



Hardware Location and Clinical Outcome in Ulna Shortening Osteotomy

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Background: The purpose of this study was to investigate the influence of plate location during ulna shortening osteotomy on the incidence of hardware irritation and clinical outcome.

Methods: Forty patients (17 women, 23 men; mean age, 47 years) who underwent a shortening osteotomy of the ulna due to idiopathic ulna impaction syndrome were examined after a mean of 36 months. All complications and secondary procedures were extracted from the patients' records.

Results: The rate of hardware removal was higher in patients who had a dorsal placement of the plate in comparison with ulnar or palmar placements, although this difference was not statistically significant. Apart from hardware irritation, there were 4 nonunions, 1 secondary osteoarthritis of the distal radioulnar joint, and 1 case of chronic irritation of the dorsal branch of the ulnar nerve, which required secondary surgery. The incidence of secondary surgery other than hardware removal was not significantly related to the original location of the plate.

Conclusions: Secondary surgery after ulnar shortening osteotomy is common. However, we found no difference in clinical outcomes based on plate location. (*Plast Reconstr Surg Glob Open* 2015;3:e549; doi: 10.1097/GOX.0000000000000521; Published online 26 October 2015.)

Ulna shortening osteotomy is an accepted treatment modality to address ulna impaction syndrome, especially in patients with persistent symptoms after arthroscopic resection of the articular disk.¹ During this procedure, some form of dynamic compression plate is commonly

used to stabilize the bone. Plate placement has been reported on the dorsal,² ulnar,³ and palmar surface⁴ of the ulna. However, despite a considerable number of publications, which report the overall outcome after this procedure, it is currently unknown whether there is an advantage of one plate location over the others concerning the incidence of hardware irritations, the number of secondary procedures, and overall clinical outcomes. Some authors have suggested ulnar or palmar placement to be superior to dorsal placement because of better coverage by the forearm muscles, whereas others prefer dorsal placement.^{2,4,5}

The purpose of this study was to compare clinical outcomes after ulnar shortening osteotomy in relation to different locations of the osteotomy plate.

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PATIENTS AND METHODS

Inclusion and Exclusion Criteria

A protocol for the retrospective review of medical records and radiographs and selective invitation for a follow-up examination with informed consent was approved by our institutional review boards. Written consent was obtained from all participants.

The inclusion criterion of this study was¹ treatment of persistent, idiopathic ulna impaction syndrome by ulna shortening osteotomy between 2000 and 2004 at our institution after² failed arthroscopic debridement of the triangular fibrocartilage complex in³ patients with a minimum age of 18 years. Exclusion criteria were posttraumatic ulna impaction syndromes and Madelung's deformities or other significant congenital variations. A total of 53 patients satisfied the inclusion criteria. Six patients had to be excluded because of congenital deformities. Of the remaining 47 patients, we were not able to contact 5 patients because of wrong or missing contact information. Another 2 patients refused a follow-up examination, resulting in a study group of 40 patients.

Patients

There were 17 women and 23 men with an average age of 47 years (range, 18–66 years). About 26 right hands and 14 left hands were involved. The mean delay from arthroscopic debridement to the shortening osteotomy was 5 months (range, 2–12 months).

Operative Technique and Postoperative Management

All procedures were performed under regional anesthesia and tourniquet control with the forearm in supinated position. An incision was made on the ulnar side of the forearm preserving the dorsal sensory branch of the ulnar nerve. The ulna was exposed through the intermuscular septum between the flexor carpi ulnaris and extensor carpi ulnaris muscles. After complete exposure of the bone, a 6-hole AO 3.5-mm-low contact dynamic compression plate (Synthes, Tuttlingen, Germany) or 7-hole ulnar shortening plate with sliding holes (Martin, Tuttlingen, Germany) was slightly bent to fit to the ulna on the dorsal, ulnar, or palmar aspect of the bone. If necessary, the pronator quadratus was mobilized to expose the distal ulna. The type of implant and location of placement were chosen according to the treating surgeon's preference. The plate was then fixed distally by 2 screws and the locations of the proximal plate holes were marked on the ulna to avoid malrotation after the osteotomy. The plate was lifted again to facilitate the osteotomy. A transverse or oblique osteotomy was performed with 2 parallel

sawing blades to shorten the ulna by the amount that was determined preoperatively at level of the middle hole (7-hole plate) or between the 2 central holes (6-hole plate). The osteotomy gap was closed by manual traction or the application of a traction device. All screw holes were then filled, putting compression on the osteotomy site. An additional interfragmentary compression screw was placed perpendicularly to the osteotomy.

A long-arm splint was then applied for 2 weeks; after that, patients were splinted for another 4 weeks in a forearm cast.

Clinical Examination and Radiographic Analysis

The patients were evaluated after a mean of 36 months (range, 12–96 months) after the osteotomy by an investigator not involved in prior treatment. All secondary complications and procedures after the osteotomy were obtained from the patients' records.

Objective measurements included the total range of motion for flexion/extension and pronation/supination movements, grip strength, and radiographic assessments. The range of motion was measured with a hand-held goniometer for both wrists. Grip strength was measured for both wrists in kilograms 3 times using a JAMAR dynamometer (NexGen, Quebec, Canada) in position 2. Pain levels were assessed at rest and in activity using a visual analogue scale ranging from 0 (no pain) to 10 (worst imaginable pain).

All patients completed a Disability-of-Arm-Shoulder-Hand (DASH) questionnaire at the time of follow-up.⁶ A modified version of the Mayo wrist score was determined as described by Krimmer.⁷ In contrast to the original wrist score, this modified score emphasizes the usage of the wrist in activities of daily living instead of the occupational situation of the patient.

X-ray studies of the injured wrist were obtained in posterior-anterior (PA) and lateral view in 90-degree abduction of the shoulder and 90-degree flexion of the elbow (PA view) or adducted elbow flexed at 90 degree in neutral rotation with the shoulder, elbow, and wrist in 1 plane (lateral view). A radiographic analysis of preoperative, first postoperative, and follow-up radiographs was performed concerning the amount of ulna shortening and the location of the osteotomy plate. Postoperative ulnar variance was determined on the preoperative and postoperative PA views as described by Palmer.⁸ Using both, PA and lateral views, the location of the osteotomy plate was classified as dorsal, ulnar, or palmar (Figs. 1, 2). In case of doubt, the width of plate projections was measured in both views to determine the correct location of the plate.

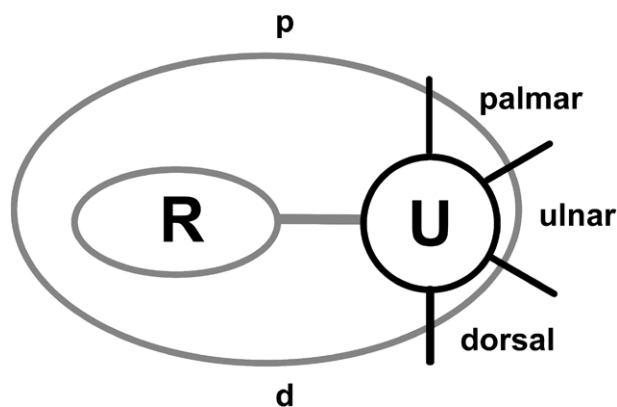


Fig. 1. Determination of plate location: schematic cross-section of the forearm. Osteotomy plate placements were classified as dorsal, ulnar, and palmar, according to their appearance on PA and lateral radiographs of the wrist. d indicates dorsal; p, palmar; R, radius; U, ulna.

Statistics

When comparing outcomes measures in relation to plate locations, patients with other secondary procedures than sole hardware removal were excluded, resulting in a study group of 34 patients. Continuous outcome measures were compared for dorsal and palmar/ulnar plate locations with Mann-Whitney *U* tests. To determine risk factors for the development of ulna nonunion, patients' clinical and demographic data were compared using Mann-Whitney *U* tests and chi-square tests where appropriate. The significance level was determined at $P < 0.05$.

RESULTS

The ulnae were shortened by a mean of 3 mm (range, 1–5 mm). The final ranges of motion averaged 62 degrees (range, 40–90 degrees) of pronation, 64 degrees (range, 30–90 degrees) of supination, 57 degrees (range, 30–70 degrees) of wrist extension, and 57 degrees (range, 35–70 degrees) of wrist flexion. Final grip strength averaged 81% (range, 18–97%) of the contralateral side. Pain levels averaged 4.9 (range, 0–8) on the visual analogue scale.

The average DASH score improved from 34 preoperatively to 29 (range, 22–42). Average DASH scores were 32 for patients with plate removal and 28 for patients with the hardware left in place. According to the Krimmer wrist score, there were 7 good, 31 fair, and 2 poor results.

About 17 patients had additional operations before the final follow-up. Four patients required secondary bone grafting due to nonunion of the ulna. After revision surgery, osseous union could be achieved in all of these patients. Eleven patients complained of prominent hardware; therefore, they had the implant removed after an average of 16 months

(range, 6–27 months). One patient developed osteoarthritis of the distal radioulnar joint; therefore, a hemiresection of the ulna head (Bowers procedure) was performed. In 1 patient, a neurolysis of the ulnar nerve was performed due to chronic nerve irritation, which was persistent after primary removal of the hardware.

Twenty-six plates were located dorsally, 9 were located ulnarly, and 5 plates were located palmarly. When excluding the 6 patients with other secondary operations, a larger proportion of plates was removed on the dorsal aspect of the ulna than on the other plate locations (7 of 24 vs 2 of 11) (Fig. 3). However, this difference was not statistically significant ($P = 0.3$). Furthermore, a dorsal location of the plate did not correlate with the occurrence of nonunion ($P = 0.5$) or the necessity of a secondary procedure ($P = 0.5$). The clinical results of patients with original dorsal plate location were slightly better at the time of follow-up; however, this difference was not statistically significant (Table 1).

The age of the patient, a smoking habit, the position of the osteotomy, and the amount of shortening were significant risk factors for the development of nonunion (Table 2).

DISCUSSION

A large number of publications describe successful treatment of ulna impaction syndrome by a shortening osteotomy of the ulna. However, there is only little information about the influence of plate placement on the subsequent need of hardware removal, other secondary procedures, or clinical results. In our study, we were able to demonstrate that dorsal placement of the plate resulted in a slightly higher number of hardware removals, although this difference was not statistically significant.

About one-third of patients (11 of 36 patients) complained of hardware irritation and had their plate removed. Despite the large number of publications related to ulna shortening osteotomy, hardware removal is not frequently reported. In the articles in which it is specifically mentioned in addition to the plate location, the rate ranges between 0% (no removal in 10 patients) and 64% (7 of 11 patients) (Table 3).^{2,3,5,9–12} Kitzinger et al⁴ and Moermans et al¹³ mention plate irritations, but do not report plate removals. Interestingly, in the study with the highest rate of hardware irritation, the plate had also been placed on the dorsal aspect of the ulna.² This high incidence of hardware irritation with dorsal plate placement in comparison with ulnar or palmar locations seems to be confirmed by trends in our study. Although there is no publication with a greater

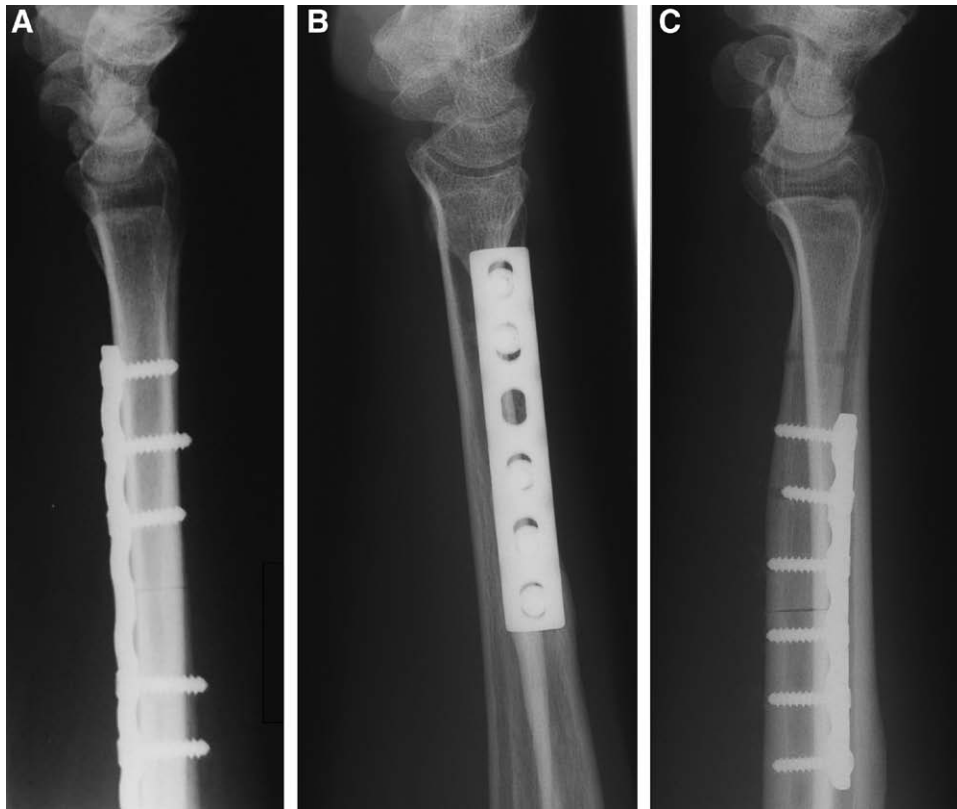


Fig. 2. Radiographic examples (lateral views) for palmar (A), ulnar (B), and dorsal (C) placements of hardware.

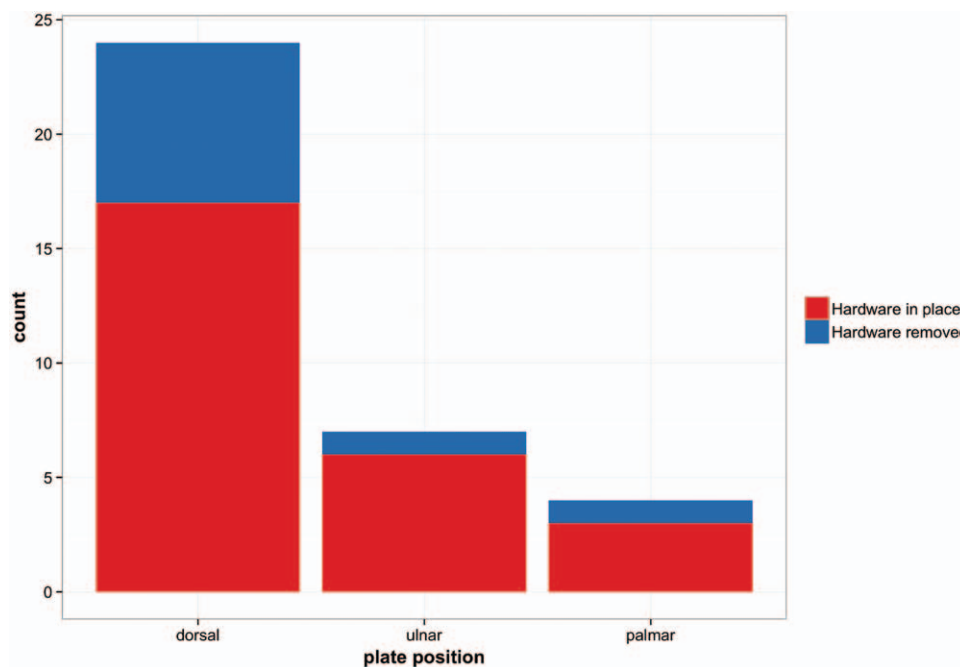


Fig. 3. Hardware removal in relation to location. Stacks indicate the number of patients with and without removal of the osteotomy plate.

number of patients after ulnar shortening osteotomy than our study, the total number of patients might not be enough to detect a statistical difference. In

contrast, Das De et al⁵ have found increased relative grip strength and significantly fewer complications including hardware irritation for dorsal placement

Table 1. Clinical Results in Relation to Plate Location

	Dorsal Plate Location	Ulnar or Palmar Plate Location	P Value
Age of patient	41 years	48 years	0.1
Range of motion (pronation/supination)	85%	83%	0.4
Grip strength	82%	78%	0.8
Pain level (VAS)	5.4	4.6	0.7
DASH score	29	29	0.7

Range of motion and grip strength are indicated as percentages of the contralateral side.

VAS, visual analogue scale.

of the implant. However, the plates placed on the palmar surface on the ulna were thicker than those placed dorsally. Although it is not objectively backed by our data, we usually prefer placing the shortening plate on the palmar aspect of the bone, arguing that in this location it should be covered best by the forearm muscles.

Timing of hardware removal seems worth mentioning. In our practice, we suggest retaining the plate at least 18 months postoperatively to ensure osseous healing. Ossification has been observed to be slower in the ulna as compared to other bones, possibly due to the unfavorable cortex/medulla ratio. Although Minami and Kato¹⁴ and Boulas and Milek¹⁵ suggest leaving the plate for 1.5 or 2 years, others report on successful plate removal after 6 months.³ Further studies will be necessary to investigate this matter.

It is difficult to compare our overall clinical outcomes with other publications because a large number of different outcome measurements have been reported. However, although our clinical results

seem rather unfavorable at first sight, they are within the range of the published literature. Although other studies have found postoperative DASH scores between 12 and 37, our average score is 29.^{2,4,12,13,16,17} Reported pain levels in the literature range between 1.6 and 5.2^{4,10,12,16,18} and grip strength between 73% and 98% of the contralateral side.^{2,4,11-13,19,20} At the same time, the nonunion rate in our study group (10% with 4 of 40 patients) is matched by previous publications.^{9,13}

Our study is limited by its retrospective nature. Moreover, during the study period, only first-generation, rather bulky fixation plates have been available. Today, advances in plate design have led to slimmer implants, so that hardware irritation might be less frequent today. Also, we hypothesized that once healing of the bone has been established, the location of the plate should be the most significant factor influencing the decision to remove the hardware. It certainly can be argued that there are more variables contributing to the ultimate decision, especially as slightly different operation techniques have been applied. However, because very similar operative approaches have been utilized to expose the ulna and plates were of comparable sizes, these differences might not influence the decision for plate removal. Unfortunately, we were not able to include preoperative clinical data except DASH scores in our analysis. However, this does not affect our overall conclusions from this study.

CONCLUSIONS

We have found a significant number of hardware irritations after ulnar shortening osteotomy,

Table 2. Risk Factors for the Development of Nonunion

	Union	Nonunion	P value
Age of the patient	43 years	52 years	0.2
Smoking habit	16/36	1/4	0.5
Amount of shortening	3 mm	4 mm	0.3
Location of osteotomy	76 mm	67 mm	0.6
Dorsal location of plate	24/36	2/4	0.5

Table indicates averages or number of affected patients in relation to the total number for patients with or without osseous union after primary osteotomy.

Table 3. Incidents of Plate Removal in the Literature

Author	Year	Plate Location	Plates Removed/ Total No. of Plates
Hulsizer et al ⁹	1997	Palmar	2/13
Loh et al ¹⁰	1999	Ulnar	7/23
Van Sanden and De Smet ²	2001	Dorsal	7/11
Pomerance ³	2005	Ulnar	14/40
Wolf et al ¹²	2010	Palmar	0/5
Ahsan et al ¹⁷	2013	Palmar	4/30
Das De et al ⁵	2014	Dorsal/palmar	1/16 dorsal; 4/18 palmar

especially with dorsal hardware placement. However, our data have not indicated a plate position that is superior to others. In general, it should be acknowledged that ulna shortening osteotomy is a technically demanding procedure that will improve clinical symptoms, but can also be associated with a certain amount of residual pain and a considerable incidence of secondary procedures.

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