutaneous border of the ulna between the distal third and halfway point of the ulna between the flexor carpi ulnaris and extensor carpi ulnaris, with identification and retraction of the dorsal sensory branch of the ulnar nerve (►**Fig. 3**). A subperiosteal dissection is performed at the planned osteotomy site.

Next a six-hole 3.5-mm Synthes dynamic compression plate (Synthes Corp., West Chester, PA, USA) is selected and placed over the ulna to evaluate the plate position. Ideally, the plate is placed over the volar aspect of the ulna under the flexor carpi ulnaris to protect against plate irritation. If this is not possible, then the plate is placed on the dorsal surface under the extensor carpi ulnaris. The site of the osteotomy is then marked, and the holes distal to the planned osteotomy site are predrilled. Bicortical screws are placed in these holes. A longitudinal groove is created in the ulna with a sagittal saw to help re-establish the rotational alignment once the osteotomy is done (►**Fig. 4**).

The plate is then swung away, keeping the distal screw in place, and the two osteotomy cuts are planned based on the preoperative measurements (►**Fig. 5**). The cuts are planned exactly parallel to one another and at a 45° oblique angle to the plate such that the proximal bone fragment can key into the distal fragment when compressed. Regardless of whether the plate is placed on the dorsal or volar surface of the ulna, the oblique osteotomy is performed such that an acute angle is formed between the plate and cut end of the distal fragment, allowing the proximal fragment to key in. The

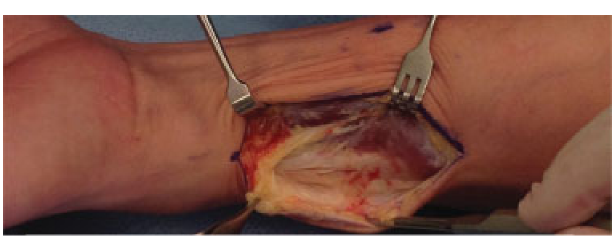

Fig. 3 Identification of dorsal sensory branch of ulnar nerve distally.

Fig. 4 Osteotomy site is marked, distal holes are drilled, and screws placed.

Fig. 5 A longitudinal mark is made, and a small groove created with a sagittal saw to adjust for rotation. The distal screw is left in place and the plate swung away to perform the osteotomy.

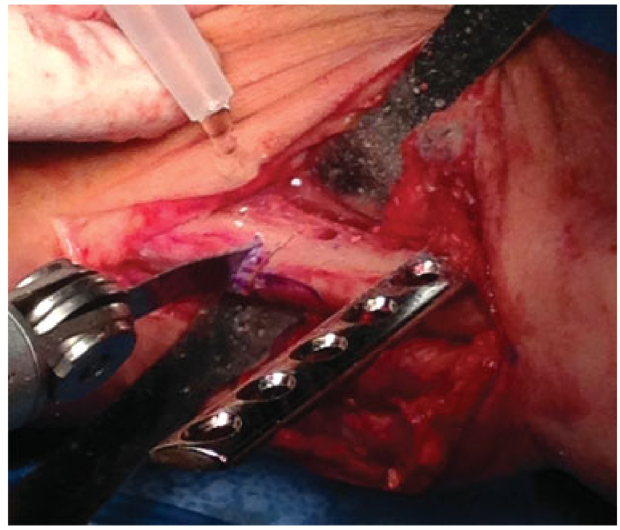

Fig. 6 Alternate between proximal and distal osteotomies to ensure parallel cuts.

osteotomies are performed using a sagittal saw, keeping in mind the cutting kerf of the blade, which can add 1–2 mm of shortening. The surgeon alternates between the distal and proximal cuts, keeping a small intervening bone bridge intact for stability (►**Fig. 6**). The bone segment is removed, and the plate is swung back into position and secured distally using the predrilled holes and screws previously described. The distal and proximal bone fragments are then approximated, ensuring the longitudinal groove is perfectly aligned (►**Fig. 7**). Approximation of the fragments may be difficult with large bone resections due to the tension of the interosseous membrane. Closing the gap can be facilitated using unicortical screws on either side of the osteotomy site and maxillary reduction forceps, an AO wire tightener, or using the plate attached distally to pull the distal ulna proximally. In addition, being very particular with the osteotomies will help avoid incongruent approximation of the bone fragments. The reduction is held using bone-reducing forceps. A lag screw can be inserted for maximum interfragmentary compression. Similarly, the first proximal plate hole is drilled eccentrically to compress the fracture site. The remainder of the holes are drilled in a bicortical fashion. Three screws are placed distal to the osteotomy and three proximal to the osteotomy. The osteotomy alignment and plate and screw position are checked with intraoperative fluoroscopy.

Fig. 7 Proximal and distal bone fragments are reduced.

Our postoperative protocol is to immobilize the wrist in a volar splint for 10–14 days, followed by a short arm cast for 6 weeks. Wrist ROM exercises begin at week 6 and strengthening at week 10–12. ►**Figs. 8a**, **b** show the postoperative X-ray images of ulnar impaction syndrome treated with a USO.

Results

There was a statistically significant improvement in pain, based on the VAS, before and after the ulnar shortening osteotomy with a preoperative mean of 7.9 (range 6–10) as compared with a postoperative mean of 3.1 (range 1–5), $P < 0.0001$). This improvement; however, was more modest in the patients receiving workers' compensation (VAS mean 5.2) versus those who were not (VAS mean 2.0, $P = 0.0002$), which was also statistically significant. The average postoperative DASH score in our cohort was 37.2 (1 to 79).[12]

ROM and grip strength were compared with the contralateral unaffected side postoperatively. A statistically significant reduction was observed in wrist flexion (53° versus 63°, $P = 0.02$), extension (47° versus 57°, $P = 0.03$), and supination (67° versus 79°, $P = 0.04$). The postoperative grip strength was ~80% that of the contralateral unaffected hand.[12]

The average ulnar variance postoperatively was −0.8 mm (range −2.8–1.2), compared with +2.3 mm preoperatively (range 0.44–4.16). We generally aim for a –2 mm ulnar variance post-operatively, and an average postoperative ulnar variance of –0.8 mm is within the error we would expect when evaluating X-rays. The most common complications associated with USO

Fig. 8 (**a**) Postoperative PA X-ray of USO. (**b**) Postoperative lateral X-ray of USO.

were hardware removal and nonunion. Thirty-nine percent (11/28) of patients required hardware removal for plate irritation, and nonunion occurred in five of 28 patients (18%). Patients with established nonunion were managed with débridement of the nonunion site, placement of bone graft and replating. In addition, one patient developed complex regional pain syndrome (CRPS), and one other patient developed symptoms consistent with carpal tunnel syndrome.[12]

A subgroup analysis in this study examined the effect of age, gender, smoking status, and whether a patient was receiving workers' compensation on outcomes. Those patients receiving workers' compensation reported greater pain and disability compared with those who did not receive workers' compensation based on the VAS (5.2 vs 2.0, $P = 0.0002$) and the DASH (60.2 vs 25.7, $P < 0.0001$).[12] When patients were stratified based on smoking status, those who smoked had significantly higher mean pain scores postoperatively (VAS 4.4 vs 2.4, $P < 0.05$), weaker grip, and higher DASH scores (DASH 51.1 vs 29.7, $P < 0.05$). There were no significant differences observed based on gender or age.[12] There was not a higher incidence of nonunion in smokers.

Discussion

USO for the management of ulnar impaction syndrome was originally described by Milch in 1941.[6] Since this report, multiple variations of osteotomy techniques, fixation devices, and arthroscopic procedures have been detailed. The common aim of these procedures is to unload the ulnocarpal joint. Palmer and Werner[14] demonstrated in a cadaver model that in an ulnar neutral wrist, the DRUJ bore 18% of the total load. An increase in the length of the ulna by 2.5 mm increases the load on the ulnar wrist to 42%, whereas a decrease in length of the ulna by 2.5 mm decreases the load to 4.3%.

Limitations of our previous study include selection bias, as only 28 of 50 eligible patients consented to inclusion in the study.[12] This may have influenced the incidence of nonunion and hardware removal, as a portion of the 28 patients who consented were likely still being followed due to these conditions, whereas the other 22 patients who did not consent were likely no longer routinely followed and did not wish to come into clinic for reassessment. We have not significantly changed our technique based on this point. In addition, because of the retrospective nature of that study, preoperative measures were not consistently available, and patient-reported pain based on the VAS was subject to recall bias.

Moermans et al demonstrated the effectiveness of a USO for ulnar impaction syndrome in a cohort of 29 patients showing an improvement of grip strength (67 to 75%), mean ROM (80 to 88%), and mean DASH score (40 to 26).[15] In this study, three patients developed a nonunion, two had a delayed union, and six had pain related to their hardware. Likewise, Loh et al showed that in 23 wrists there was an improvement in pain on a VAS; however, there was no significant difference in grip strength and patient questionnaire responses using the Wrightington Wrist Evaluation Form.[16] They found a trend toward a decrease in ROM of the affected wrist postoperatively. Fifteen of 22 patients complained of plate irritation, with seven patients requesting plate removal. Chun and Palmer report slightly more favorable results with improvements in pain, ROM, and overall result. There were no nonunions, and complications occurred "rarely" in their study.[17] Fricker et al also report no nonunions with comparable functional outcomes; however, 20 out of 28 plates had to be removed.[18]

Baek found that 6 of 36 wrists following a USO had X-ray signs of DRUJ osteoarthritis at the 5-year follow up visit.[19] Five of the 6 wrists with DRUJ osteoarthritis had a type III DRUJ configuration. In addition, DRUJ osteoarthritis occurred particularly in those that were significantly ulnar positive preoperatively (6.7 mm versus 4.3 mm) and those with more bone resection (7.0 mm versus 4.8 mm). Despite the development of DRUJ osteoarthritis, there was no difference in clinical outcomes (Gartland and Werley wrist score) between those with osteoarthritis and those without.[19] At a mean follow-up of 18 months, Koppel et al did not observe X-ray signs of DRUJ osteoarthritis, however, radiographic changes ("various degrees of sclerosis of the sigmoid notch, focal osteolysis in the sigmoid fossa of the radius, or subtle changes in the slope of the ulnar head") were present at the DRUJ in 18 of 47 wrists that had a USO.[20] These changes did not affect clinical outcome. Likewise, Minami and Kato[21] showed slight degenerative changes at the DRUJ in 7 of 25 patients (average follow-up 35 months) following a USO for TFCC tears and ulnar positive variance. They also showed good clinical outcome, with 23 of 25 patients having complete relief of pain or mild pain.[21]

Although ulnar impaction syndrome has been primarily described for wrists with ulnar positive variance, it has also been observed in ulnar neutral and negative variance wrists. Tatebe et al performed USOs in 6 patients with an ulnar neutral and negative variance and ulnar impaction syndrome, with good results.[22]

The decision to offload the ulnar carpus with an ulnar-shortening procedure should be based on the clinical and radiographic findings of the patient. We present our technique to accomplish this using a USO. The USO technique allows precise amounts and larger segments of bone to be removed without affecting the TFCC, effectively relieves pain, and tightens the extrinsic ulnar ligaments of the wrist.[1,2,23] Hardware irritation and nonunion risks must be acknowledged with this technique and mitigated by covering the plate as much as possible with overlying flexor or extensor muscle and encouraging smoking cessation. Risks of complications should be thoroughly reviewed with patients receiving workers' compensation, as there is a higher risk of poor outcomes in this population.

Conflict of Interest
None

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