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## ORIGINAL STUDY

# Corrective Osteotomy of Dorsal Malunited Fractures of the Distal End Radius Using Volar Locking Plate and Bone Block Graft Substitute

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### Abstract

**Objective:** To evaluate the results of corrective osteotomy of dorsal malunited fracture lower end radius using volar locking plates and bone block graft substitutes.

**Background:** Malunion of the distal radius usually occurs following conservative treatment. The indication for corrective osteotomy is symptomatic, rather than radiological malunion.

**Patients and methods:** All the patients had dorsally malunited (dorsal tilt) extra-articular distal radius fracture following conservative management. The mean time of postfracture intervention was 4 months (range, 3–5 months). All the patients underwent open wedge corrective osteotomy through the volar approach and fixation with volar locking plates and filling the osteotomy gap with bone block graft substitutes.

**Results:** A total of 12 patients (nine men, three women) were included in our study; their mean age was 39 years (range, 26–53 years). The dominant arm was involved in nine patients. All the patients had significant improvement in the range of wrist motion and forearm rotation. An excellent or good modified Mayo wrist score outcome had been achieved for all patients. The mean score was 85.4 (range, 90–80) at the end of follow-up.

**Conclusion:** Volar approach and the use of locking plates is an effective and safe technique in the treatment of malunited extra-articular fracture distal end radius.

**Keywords:** Malunited distal radius, Osteotomy, Volar locking plate

## 1. Introduction

Malunion of the distal radius usually occurs following conservative treatment. The most common deformity following a malunited extra-articular fracture of the distal radius is the loss of the normal palmar tilt of the articular surface in the sagittal plane, and loss of length relative to the ulna [1].

The indication for corrective osteotomy is symptomatic, rather than radiological, malunion. It depends on the limitation of function, severity of pain, presence of midcarpal instability, associated problems of the distal radioulnar joint, and the displeasing appearance of the wrist. The radius carries 80% of the axial load through the wrist and the distal ulna only 20%. Malalignment of the distal radius

due to an osseous deformity affects the normal load transmission, causing a limitation in the extension–flexion arc of motion [2]. Once angulation of the distal articular surface of the radius becomes greater than 25–35° in the sagittal plane, Fernandez [3,4] recommended corrective osteotomy. Because of the long-term problems associated with a distal radius malunion, multiple techniques for corrective osteotomy have been developed, these techniques have been shown to improve radiographic parameters and more importantly, to improve motion, pain, and grip strength [5–8].

Volar-fixed angled plates have added a new dimension to the treatment of distal radius fractures. The low morbidity of the surgical approach and strength of final construct allow early mobilization and return to function. While volar locking

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plates are not indicated for all fractures, their advent has made the use of external fixation or dorsal plating far less common [9,10]. When bone graft is needed to fill defects left by corrective osteotomy, there are multiple options available to the treating surgeon [11]. The aim of this study is to evaluate the results of surgical treatment of patients affected by symptomatic dorsally malunited extra-articular fractures of the distal radius, who underwent corrective osteotomy using a volar locking plate with additional bone block substitute grafts.

## 2. Patients and methods

A total of 12 patients were included in our study from April 2018 to February 2021. All the patients had dorsally malunited (dorsal tilt) extra-articular distal radius fracture following conservative management. Pain, deformity, decreased range of mobility, and decreased grip strength compared with the normal side clinically were the indications of surgery. Written informed consent was taken from all patients before enrollment in the study. Approval by Medical Ethics Committee of the Faculty of Medicine, Menoufia University, was obtained.

Patients who had clinical and radiological signs of reflex sympathetic dystrophy, degenerative joint disease, fixed intercarpal malalignment, midcarpal instabilities, and complex multiplanar intra-articular malunions were excluded from the study. Comparison of the opposite side is helpful to determine ulnar variance and the inclination in the frontal and sagittal planes. Preoperative radiographic measurements (dorsal tilt, radial inclination, and amount radial shortening) are shown in Table 2. The mean time of postfracture intervention was 4 months (range, 3–5months).

Table 1. Clinical assessment.

Range of motion of wrist	Mean (range)	Paired sample <i>t</i> test significance ( <i>P</i> < 0.05)
Flexion		
Preoperative	31.4 (22–40)	<i>P</i> = 0.000
End follow-up	67.1 (60–73)	
Extension		
Preoperative	33.3 (25–42)	<i>P</i> = 0.000
End follow-up	70.4 (65–75)	
Supination		
Preoperative	36.9 (20–45)	<i>P</i> = 0.000
End follow-up	72.9 (65–80)	
Pronation		
Preoperative	54.2 (40–65)	<i>P</i> = 0.000
End follow-up	78.7 (70–85)	
Pain score (VAS)		
Preoperative	8 (7–9)	
End follow-up	1.91 (1–3)	

VAS, visual analog scale.

Table 2. Radiological assessment.

Radiological measurement	Mean (range)
Preoperative dorsal tilt	–13° (8 to –20)
End follow-up volar palmer tilt	10° (8–14)
Preoperative radial shortening	6.3 mm (4–8 mm)
End follow-up radial shortening	1.4 mm (0–2)
Preoperative radial inclination	15.5° (14–19)
End follow-up radial inclination	22.3° (22–26)

### 2.1. Operative technique

A volar approach to the distal radius was performed in all patients. A longitudinal incision of about 6 cm along the flexor carpi radialis was made. The radial artery was preserved and dislocated radially. The pronator quadratus was released using an 'L' incision from the radial insertion, exposure of the volar surface, and margin of the distal radius. Malunion was exposed under direct vision, and any signs of fracture line at the site were inspected. Anatomic locked plate system was used in all patients (the same plate type was used in all patients).

Fluoroscopy images were taken to assure appropriate position of the plate just at the distal edge of the distal radius. The plate was temporarily fixed distally through two screws in the distal row, then the plate was removed and was attempted to place the osteotomy at the site of deformity and roughly perpendicular to the shaft of the radius. After the osteotomy was completed, the dorsal periosteum was further released. The plate then was fixed to the distal fragment and osteotomy site gradual distracted under c arm using a small lamina spreader and small osteotome with gradual rotation of the distal fragment to correct the radius inclination and length. Finally the proximal portion of the plate was held to the radial shaft using a tenaculum. Fluoroscopy was then used to assess plate position, and adjustments to radial inclination and height were made and then fixation proximally was carried out. Synthetic bone block substitute was shaped to the defect and impacted to fill the gap, aiming to give a good maintenance of the achieved intraoperative correction.

### 2.2. Postoperative

The wrist is immobilized in a palmar plaster splint until the wound has healed properly. The patient begins active exercises of the fingers immediately after surgery. The day after surgery, elbow motion and forearm rotation start. The suction drain is removed on the second day after operation and the sutures after 2 weeks. Usually this coincides with

the removal of the plaster splint. Physiotherapy includes wrist motion as well as forearm rotation. Follow-up radiographs were done every 4 weeks in the outpatient clinic, then every 2–3 months after fracture healing. Radiological assessment include radial inclination and volar tilt, and radial shortening was done preoperatively and compared with the end follow-up one.

Clinical assessment included the analysis of passive range of motion, pain level during activities of daily living evaluated with a 10-cm visual analog scale.

Functional evaluation was done using disabilities of the arm, shoulder, and hand (DASH) score [12]. The modified Mayo wrist score (MMWS) [13] was done at the end of follow-up. There is a total of 100 points, which are divided among the evaluator's assessment of pain (25 points), active flexion/extension arc as a percentage of the opposite side (25 points), grip strength as a percentage of the opposite side (25 points), and the ability to return to regular employment or activities (25 points). Pain is rated as none (25 points), mild (20 points), moderate (10 points), or severe (0 points) by the evaluator, based on the patient's subjective description. The total score ranges from 0 to 100 points with higher scores indicating a better result. An excellent result is defined as 90–100 points, good is 80–89, fair is 65–79 points, and poor is less than 65 points.

### 2.3. Statistical analysis

Statistical analysis was carried out using SPSS 18.0 software (SPSS, Chicago, Illinois, USA). Data are presented as means  $\pm$  SD. Preoperative and the last follow-up variables were compared using Student's paired *t* test. *P* value less than 0.05 was considered statistically significant difference.

## 3. Results

A total of 12 patients (nine men and three women) were included in our study. Their mean age was 39 years (range, 26–53 years). The dominant arm was involved in nine patients. The mean duration of follow-up was 15.3 months (range, 12–19). Union was defined radiologically by the presence of bone trabeculae observed crossing the osteotomy site in radiographs. This was achieved in all the patients at a mean of 10.6 weeks (9–12 weeks). Union is considered complete when the delineated trabeculae bridging the graft host junction became visible.

The measurements of pain (visual analog scale) score and the final range of motion significantly improved at the last follow-up compared with preoperative measurements (Table 1).

All the patients had either excellent or good MMWS. The mean score was 85.4 (range, 90–80) (Fig. 1). The mean preoperative DASH score decreased from  $53.6 \pm 4.1$  preoperatively to  $24.8 \pm 3.2$  at the end of follow-up. Radiological assessment at the end of follow-up had been improved compared with the preoperative one (Table 2). There were no intraoperative complications noted. There was one case of transient median nerve neuropraxia that resolved before the eighth week follow-up appointment. No other major complications, including nonunion and infection, were observed.

## 4. Discussion

Corrective osteotomy of malunited extra-articular fracture lower end radius will restore anatomical configuration and can effect an improvement in wrist function and forearm rotation [14]. The use of dorsal plates with corrective osteotomy have a high incidence of tendon irritation, tendon rupture, and necessity of hardware removal [15–17]. Rothenfluh et al. [18]. compared distal radius osteotomy on an anterior versus a posterior approach, finding no significant radiological or clinical differences.

Several surgical techniques have been described for the correction of the distal radial malunion, including closed or open wedge osteotomy. Closing wedge osteotomy although it allows direct bone-to-bone contact and offers more stability, it can cause shortening of the distal radius relative to the ulna and often paired with shortening the ulna to maintain the distal radio ulnar joint. Opening wedge osteotomies are more popular as they restore the radial length. This technique can also correct angular deformities in both the frontal and sagittal planes. The disadvantage of opening wedge osteotomies is the risk of increased instability of the construct but with the trend of using locking plates, more stability can be achieved [19].

Prommersberger et al. [20] have published studies using a volar approach to treat 29 malunions of the distal radius. They used a fixed-angled device as a joystick after attaching it to the predrilled distal fragment to achieve reduction. Peterson et al. [21]] described eight cases of dorsally malunited fractures with the use of a volar fixed angle plate. They used an autogenous inner table iliac crest bone graft in all cases.

In our series of 12 patients, a single design of volar locking distal radius plate was used. The contour of this plate simplified the restoration of normal or near-normal distal radius anatomy. In addition, the strength of the plate led to a stable construct. In all





Fig. 1. (A, B) Preoperative radiographs; (C, D) postoperative radiographs with volar locking plate fixation and bone block substitute; (E, F) end follow-up radiograph.

of our cases, the deformity was corrected in that there was no cortical apposition between the distal and proximal fragments once the plate was in its final position. The resulting gap from the osteotomy was filled with bone block substitute, which give cortical continuity and add more mechanical stability. Malone et al. [22] not recommend the use of structural graft as routine, as the rigid characteristics of the volar locking plates are strong enough. Donor site morbidity, especially at the iliac crest, has been well described and minor complications such as persistent pain at the harvest site, superficial

sensory nerve injury, superficial hematoma or seroma, and superficial infection have been reported. Our use of bone block substitute give the advantage to avoid such complications [23].

All our patients have expressed improved pain and function. Wrist joint flexion–extension and supination–pronation have all shown significant improvement. All patients by MMWS had either excellent or good results. The improvement in the DASH score obtained in the present study was 28.8 points, which was close to that reported by other studies [24,25].

#### 4.1. Conclusion

The volar approach and the use of locking plates is an effective and safe technique in the treatment of malunited extra-articular fracture distal end radius. Routine use of adjuvant bone block substitute as graft is a good option but needs further evaluation in future.

#### Conflicts of interest

There are no conflicts of interest.

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