SCIENTIFIC ARTICLE

Soft Tissue Complications of Dorsal Versus Volar Plating for Ulnar Shortening Osteotomy

Soumen Das De, MD, MPH, Parker H. Johnsen, BS, Scott W. Wolfe, MD

Purpose To compare the results and complications of fixed-angle dorsal locking plate fixation for ulnar shortening osteotomy (USO) with the conventional technique of volar plating.

Methods We performed a retrospective review of 32 patients undergoing USO on 34 wrists and compared the outcomes of 16 consecutive cases with dorsal 2.4/2.7-mm fixed-angle plating and 18 consecutive cases with volar 3.5-mm plating. A minimum of 12 months' follow-up was used to assess outcomes. Primary outcomes were painful hardware and removal of symptomatic implants. Secondary outcomes were pain, Patient-Rated Wrist Evaluation, range of motion, time to union, grip strength, and complications.

Results There were no significant differences in Patient-Rated Wrist Evaluation, pain score, range of motion, or time to union. Relative grip strength compared with the contralateral upper extremity in the dorsal group was higher than the volar group. After adjusting for hand dominance, dorsal plating was significantly associated with higher relative grip strength. There were 2 complications in the dorsal group, including one case with painful hardware. This was significantly lower than in the volar group, which had 10 complications including 2 nonunions and 6 cases of hardware-related soft tissue irritation.

Conclusions Both volar and dorsal plating techniques for USO yielded good functional outcomes. There was a higher incidence of painful hardware requiring removal of implants in the volar group. Based on these findings, we advocate dorsal plate position using a smaller fixed-angle plate for USO in ulnar impaction syndrome. *(J Hand Surg Am. 2015;■(■):■−■. Copyright © 2015 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Therapeutic III.

Key words Complications, hardware, ulnar impaction syndrome, ulnar shortening osteotomy.

Ulnar impaction syndrome is usually associated with ulnar positive variance and can lead to a number of degenerative processes, including triangular fibrocartilage complex tears, lunotriquetral ligament tears, ulnocarpal chondromalacia, and osteoarthritis. Ulnar shortening osteotomy (USO) is the most commonly used procedure to treat symptomatic wrists with ulnar positive variance that have failed nonsurgical management. The most common techniques involve fixation with a volar- or ulnar-positioned 3.5-mm plate. The reported incidence of hardware complications and plate removal is up to 55% with such techniques.[1] The aim of this study was to compare the outcomes and complications of USO using a 2.4/2.7-mm dorsal fixed-angle plate technique with a traditional volar plate technique.

From the Hand and Upper Extremity Service, Hospital for Special Surgery, New York, NY.

Received for publication July 17, 2014; accepted in revised form December 29, 2014.

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

Corresponding author: Scott W. Wolfe, MD, Hand and Upper Extremity Service, Hospital for Special Surgery, 535 E. 70th Street, New York, NY 10021; e-mail: wolfes@hss.edu.

0363-5023/15/■ ■-0001$36.00/0
http://dx.doi.org/10.1016/j.jhsa.2014.12.042

MATERIALS AND METHODS

Patients

A single surgeon performed 46 ulnar shortening procedures in 44 patients from 2003 to 2014. A minimum follow-up of 12 months was used for the purpose of this study and 6 patients who had had dorsal plating less than 1 year earlier were excluded. After we obtained approval from the institutional review board, we performed a retrospective chart review. Primary outcomes of interest were complications including painful hardware and the need for implant removal. Secondary outcomes included pain, Patient-Rated Wrist Evaluation (PRWE) score,[2] range of motion (ROM), time to union, grip strength, grip strength relative to the contralateral limb, and other complications or revision surgery. Clinical evaluation of grip strength and ROM were possible in 13 of 16 wrists in the dorsal group and 10 of 18 wrists in the volar group. All patients were contacted by phone to ascertain the presence of pain or other complications and to determine whether they had had the implants removed. Union was defined as absence of tenderness at the osteotomy site and radiographic evidence of trabeculae crossing the osteotomy site on 3 radiographic projections. Time to union was categorized as follows: 8 weeks or less, 9 to 12 weeks, and greater than 12 weeks. Nonunion was diagnosed in any patient who required bone grafting and revision of fixation because of persistent tenderness at the osteotomy site 16 weeks or more from surgery, or who had radiographic lucency despite immobilization and bone stimulation, or hardware failure. We measured grip strength using a handheld dynamometer. Relative grip strength was calculated by dividing grip strength in the operated limb by grip strength in the contralateral limb. Plate dimensions (thickness and length) were directly measured from radiographs and corrections were applied for magnification error. We compared continuous data using either Student *t* or Wilcoxon rank sum test. Categorical outcomes were compared using chi-square or Fisher exact test. We further examined significant associations by linear regression methods to adjust for potential confounders. An alpha error of less than 5% ($P < .05$) was considered statistically significant.

Surgical technique

Volar plate technique: Between 2003 and 2009, the senior author (S.W.W.) performed 22 consecutive USOs in 21 patients using a variation[3] of the Chun and Palmer technique.[4] In brief, the ulna shaft was approached using an 8- to 10-cm incision over the subcutaneous border of the ulna followed by exposure of the interval between the extensor carpi ulnaris and flexor carpi ulnaris. A 6- or 7-hole, 3.5-mm dynamic compression plate was placed on the volar surface of the distal ulna. After 2 distal screws were predrilled and inserted, a compression/distraction device (Synthes, Paoli, PA) was applied to the most proximal screw hole and a unicortical screw was applied through the distractor 1 to 2 cm proximal to the plate.[3] Next, the osteotomy site was marked and subperiosteal dissection was performed exclusively at the site of the osteotomy and in a limited fashion to minimize vascular disruption. One of the distal screws was removed and the plate was rotated away in preparation for osteotomy. Two parallel oblique osteotomy cuts were performed with the goal of obtaining 0 to 2 mm of ulnar negative variance. The plate was rotated back into position and the compression/distraction device was reapplied and compressed. The gliding hole for an interfragmentary screw was drilled, followed by placement of a proximal screw in compression mode. The hole for the lag screw was then extended across the osteotomy site through the plate and the lag screw was placed to achieve further interfragmentary compression. The remaining screws were placed in neutral position. Patients were immobilized in a short-arm plaster orthosis for 10 days, followed by a short-arm fiberglass cast until healing.

Dorsal 2.4/2/7-mm plate technique: Based on the high incidence of hardware irritation and plate removal and the emergence of lower-profile locked plate technology, the senior author initiated a technique using a smaller fixed-angle plate in a dorsal position. Adams[5] had previously proposed that the use of a dorsal 3.5-mm plate would lessen the incidence of hardware irritation and plate removal. The dorsal technique has been used on 23 consecutive patients since January, 2010; the 15 patients (16 wrists) with greater than 12 months' follow-up are presented here.

Through a smaller (6- to 8-cm) longitudinal skin incision, a 6- or 7-hole, fixed-angle, 2.4/2.7-mm, low-profile, dynamic compression plate was applied on the flat dorsal surface and contoured slightly to increase compression (Fig. 1). Minimal division of the most proximal attachment of the extensor retinaculum on the ulna and gentle retraction of the extensor carpi ulnaris with a Hohmann retractor aided exposure. The remainder of the procedure was performed as described above. Generally, 2 locked 2.7-mm screws were placed distally in the softer metadiaphyseal bone and nonlocked screws placed in compression mode were used proximal to the osteotomy. An oblique interfragmentary screw was used in all cases. A short-arm orthosis was applied for 10 to 12 days followed by a short-arm fiberglass cast until healing was evident.

RESULTS

We identified 38 patients who had undergone USO at least 1 year before this investigation. There were

FIGURE 1: A Postoperative and **B** lateral radiographs show application of the smaller 2.4/2.7-mm fixed-angle dorsal plate.

TABLE 1. Patient Characteristics by Type of Plate Fixation (N = 34 Wrists)

	Dorsal Plating (n = 16)	Volar Plating (n = 18)	*P* Value
Age at surgery, y (mean [SD]),	44 (15)	50 (14)	.22
Gender (%)			.53
Male	7 (44)	6 (33)	
Female	9 (56)	12 (67)	
Involvement			< .01
Dominant wrist	12 (75)	7 (39)	
Nondominant wrist	4 (25)	11 (61)	
Preoperative ulnar variance, mm (mean [SD])	2.6 (1.3)	2.6 (1.3)	.92

TABLE 2. Comparison of Outcomes Between Dorsal and Volar Plating Groups (N = 34 Wrists)

	Dorsal Plating (n = 16)	Volar Plating (n = 18)	*P* Value
Tourniquet time, min (mean [SD])	82 (13)	92 (18)	.22
Postoperative ulnar variance, mm (mean [SD])	−1.8 (1.6)	−1.5 (1.8)	.72
Time to union, wk (%)			.60
≤ 8	6 (38)	4 (22)	
9–12	4 (25)	7 (39)	
> 12	3 (19)	3 (17)	
Nonunion	0	2 (11)	
Excluded from analysis	3 (19)	2 (11)	
PRWE (mean [SD])	12 (12)	15 (12)	.51
PRWE pain score (mean [SD])	0.1 (0.3)	0.4 (0.9)	.15
Range of motion, degrees (mean [SD])			
Supination	76 (9)	73 (14)	.58
Pronation	79 (10)	70 (17)	.16
Flexion	68 (19)	68 (24)	.98
Extension	68 (15)	59 (25)	.35
Radial deviation	24 (7)	25 (7)	.80
Ulnar deviation	38 (9)	35 (21)	.69
Grip strength, kg (mean [SD])	31 (10)	20 (14)	.06
Relative grip strength compared with contralateral extremity (%) (mean [SD])	101 (25)	71 (26)	.01

inadequate follow-up data on 6 of these patients because they could not be contacted by phone. Four patients were in the volar group and 2 were in the dorsal group; they had an average clinical follow-up of 2 months (range, 1.5–3.5 mo). At the last clinical visit, all 6 had clinical and radiologic evidence of union, all had been released to strengthening and activities as tolerated, and none had complications. In the remaining cohort of 32 patients (34 wrists), there were 12 men and 20 women; mean age at surgery was 47 years (SD, 15 y). Both groups were comparable with respect to age, sex, preoperative ulnar variance, length of surgery, and degree of correction (Tables 1, 2). There was a statistically significant difference in involvement of the dominant extremity between groups. A greater proportion of patients with dorsal plating had had surgery on the dominant wrist (75% vs 39%; $P < .01$). In the dorsal group 14 7-hole and 2 6-hole, 2.4/2.7-mm plates were used. The 2.4/2.7-mm plates were 2.7 mm thick and between 60 mm (6-hole plate) and 69 mm (7-hole plate) long. In the volar group 17 6-hole and 1 7-hole 3.5 mm plates were used. These plates were 3.4 mm thick and between 80 mm (6-hole plates) and 92 mm (7-hole plates) long. Mean length of the 2.4/2.7-mm plates used in the dorsal group was significantly shorter than the 3.5-mm plate used in the volar group (67 vs 80 mm; $P < .01$). Follow-up was longer in the volar group because dorsal plating began in January, 2010.

Clinical and radiographic follow-up was 14 ± 10 months in the dorsal group compared with 23 ± 17 months in the volar group ($P = .06$). Telephone interviews to assess pain, PRWE scores, complications, and secondary surgery were conducted at an average of 24 ± 7 months after USO in the dorsal group compared with 82 ± 21) months in the volar group ($P < .01$).

Table 2 compares objective and subjective outcomes of the dorsal and volar groups. There were no significant differences in PRWE scores, PRWE pain subscale score, ROM, or time to union. Five patients returned for follow-up at 4 to 5 months postoperatively with fully united osteotomies but did not have radiographs in the interim period; consequently, these patients' data could not be used in the analysis of time to union. The dorsal group had significantly higher relative grip strengths compared with the volar group. After adjusting for hand dominance using linear regression, dorsal plating was significantly associated with relative grip strength ($P = .02$). This association with relative grip strength remained significant when the analysis was repeated after excluding the 2 patients who had bilateral USO.

There were 2 complications in the dorsal group (13%) compared with 10 in the volar group (56%) ($P = .01$). Painful hardware was noted in one patient in the dorsal group (6%) and 6 in the volar group (33%). Five patients required removal of symptomatic hardware (1 in the dorsal group [6%] and 4 in the volar group [25%]). The dorsal plate was removed 14 months after USO. The four volar plates were removed at 12, 12, and 17 months after USO (average, 13 mo). One patient in the dorsal group had progressively painful radiocarpal arthritis, which was noted preoperatively and was related to a prior distal radius fracture; eventually the patient required a radiocarpal arthrodesis. In the volar group, other complications were nonunion requiring bone grafting and revision of fixation (2), wound infection requiring incision and drainage (1), and limitation of pronosupination requiring contracture release (1).

DISCUSSION

Ulnar impaction syndrome presents with ulnar-sided wrist pain and can result in triangular fibrocartilage complex tears, lunotriquetral ligament tears, ulnocarpal chondromalacia, and osteoarthritis.[4,6,7] Ulnar positive variance is a risk factor for this condition and a 2.5-mm increment increases ulnocarpal loading by more than 40%.[8] Ulnar positive variance can result from congenital or acquired causes including malunited distal radius fractures, physeal injuries, Essex−Lopresti injuries, radial head excision, and developmental disturbances (eg, Madelung deformity).[7] Nonsurgical management is the mainstay of initial treatment. The condition must be differentiated from radioulnar instability, although the 2 conditions may coincide. Surgery should be considered in the setting of persistent symptoms with functional limitation.

Ulnar shortening osteotomy has been successfully used to relieve pain in ulnocarpal and stylocarpal impaction syndromes[7] and can concomitantly address dorsal subluxation of the distal ulna.[9] In one study with a minimum follow-up of 5 years, patients with USO had persistently good functional outcomes scores, maintenance of a negative ulnar variance, and reduced dorsal ulna subluxation.[10] Radiographic evidence of distal radioulnar joint osteoarthritis was associated with greater preoperative ulnar positive variance, longer distal radioulnar distance on lateral radiographs, and greater correction during USO.[10]

Many techniques of USO have been described, with variations in site and orientation of osteotomy, plate position, and type or size of fixation devices. The most commonly employed method involves a diaphyseal osteotomy, but several authors have reported success with metaphyseal osteotomies as well, citing better union rates and less irritation from hardware as potential advantages.[11−13] Diaphyseal osteotomies have the advantage of improving radioulnar stability because of the tensioning effect on the distal interosseous ligament.[14] Oblique,[4,15−17] transverse,[9,18,19] and step-cut[11] osteotomies have been described. Rayhack and associates[15] showed a significantly shorter time to union with the oblique osteotomy. Wehbe and Cautilli[19] reported similar healing times with a transverse osteotomy. Most studies reported using 3.5-mm or similarly sized plates,[3,4,9,15,18] although Wehbe and Cautilli described using a 2.7-mm dynamic compression plate. Headless compression screws and wires have been used with success, as well.[11,12] Finally, Chun and Palmer[4] and Adams[5] advocated dorsal 3.5-mm plate placement whereas others have recommended volar plating.[3,9,18] Most of these studies presented a single technique and not all detailed need for plate removal. It is difficult to compare the results of these techniques across different study populations and institutions. Both of our study groups had similar baseline characteristics and were evaluated with a combination of validated, patient-reported, and objective clinical criteria. Our results indicated that both methods achieved timely union with comparable wrist motion and functional scores. The smaller, dorsally applied, fixed-angle plates seemed to provide the same rigidity of fixation with fewer soft tissue complications, no nonunions, and a reduced need for hardware removal.

Patients with dorsally applied 2.4/2.7-mm plates had higher relative grip strength compared with those with volar plates. This relationship persisted even after adjusting for hand dominance. It is possible that volarly applied plates irritated the flexor carpi ulnaris and ulnar-sided flexor digitorum profundus tendons, either directly or as a consequence of postoperative scarring in the area. Other differences in the 2 groups were the higher rates of complications and secondary procedures in the volar group. Painful hardware was noted in 33% of patients in this group compared with 6% in the dorsal group. Similarly, hardware removal was necessary in 22% in the volar group compared with 6% in the dorsal group. Rates of reported hardware removal have been between 10% and 55% for volar or ulnar plate placement[1,4,17,20]; no data are available on the rate of hardware removal of dorsal plates. Wehbe and Cautilli[19] noted mild tenderness over the 2.7-mm plate in all of their patients and they removed all implants in their series. A plausible explanation for the difference in hardware irritation and plate removal related to plate position is that the functional position of the forearm is in pronation (eg, typing, writing), which accounts for the greater direct pressure on hardware and soft tissue irritation in volarly and ulnarly placed implants. However, a limitation of this retrospective review was that the volar and dorsal cohorts differed with respect to 2 variables: implant size and plate position. It is therefore difficult to determine which of these variables led to the decreased incidence of soft tissue irritation.

There were 2 cases of nonunion overall, both in the volar group. Neither of these patients had a predisposition to poor healing such as diabetes, steroid use, or smoking. In other series, the incidence of nonunion requiring revision surgery ranged from 0% to 18%[9,10,17,19,21] and some series report delayed healing times of up to 7 months.[7] Whether absence of nonunion in this group may be related to plate position or to the newer fixed-angle plate technology is speculative. Limitations of this study include the retrospective design with its inherent confounding and potential biases (eg, differences in hand dominance) between groups. Any observed baseline differences likely resulted from chance because they were not criteria for selecting plate position. We attempted to address this by adjusting for hand dominance when comparing grip strength. It is also possible that there were preexisting differences in grip strength between the 2 cohorts, because grip strength was not measured before surgery. It was also difficult to ascertain whether reduced soft tissue irritation in the dorsal group was a consequence of plate position or simply because we used a smaller, lower-profile plate. The only other series that used a 2.7-mm compression plate had a 100% rate of hardware removal[19]; conversely, Chun and Palmer[4] used a 3.5-mm plate applied dorsally but did not report the incidence of implant removal. Consequently, we speculate that plate position is the more important factor. Those reports were from the 1990s and it is possible that newer implants will perform better with regard to soft tissue irritation. Longer follow-up data were available for the volar group because the dorsal technique was initiated in 2010. However, we think that the minimum follow-up period of 16 months in the dorsal groups was adequate to detect hardware-related soft tissue irritation. This is supported by our findings that 4 of the 5 symptomatic plates were removed at an average of 13 months after USO.

ACKNOWLEDGMENT

The authors thank Schneider Rancy and Phillip Tow for assistance with data collection and editorial support.

REFERENCES

1. Iwasaki N, Ishikawa J, Kato H, Minami M, Minami A. Factors affecting results of ulnar shortening for ulnar impaction syndrome. *Clin Orthop Relat Res*. 2007;(465):215−219.
2. MacDermid JC, Turgeon T, Richards RS, Beadle M, Roth JH. Patient rating of wrist pain and disability: a reliable and valid measurement tool. *J Orthop Trauma*. 1998;12(8):577−586.
3. Chen NC, Wolfe SW. Ulna shortening osteotomy using a compression device. *J Hand Surg Am*. 2003;28(1):88−93.
4. Chun S, Palmer AK. The ulnar impaction syndrome: follow-up of ulnar shortening osteotomy. *J Hand Surg Am*. 1993;18(1):46−53.
5. Adams B. Distal radioulnar joint instability. In: Wolfe SW, Hotchkiss RN, Pederson WC, Kozin SH, eds. *Green's Operative Hand Surgery*. 6th ed. Philadelphia, PA: Elsevier Churchill Livingston; 2011:523−560.
6. Friedman SL, Palmer AK. The ulnar impaction syndrome. *Hand Clin*. 1991;7(2):295−310.
7. Sammer DM, Rizzo M. Ulnar impaction. *Hand Clin*. 2010;26(4): 549−557.
8. Palmer AK, Werner FW. Biomechanics of the distal radioulnar joint. *Clin Orthop Relat Res*. 1984;(187):26−35.
9. Baek GH, Chung MS, Lee YH, Gong HS, Lee S, Kim HH. Ulnar shortening osteotomy in idiopathic ulnar impaction syndrome. *J Bone Joint Surg Am*. 2005;87(12):2649−2654.
10. Baek GH, Lee HJ, Gong HS, et al. Long-term outcomes of ulnar shortening osteotomy for idiopathic ulnar impaction syndrome: at least 5-years follow-up. *Clin Orthop Surg*. 2011;3(4):295−301.
11. Kawano M, Nagaoka K, Fujita M, Fukumoto M. New technique for ulnar shortening osteotomy. *Tech Hand Up Extrem Surg*. 1998;2(4): 242−247.

12. Hammert WC, Williams RB, Greenberg JA. Distal metaphyseal ulnar-shortening osteotomy: surgical technique. *J Hand Surg Am*. 2012;37(5):1071–1077.
13. Greenberg JA, Werner FW, Smith JM. Biomechanical analysis of the distal metaphyseal ulnar shortening osteotomy. *J Hand Surg Am*. 2013;38(10):1919–1924.
14. Arimitsu S, Moritomo H, Kitamura T, et al. The stabilizing effect of the distal interosseous membrane on the distal radioulnar joint in an ulnar shortening procedure: a biomechanical study. *J Bone Joint Surg Am*. 2011;93(21):2022–2030.
15. Rayhack JM, Gasser SI, Latta LL, Ouellette EA, Milne EL. Precision oblique osteotomy for shortening of the ulna. *J Hand Surg Am*. 1993;18(5):908–918.
16. Clark SM, Geissler WB. Results of ulnar shortening osteotomy with a new plate compression system. *Hand (N Y)*. 2012;7(3):281–285.
17. Ahsan ZS, Song Y, Yao J. Outcomes of ulnar shortening osteotomy fixed with a dynamic compression system. *J Hand Surg Am*. 2013;38(8):1520–1523.
18. Baek GH, Chung MS, Lee YH, Gong HS, Lee S, Kim HH. Ulnar shortening osteotomy in idiopathic ulnar impaction syndrome: surgical technique. *J Bone Joint Surg Am*. 2006;88(suppl 1 pt 2): 212–220.
19. Wehbe MA, Cautilli DA. Ulnar shortening using the AO small distractor. *J Hand Surg Am*. 1995;20(6):959–964.
20. Fufa DT, Carlson MG, Calfee RP, Sriram N, Gelberman RH, Weiland AJ. Mid-term results following ulna shortening osteotomy. *HSS J*. 2014;10(1):13–17.
21. Fulton C, Grewal R, Faber KJ, Roth J, Gan BS. Outcome analysis of ulnar shortening osteotomy for ulnar impaction syndrome. *Can J Plast Surg*. 2012;20(1):e1–e5.