Distal Metaphyseal Ulnar Shortening Osteotomy: Technique, Pearls, and Outcomes

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Abstract

Keywords

- distal metaphyseal ulnar shortening osteotomy
- ulnar impaction syndrome
- wafer procedure
- diaphyseal ulnar shortening osteotomy
- ulnar sided wrist pain

Background Ulnar sided wrist pain is a commonly encountered complaint of the hand surgeon, and ulnar impaction is a common cause. Surgical treatment aims to reduce the force transmitted through the ulna and traditionally includes diaphyseal ulnar shortening osteotomy and the “wafer” procedure. These procedures have known shortcomings. We describe an alternative option known as the distal metaphyseal ulnar shortening osteotomy (DMUSO).

Materials and Methods Retrospective review of eight procedures was undertaken to assess radiographic healing, objective measurements of wrist and forearm motion, grip and pinch strength, and subjective measures of Disabilities of the Arm, Shoulder, and Hand (DASH), Patient-Rated Wrist Evaluation (PRWE), and Michigan Hand Outcomes Questionnaire (MHQ) at a minimum of 12 months following surgery.

Description of Technique A wedge osteotomy is made in the osteochondral region of the distal metaphysis of the ulna, and a headless compression screw is used for fixation.

Results Five women and three men underwent DMUSO with average follow up at 13 months; the dominant wrist was affected in 7 of 8 patients. The affected wrist had less motion in all planes, and grip and pinch strength was also less in the affected wrist, but only wrist extension was significantly different from the contralateral side. These findings likely did not have an effect on the clinical outcome. Subjective outcomes included average DASH score of 13 (0–35), PRWE 19 (40–11), and MHQ score of 88 (85–100).

Conclusions DMUSO is a viable option for patients with ulnar impaction syndrome. It requires intra-articular exposure of the distal radioulnar joint (DRUJ) but is less invasive than diaphyseal shortening. It permits early and reliable return of joint motion and function while avoiding the potential need for hardware removal by using a buried screw.

Ulnar sided wrist pain is a commonly encountered complaint of the hand surgeon. Common causes include triangular fibrocartilaginous complex (TFCC) injuries, lunotriquetral ligament injuries, or ulnar impaction syndrome (UIS). The ulnocarpal joint is a restricted contact area, and since a significant amount of force is transmitted through this area, it is at an increased risk for articular degeneration. UIS is a

degenerative condition that commonly occurs as a result of natural or acquired ulnar-positive variance, distal radius fracture malunion, collapse of a fractured radial head, or excessive chronic load across the ulnocarpal joint.^{1,2}

Treatment of UIS involves methods aimed at decreasing the force transmitted through the distal ulna. These include the diaphyseal ulnar shortening osteotomy, the “wafer”

procedure, and the relatively new distal metaphyseal ulnar shortening osteotomy (DMUSO), further described herein.

The ulnar shortening osteotomy, as originally described by Milch in 1941, used wire suture to fix the osteotomy; it has predictably undergone numerous modifications and improvements.^{3–11} Current technique involves placement of a plate deep to the flexor carpi ulnaris (FCU) muscle belly no closer than 2–3 cm from the sigmoid notch, and an oblique osteotomy with lag screw fixation—which has been shown to heal more reliably.¹² The ulnar shortening osteotomy has been consistently beset with complications such as irritation from hardware leading to additional procedures for hardware removal, variable malunion, nonunion, and delayed union, tendonitis, refracture, and distal radioulnar joint (DRUJ) incongruity.^{3–11} The variability and delay in union and/or healing can be attributed to the fact that this procedure involves a diaphyseal osteotomy, which can be quite slow to heal.^{10,13,14}

The wafer procedure is a partial distal ulnar resection, described by Feldon in 1992. It involves excision of the distal 2–4 mm of the ulnar head and can be performed as an open or arthroscopic procedure.^{12,15} A significant pitfall of this procedure is that excessive resection may cause damage to the DRUJ.^{12,15} The resection of the distal articular cartilage and subchondral bone leaves metaphyseal trabecular bone exposed, which continues to bleed into the distal radioulnar, ulnocarpal, and radiocarpal joints.^{15,16} This procedure often requires extensive recovery time, which is likely caused by this persistent hemarthrosis.^{12,15,16}

Slade and Gillon described an osteochondral ulnar shortening in 2007.¹⁶ Their premise was that the prolonged

recovery period often seen after the wafer procedure might be a result of a persistent hemarthrosis. They believed that an osteotomy through metaphyseal bone would be expected to have a shorter time to union and be less painful. The distal ulnar osteotomy was performed via a dorsal approach through the floor of the fifth extensor compartment just beneath the articular dome, which kept the stability of the DRUJ and TFCC intact. Subsequent to this, Barry and Mack-soud described the same technique, except without using internal fixation.¹⁷ Hammert et al changed the name of the procedure from “osteochondral” shortening osteotomy to “distal metaphyseal” to describe the location of the osteotomy more accurately.¹⁴ In a cadaver model, Greenberg et al have demonstrated decreased joint forces across the ulnar carpal joint without a change in transverse forces across the DRUJ.¹⁷

DMUSO is an attractive alternative option for treatment of UIS. It is indicated in patients with UIS who have failed nonoperative treatment modalities. Preoperative imaging consists of zero-rotation posteroanterior (PA) view and pronated grip view (►Fig 1) Magnetic resonance imaging (MRI) can be obtained for confirmation (►Fig. 2). This procedure is contraindicated in patients with evident DRUJ arthritis, as these patients are better served with DRUJ arthroplasty or distal ulna resection.^{14,16}

Materials and Methods

Following institutional review board (IRB) approval, we retrospectively reviewed eight nonconsecutive procedures. Our goal was to obtain data on our first 15 patients, but we were unable to get all to return for evaluation. Outcomes assessed included radiographic healing, objective measurements of wrist and forearm motion, grip and pinch strength and subjective measures of Disabilities of Arm, Shoulder, and Hand (DASH), Patient-Rated Wrist Evaluation (PRWE), and Michigan Hand Outcomes Questionnaire (MHQ) at a minimum of 12 months following surgery. A visual analog pain score was not used, as we do not find this useful as an

Fig. 1 Preoperative pronated grip radiograph demonstrating positive ulnar variance.

Fig. 2 Preoperative magnetic resonance image (MRI) showing ulnar-sided marrow edema of the proximal ulnar aspect of the lunate.

Fig. 3 Preoperative marking of incision site.

individual number due to the great variability between patients.

Surgical Technique

The procedure is typically performed under regional anesthesia. We routinely begin by performing arthroscopy to evaluate for central TFCC tear, lunate impaction with chondromalacia, and lunotriquetral interosseous ligament tears.^{14,16} This allows staging and treatment of any TFCC tears that require treatment or ulnocarpal arthrosis.^{14,16} Upon completion of the arthroscopy, the arm is placed pronated on the hand table and a longitudinal incision is made ulnarly over the fifth dorsal compartment spanning ~4–5 cm from the distal aspect of the ulnar head proximally to expose the ulnar neck (►Fig. 3). Care is taken to identify and protect the dorsal sensory branch of the ulnar nerve, which is most often found deep to the ulnar skin flap and distal to the skin incision.^{14,16} Sharp dissection is continued down through the fifth extensor compartment and the extensor digiti quinti (EDQ) tendon is retracted. The ulnar head is exposed with an inverted L-shaped capsulotomy by sharply incising the floor of the fifth compartment, directing the transverse limb ulnarly along the distal aspect of the ulnar head, just proximal to the dorsal radioulnar ligament.¹⁶ To achieve reduction and stabilization, it is necessary to expose the dorsal and distal portion of the ulnar head fully; this is achieved by a combination of pronation, dorsal-directed pressure on the ulnar head, and volar-directed pressure on the radius.¹⁴

At this point, the distal ulnar metaphysis is adequately visualized, and the osteotomy site may be located just proximal to the articulation of the ulnar head with the sigmoid notch (►Fig. 4).¹⁴ A Kirschner wire (K-wire) is placed into the distal ulnar metaphysis along the radial one-third of the bone, proximal to the DRUJ (►Fig. 5). The amount of preoperative ulnar-positive variance dictates the amount of metaphyseal bone to be resected, which is measured along the radial aspect of the ulna. A second parallel K-wire can be used for orientation for making the cuts.^{14,16} Convergent lines are created such that they will meet at the ulnar cortex. The angulation of the osteotomies is important, and the wires

Fig. 4 Intraoperative exposure of the right distal ulnar metaphysis with markings showing planned osteotomy site located just proximal to the articulation of the ulnar head with the sigmoid notch. Note the design of the osteotomy is a triangular piece of bone tapering to meet at the ulnar cortex.

help ensure that the cuts are perpendicular to the shaft of the ulna. Since the site of impaction is along the radial distal aspect of the ulna, where it abuts the proximal ulnar aspect of the lunate, this is the area that requires shortening. The cuts are oriented in a v shape, with the point at the ulnar cortex, creating a green stick fracture through the ulnar cortex.¹⁴ Depending on the preoperative ulnar variance, a 2- to 5-mm wafer of bone is resected with a microsagittal saw at the level of the DRUJ, leaving the distal ulna articular surface and the TFCC foveal attachments intact. These cuts should be made carefully so that the periosteum remains intact to facilitate osteotomy closure and enable the existing soft tissue attachments to accommodate in rotational support while simultaneously minimizing the possibility that the osteotomy site will distract postoperatively.¹⁴ The goal is to end with a –1-mm ulnar variance. Confirmation that the osteotomy is completely through the volar cortex is completed with small osteotomes (►Fig. 6).

To reduce the ulna, the assistant directs pressure dorsally on the ulna with concurrent volar-directed pressure on the radius, exposing the ulnar head so that it can be reduced to the shaft and held in place with reduction forceps or proximal-directed pressure on the ulnar head with a curved hemostat.^{14,16} Under fluoroscopy, a K-wire is then placed through the ulnar head, perpendicular to the osteotomy, in a proximal direction into the ulnar cortex. A second antirotation K-wire is placed to maintain reduction. Fluoroscopy is used to confirm reduction and adequate positioning of the wire prior to placement of a cannulated headless compression

Fig. 5 Intraoperative fluoroscopy showing KK-wire placed at proposed osteotomy site to ensure cut is perpendicular to bone.

screw^{14,16} We have used the Mini Acutrak II (Acumed, Hillsboro, OR), but others can work equally well. Slade and Gillon describe placement of a second screw in the event that fixation is inadequate, taking care to avoid fracturing the ulnar head.¹⁶ We have found that the size of the ulnar head makes this unpredictable, and as long as the initial screw engages the ulnar cortex, we do not feel that a second screw is necessary.

Final fluoroscopic images are obtained after removal of the K-wires. The DRUJ and TFCC are inspected for stability and the dorsal capsule and extensor retinaculum are closed, leaving the EDQ in the subcutaneous position. The skin is closed, and the patient is placed in a volar plaster splint.^{14,16} In spite of the incision through the dorsal capsule of the DRUJ, we have not found it necessary to immobilize with an above elbow splint.

Rehabilitation

The patient is encouraged to perform immediate finger and elbow active motion. Between post-operative days 7 and 10, the patient is placed in a custom removable wrist splint and hand therapy program is initiated, with light use of the wrist. Slade and Gillon advocate robust active strengthening program to stimulate bone healing, while our practice is to await confirmation of osseous healing to permit unrestricted wrist motion.^{14,16} Slade and Gillon also report obtaining computer tomographic (CT) scans of all postoperative wrists at 4 weeks, owing to their experience that negligible callus formation after the rigid internal fixation obfuscates assessment of osseous healing with plain radiography.¹⁶ We routinely use plain radiographs at 4–6 weeks to assess osseous healing (–Fig. 7); if at this time the osteotomy site is not visible and there is no pain with palpation over the site, patients are permitted unrestricted use of the wrist.^{14,16} Our practice is to obtain CT scans only when osseous healing is in question.

Results

There were eight patients with average follow up data at 13 months (range 11–18) following surgery. There were five

Fig. 6 Intraoperative photo (from a different patient) of the left wrist after osteotomy has been created.

women and three men, and the dominant wrist was affected in seven of the eight patients. Three of the eight patients were involved in workers' compensation claims regarding their affected wrist. The affected extremity had slightly less motion in all planes, but only the postoperative wrist extension was significantly different ($p < 0.003$) (–Table 1). For individual patients, wrist extension on the operated side averaged 85%, flexion 95%, radial deviation 80%, ulnar deviation 95%, and pronation/supination averaged 95–99% compared with the contralateral wrist. Clinically, these differences were typically 10–15 degrees. Averages and ranges of motions are presented in –Table 1. Grip and pinch strength was also slightly less in the affected wrist (grip = 85%, key pinch = 95%, and oppositional pinch = 93% of contralateral wrist), with only grip significantly different ($p < 0.008$) (–Table 2). Average and range of grip and pinch strength are reported in –Table 2. Subjective outcomes included average DASH score of 13 (0–35), PRWE 19 (11–40), and MHQ score of 88 (85–100). All patients demonstrated radiographic healing at the appointment between 6 and 8 weeks.

Discussion

In the series by Barry and Macksoud, all seven osteotomies progressed to union without internal fixation.¹⁸ The patients regained a full range of wrist motion by 3 to 5 weeks after the procedure, with an improvement in their pain levels as assessed with a visual analog scale.¹⁸ The patients had an average 1.29-mm decrease in the ulnar variance with a mean postoperative variance of –0.43 mm (range 0 to 1 mm).¹⁸

Fig. 7 Postoperative (a) PA and (b) lateral radiographs.

However, their mean long-term (range 14 to 38 months) postoperative ulnar variance was -0.2 mm (range $+1$ to -1 mm).¹⁸ Thus, at least one of these patients healed with an ulnar positive variance. A recent paper by Yin et al described an arthroscopic technique of distal metaphyseal ulnar shortening osteotomy for ulnar impaction syndrome, but no series was reported.¹⁹

Slade and Gillon reported one case that required percutaneous screw removal after computed tomography showed bony union; this was because the screw used was too long; they do not provide the total number of cases performed.¹⁶ In a previous report by the senior author (WCH), two patients experienced complications, both

related to technical errors.¹⁴ The first was due to violation of the ulnar cortex during the osteotomy, precluding adequate reduction and stabilization with a headless compression screw, requiring an ulnar column plate to achieve adequate stabilization.¹⁴ This experience galvanized and underscored for us the importance of keeping the ulnar periosteum intact.^{14,16} The second complication reported was a fracture of the ulnar head that occurred while an attempt was made to place a second screw to augment an inadequate initial fixation; this also required ulnar column plate salvage.¹⁴ This occurred early in our experience with the procedure, and we were not able to get this patient to return for the outcomes assessment.

Table 1 Average degrees of wrist motion in the post-DMUSO versus the contralateral wrist, rounded to the nearest whole number

Direction	Post-DMUSO wrist	Contralateral wrist	% of contralateral wrist	<i>p</i> Value
Extension	50° (35–60)	59° (40–70)	84	0.003
Flexion	51° (30–65)	59° (40–75)	91	0.14
Radial deviation	21° (10–35)	24° (10–40)	96	0.17
Ulnar deviation	33° (20–55)	37° (15–55)	95	0.2
Pronation	74° (10–90)	84° (75–90)	95	0.2
Supination	67° (30–90)	72° (30–90)	94	0.2

Table 2 Average grip, pinch, and three-point pinch strength in the post-DMUSO versus the contralateral wrist, rounded to the nearest whole number

Measure	Post-DMUSO wrist	Contralateral wrist	% of contralateral wrist	<i>p</i> Value
Grip strength	26 kg (4–60)	30 kg (12–56)	88%	0.008
Key pinch	8 kg (1.5–14.5)	8 kg (3–14)	100%	0.85
Oppositional pinch (3 point pinch)	7 kg (1–12)	7 kg (3–15)	100%	0.29

Additional possible complications include disruption of the TFCC foveal insertion and dorsal radioulnar ligament, which may lead to instability or arthritis; the intra-articular approach may induce capsular scarring and stiffness; potential compromise of the distal fragment; iatrogenic injury to the ulnar sensory branch; as well as delayed union or nonunion, although there are no reports of such complications in the current literature.^{14,16,17} To optimize outcomes and minimize complications, there are several technical points that the surgeon should remember. First, to determine the correct amount of shortening necessary and avoid excess bony resection, which may affect DRUJ stability, one must obtain a preoperative zero-rotation PA radiograph.¹⁴ Second, the surgeon is advised to begin by first performing a thorough wrist arthroscopy so that any existing intra-articular pathology may be addressed.¹⁴ Third, to assist in maintaining the osteotomies proximal to the DRUJ, intraoperative fluoroscopy should be used to identify the level of the proposed osteotomy.¹⁴ Fourth, paying careful attention to preserving the ulnar periosteum will allow adequate stabilization of the radial closing wedge osteotomy.¹⁴ Finally, the screw should be centered in the ulnar head to verify that the distal aspect of the screw fully engages the ulnar cortex such that adequate compression may be achieved; additionally, the surgeon should avoid overtightening the screw, so as to avoid perforation of the ulnar cortex¹⁴.

As with all retrospective studies, there are limitations. We were unable to compare the preoperative and postoperative objective and subjective measurements and scores and thus are unsure whether the postoperative values represent an increase or a decrease from preoperative values. There was not a direct comparison to other methods of unloading the ulnar carpal joint. One of our patients had other postoperative conditions that likely affected her objective and subjective outcomes, requiring trigger digit releases and carpal tunnel and cubital tunnel releases. Two of the final measurements were obtained during a final impairment rating for workers' compensation, and this may have affected the patient's effort. We are currently collecting prospective outcomes data in effort to determine improvement following this procedure.

Conflic of Interest

None

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