Stabilization of Volar Ulnar Rim Fractures of the Distal Radius: Current Techniques and Review of the Literature

Maureen A. O'Shaughnessy, MD¹ Alexander Y. Shin, MD¹ Sanjeev Kakar, MD¹

¹ Division of Hand Surgery, Department of Orthopedic Surgery, Mayo Clinic, Rochester, Minnesota

Address for correspondence Sanjeev Kakar, MD, Division of Hand Surgery, Department of Orthopedic Surgery, Mayo Clinic, 200 First Street South West, Rochester, MN 55905 (e-mail: Kakar.Sanjeev@mayo.edu).

J Wrist Surg 2016;5:113–119.

Abstract

Background Distal radius fractures involving the lunate facet can be challenging to manage. Reports have shown the volar carpal subluxation/dislocation that can occur if the facet is not appropriately stabilized.

Literature Review Recent emphasis in the literature has underscored the difficulty in managing this fracture fragment, suggesting standard volar plates may not be able to adequately stabilize the fragment. This article reviews the current literature with a special emphasis on fixation with a specifically designed fragment-specific hook plate to secure the lunate facet.

Case Description An extended flexor carpi radialis volar approach was made which allows access to the distal volar ulnar fracture fragment. Once provisionally stabilized with Kirschner wire fixation, a volar hook plate was applied to capture this fragment. Additional fracture stabilization was used as deemed necessary to stabilize the remaining distal radius fracture.

Clinical Relevance The volar marginal rim fragment remains a challenge in distal radius fracture management. Use of a hook plate to address the volar ulnar corner allows for stable fixation without loss of reduction at intermediate-term follow-up.

Keywords

- distal radius fracture
- volar ulnar rim fracture
- volar hook plate

Intra-articular distal radius fractures with involvement of the volar ulnar corner are particularly challenging to treat. Often deemed the “critical corner,” failure to stabilize this fragment can lead to volar subluxation of the carpus.^{1–5} Harness et al reported on devastating complications when the volar facet was not adequately stabilized with standard volar plate fixation.¹

The difficulties encountered in securing the critical corner are due to its anatomy. The volar facet is the keystone of both the radiocarpal and the distal radioulnar joints and inadequate reduction of this fragment result in altered mechanics of the radiocarpal and radioulnar articulations.⁶ The distal radius is relatively flat and then curves volarly at the distal margin, ending in the volar ulnar corner from where the short radiolunate ligament originates.⁷ Traumatic forces may cause the volar lunate facet to be rotated 180 degrees away from its

anatomic position with only a small amount of subchondral bone and limited soft tissue attachments of the volar wrist capsule and intracapsular ligaments available for reduction and fixation.⁸ An anatomical study of this facet found that the average dimensions are 19 mm by 3 mm resulting in difficulty with its fixation (► **Fig. 1**).⁹ As it is distal to the watershed line, standard volar plates are unable to safely capture and support this fragment.¹ Placing a standard plate distal to this line to capture this fragment can result in intra-articular penetration of pegs/screws as well as increasing risk for flexor tendon irritation/rupture.¹⁰

Fixation options described for the volar corner include standard volar plate, fragment-specific fixation (wire form or hook plate) or the use of supplemental fixation methods such as suture, pinning, or external fixator. Many of the fixation constructs can be technically demanding and may not be

received

January 18, 2016

accepted

January 20, 2016

published online

February 29, 2016

Copyright © 2016 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA.
Tel: +1(212) 584-4662.

DOI <http://dx.doi.org/10.1055/s-0036-1579549>.
ISSN 2163-3916.

Fig. 1 (A–C) CT scan images showing fracture of the lunate facet. Note the small dimensions and the distal location of the fragment which highlight difficulty encountered when stabilizing these fragments. CT, computed tomography.

suitable in osteoporotic bone.⁸ The goal of surgical management of the displaced volar facet is anatomic reduction and fixation that is low profile and provides secure fixation.

Volar hook plates (TriMed Orthopedics, Santa Clarita, CA; Skeletal Dynamics, Miami, FL) have been designed specifically to address this fragment in conjunction with fragment-specific fixation, and have been described previously.^{7,11} Designed as an alternative to the volar wire form, the volar hook plate is a fixed angle device whose purpose is to rigidly fix the volar marginal rim fragment. The narrow dimensions of the plate allow the surgeon a wide range of placement options and the distally fixed-angle hooks permit purchase of the cortical rim while staying distal to the watershed line (►Fig. 2).¹¹ In this study, we review the current literature and review our previously published experience with such fixation modality highlighting the surgical technique, clinical, and radiographic outcomes and complications.

Surgical Technique

Indications for the volar hook plate include a volar marginal rim fragment that is distal to the watershed line and cannot

be secured by a volar plate. The fragment should be at least 7 mm wide, 5 mm long, and 4 mm in the dorsal volar dimension. Fractures smaller than these dimensions should be stabilized with a wire form or other methods.

In brief, an extended flexor carpi radialis volar approach is made to the distal radius allowing visualization of the fracture fragments which are distal to the watershed line. To get adequate exposure distally, it is important to release the septum between the flexor carpi radialis and flexor pollicis longus. To obtain articular reduction, the proximal shaft of the radius can be pronated from the distal fragments to allow one to obtain articular reduction. After this has been performed, the shaft is supinated back to the distal fragments and a volar plate can be applied. Given that the lunate facet fragment can be distal to the plate and watershed line, it is anatomically reduced and stabilized with a Kirschner wire. A volar hook plate can be applied to capture this fragment (►Fig. 3). Alternatively, the fracture can be stabilized using the principles of fragment-specific fixation. The volar ulnar corner is anatomically reduced and provisionally stabilized with Kirschner wires. While the fragment is anatomically reduced, the distal fragment is predrilled using a guide to

Fig. 2 (A) Injury AP and (B) lateral radiographs demonstrating the volar ulnar fracture fragment. (C, D) Note the placement of the volar hook plate distal to the watershed line to allow stable, distal fixation. AP, anteroposterior.

accept the types of volar hook plate. The hook plate is inserted and secured to the proximal radius. The remainder of the distal radius fracture is addressed using the principles of fragment-specific fixation. Attention is diverted dorsally where a dorsal incision and capsulotomy to visualize the articular surface is performed as indicated. Dorsal fragments are reduced and stabilized with wireforms, pin plates, or dorsal hook plates. Use of a volar hook plate alone in a fracture pattern involving a dorsal ulnar fragment is not recommended, as a volar hook plate alone will not adequately fix the sigmoid notch, and result in the volar marginal rim fragment migrating dorsally off the tines. The radial column is reduced and stabilized (►Fig. 2) and finally the ulnar column is evaluated for distal radioulnar joint instability. Allograft bone is utilized to assist in fracture reduction and fill voids as necessary.

Postoperatively, patients are placed in a sugar tong splint for 2 weeks and transitioned into a short arm cast for an additional 3 to 4 weeks. At approximately 6 weeks postsurgery, patients are transitioned into a removable splint and advance their range of motion and strengthening as tolerated.

Discussion

The volar ulnar corner is considered to be the critical corner of the distal radius. The fracture fragment may be more common than previously thought; a large multicenter study reviewed 423 distal radius fractures treated with open reduction and internal fixation (ORIF) and noted an incidence of 13% (57 wrists) with lunate facet involvement.¹² The facet forms an articular portion of the sigmoid notch and the volar lunate facet serves as the attachment for the short radiolunate ligament. Given its propensity to fracture, anatomical reduction, and stabilization is of utmost importance.¹³

The fracture pattern of the lunate facet which is at highest risk of fixation failure was analyzed in a prospective study. A total of 52 AO type B3 fractures involving the lunate facet treated operatively with standard volar plates were analyzed for predictors of loss of reduction. Risk factors which were statistically significant for failure included fractures with a separate scaphoid and lunate facet fragment (AO B3.3 subtype), depth of lunate subsidence greater than 5 mm preoperatively and less than 15 mm lunate facet available for

Fig. 3 (A, B) Represents injury radiograph and CT scan and (C, D) postoperative views of a patient who sustained an intra-articular distal radius fracture with scapholunate ligament disruption. (E, F) The distal radius fracture was stabilized with a distal radius plate and a hook plate captured the volar ulnar corner that was distal to the watershed line. CT, computed tomography.

Table 1 Review of publications on management of Lunate Facet Fragment

Reference	Pts (gender) avg age	AO fracture type (n)	Fixation meth- od	Avg follow-up time (mo)	Radiographic outcomes	Clinical outcomes	Complications (encountered in series)
Bakker and Shin (2014) ¹¹	6 pts/8 wrists (4 M, 2 F) 46 y	6C	Volar hook plate with fragment-spe- cific fixation	7	No loss of fixation or reduction	Avg flex/ext arc 100 degrees, pron/sup 153 degrees, grip 112 lbs (93% uninjured side)	None
Beck et al (2014) ¹⁴	51 pts/52 wrists (unclear M, F) 51 y	52 B3	Volar plate ^a	6 (no revision group) 18 (revision group)	13% (7/52 loss of reduction noted at 2 wks (n = 1) and 6 wks (n = 6)	Avg flex/ext arc 118 degrees, pron/sup 156 degrees (no loss reduction) avg flex/ext arc 92 degrees, pron/sup 138 degrees (pts with loss reduction)	Loss of reduction (7), all offered revision surgery, 2 elected revision, 5 developed malunion
Chin and Jupiter (1999) ⁸	4 pts (4 M) 21 y	N/A	Wire loop suture fixation ± external fixator or K-wire stabilization	24	No loss of fixation or reduction	Avg flex/ext arc 153 degrees, pron/sup 169 degrees, and radioulnar deviation 75 degrees	None
Marcano et al (2015) ¹⁷	28 pts (16 M, 12 F) 52 y	28 B3	Volar plate	N/A	No loss of reduction or fixation	Reported as percentage of contralateral: avg flex/ext arc 88%, pron/sup 96%, grip 74%, avg DASH 13 and SF-36 83	None
Moore and Dennison (2014) ¹⁶	9 pts (4 M, 5 F) 42 y	9 C3	K-wire/wire form fixation + volar plate	12	No loss of fixation or reduction	Avg flex/ext arc 97 degrees, pron/sup 148 degrees, grip 21 kg (66% uninjured side), avg PRWE 17	None
O'Shaughnessy et al (2015) ⁷	25 pts/26 wrists (7 M, 18 F)	6 B, 20 C	Volar hook plate with fragment-spe- cific fixation	13	No loss of fixation or reduction	Avg flex/ext arc 94 degrees, grip 22 kg (84% contralateral)	Symptomatic hardware removal at 8 mo postoperative (5)
Ruch et al (2004) ¹⁵	21 pts (15 M, 6 F) 41 y	21 C3	Volar plate + external fixator	24	No loss of fixation or reduction	Avg flex/ext arc 133 degrees, pron/sup 146 degrees, grip 112 lbs (93% uninjured side), avg DASH 36	Symptomatic hardware removal at 14 mo postoperative (1)
Souer et al (2009) ¹²	57 pts (24 M, 33 F) 49 y (AO B) 52 y (AO C)	20 B 37 C	Volar plate	24 in 79%	2/57 loss of reduction in C type	Avg flex/ext arc 123 degrees, pron/sup 176 degrees (type B), avg DASH 3.9 Avg flex/ext arc 125 degrees, pron/sup 171 degrees (type C), avg DASH 11.1	Loss of reduction (2), palmar cutaneous nerve injury (1), hardware removal at 12 mo postoperative (2), EPL rupture (1)

(Continued)

Table 1 (Continued)

Reference	Pts (gender) avg age	AO fracture type (n)	Fixation meth- od	Avg follow-up time (mo)	Radiographic outcomes	Clinical outcomes	Complications (encountered in series)
Waters et al (2014) ¹⁸	1 pt (1 F) 28 y	N/A	Headless com- pression screw fixation	3	No loss of fixation or reduction	No pain, grip strength 27 kg (84% uninjured side)	None
Wiesler et al (2006) ¹⁹	N/A	N/A	Arthroscopic- aided CRPP with external fixator	N/A	N/A	N/A	N/A

Abbreviations: avg, average; CRPP, closed reduction and percutaneous pinning; DASH, disabilities of the arm, shoulder and hand (DASH) score; EPL, extensor pollicis longus; ext, extension; F, female; flex, flexion; M, male; N/A, not available or not reported in publication; pron, pronation; PRWE, patient rated wrist evaluation; pts, patients; SF-36, the short form (36) health survey score; sup, supination.
^aPlates in series include 28 Stryker VariAx plate, 22 Synthes VA LCP locking plate, 2 Hand Innovations Anatomical DVR plate. *p* values not significant relating failure and plate design.

fixation.¹⁴ There was an overall 13% incidence of loss of reduction in the series.¹⁴

Limitations of the standard volar plate to address the facet have been well outlined.¹ Harness et al reported a series of seven patients with volar shear fractures treated with standard volar plates with subsequent loss of fixation of the lunate facet leading to volar carpal subluxation.¹ All patients were deemed to have an adequate initial reduction and stabilization. Five of the seven patients went on to require further surgery, including four revision ORIF and one radiocarpal fusion. The authors concluded that overall stability of comminuted fractures of the radius is influenced by stabilization of the major fracture fragments, but also, importantly, strong fixation of the small lunate facet.

Fixation failure often requires a complex reconstruction or salvage procedures. Ruch et al reported on 13 patients who developed malunion and carpal subluxation at an average of 5 months from initial fixation.² These highlighted reports underscore the importance of recognizing and adequately stabilizing the volar marginal rim during primary fixation to avoid the need for complex secondary procedures.^{1,2}

Many fixation techniques have been described to address the fractured volar ulnar corner. Ruch et al reported no loss of fixation or reduction with preserved range of motion in 21 patients at 2 years of follow-up who were treated with supplemental external fixation in addition to the standard volar plate.¹⁵ Moore and Dennison described a series of nine patients where the lunate facet fragment was stabilized with Kirschner wire fixation held in place with a volar plate.¹⁶ The technique consisted of placing a 0.035 K-wire to capture the volar facet. The K-wire is then bent to match the curve of the volar rim and left long enough to be placed under a volar plate. The authors noted maintenance of reduction at a mean follow-up of 54 weeks, with average flexion-extension arc of 97 degrees, patient rated wrist evaluation (PRWE) score of 17 and no evidence of prominent hardware. A review of publications specifically addressing fixation of the volar ulnar corner is summarized (–Table 1).^{7,8,11,12,14–19}

Chin and Jupiter reported on the use of a wire-loop passed through the volar wrist capsule into the distal radius to reduce the lunate facet fragment with good outcomes.⁸ This may be an option for fragments which are too small for hardware fixation. The authors caution that the technique is not recommended for osteoporotic bone.

Radiographic outcomes on the management of the volar facet are varied. A multicenter review of 57 volar marginal rim fractures treated with standard volar plating noted 4% (2 of 57 fractures) with loss of reduction at final follow-up.¹² Beck et al reviewed 52 fractures treated with volar plate fixation and noted a loss of reduction in 14% (7/52).¹⁴

We previously reported on 26 wrists in patients over 18 years with an AO type B (*N* = 6) or C (*N* = 20) fracture²⁰ and a fracture of the volar ulnar corner stabilized with the volar hook plate.⁷ At approximately 13 months postsurgery, patients' range of motion averaged a 94 degree flexion-extension arc and grip strength was 84% of nonoperative side. Radiographic outcomes were satisfactory with maintenance of alignment and fixation in all patients. Articular

congruity was within 1 mm in all patients and there was no loss of reduction or fixation. Five patients underwent removal of hardware at an average of 8 months postsurgery for tenosynovitis but there were no cases of tendon ruptures.

Complication rates in the management of this subset of fractures are varied. Jupiter et al retrospective series of 49 volar marginal rim fractures with an average follow-up of 51 months noted 41% complication rate, including removal of hardware, tenosynovitis, and tendon rupture; articular incongruity was noted in 14 patients (29%).⁴ A large multicenter analysis of 57 fractures with lunate facet involvement noted a complication rate of 11%, including tendon rupture (1), loss of fixation/reduction (2), complex regional pain syndrome (CRPS) (1), and the need for hardware removal (2).¹² A series of patients treated with combined volar plate and external fixation had 14% complication rate, including two pin-site infections and one tenosynovitis necessitating hardware removal.¹⁵ In our early experience with the hook plate, the complication rate was 19% (4/26 wrists) related to the hardware removal for tendon irritation.⁷ There were no cases of tendon rupture, infection, dehiscence, and no loss of fixation. The four hook plates which were removed were the second generation of the plate which was found to have a prominent distal bend. The plate has since been modified to have a thinner and lower profile bend of the tines and subsequently no third or fourth generation plates have required removal. Patients should be followed postoperatively for any signs of tendon irritation as settling around the tines can occur, thereby making them prominent.

The volar ulnar corner is critical to the function of the radiocarpal and distal radioulnar joints. Awareness of the fractures involving the critical corner and the options available for secure fixation are important for anatomic reduction. The use of a volar hook plate in conjunction with fragment-specific fixation allows for secure stabilization of the critical volar ulnar corner. Complications related to hardware irritation were noted in four patients and continued surveillance is required relating to hardware prominence in the early generations of this plate. This technique addresses a limitation of standard volar plate fixation in the management of distal radius fractures involving the lunate facet.

Conflict of Interest

Alexander Y. Shin is a consultant for TriMed Inc., Valencia, CA. Sanjeev Kakar is a consultant for Skeletal Dynamics Inc., Miami, FL.

References

- 1 Harness NG, Jupiter JB, Orbay JL, Raskin KB, Fernandez DL. Loss of fixation of the volar lunate facet fragment in fractures of the distal part of the radius. *J Bone Joint Surg Am* 2004;86-A(9):1900-1908
- 2 Ruch DS, Wray WH III, Papadonikolakis A, Richard MJ, Leversedge FJ, Goldner RD. Corrective osteotomy for isolated malunion of the palmar lunate facet in distal radius fractures. *J Hand Surg Am* 2010;35(11):1779-1786
- 3 Mall NA, Rubin DA, Brophy RH, Goldfarb CA. Cartilage defect of lunate facet of distal radius after fracture treated with osteochondral autograft from knee. *Am J Orthop* 2013;42(7):331-334
- 4 Jupiter JB, Fernandez DL, Toh CL, Fellman T, Ring D. Operative treatment of volar intra-articular fractures of the distal end of the radius. *J Bone Joint Surg Am* 1996;78(12):1817-1828
- 5 Apergis E, Darmanis S, Theodoratos G, Maris J. Beware of the ulno-palmar distal radial fragment. *J Hand Surg [Br]* 2002;27(2):139-145
- 6 Melone CP Jr. Articular fractures of the distal radius. *Orthop Clin North Am* 1984;15(2):217-236
- 7 O'Shaughnessy MA, Shin AY, Kakar S. Volar Marginal Rim Fracture Fixation With Volar Fragment-Specific Hook Plate Fixation. *J Hand Surg Am* 2015;40(8):1563-1570
- 8 Chin KR, Jupiter JB. Wire-loop fixation of volar displaced osteochondral fractures of the distal radius. *J Hand Surg Am* 1999;24(3):525-533
- 9 Andermahr J, Lozano-Calderon S, Trafton T, Crisco JJ, Ring D. The volar extension of the lunate facet of the distal radius: a quantitative anatomic study. *J Hand Surg Am* 2006;31(6):892-895
- 10 Soong M, Earp BE, Bishop G, Leung A, Blazar P. Volar locking plate implant prominence and flexor tendon rupture. *J Bone Joint Surg Am* 2011;93(4):328-335
- 11 Bakker AJ, Shin AY. Fragment-specific volar hook plate for volar marginal rim fractures. *Tech Hand Up Extrem Surg* 2014;18(1):56-60
- 12 Souer JS, Ring D, Jupiter JB, Matschke S, Audige L, Marent-Huber M; AOCID Prospective ORIF Distal Radius Study Group. Comparison of AO Type-B and Type-C volar shearing fractures of the distal part of the radius. *J Bone Joint Surg Am* 2009;91(11):2605-2611
- 13 Mandziak DG, Watts AC, Bain GI. Ligament contribution to patterns of articular fractures of the distal radius. *J Hand Surg Am* 2011;36(10):1621-1625
- 14 Beck JD, Harness NG, Spencer HT. Volar plate fixation failure for volar shearing distal radius fractures with small lunate facet fragments. *J Hand Surg Am* 2014;39(4):670-678
- 15 Ruch DS, Yang C, Smith BP. Results of palmar plating of the lunate facet combined with external fixation for the treatment of high-energy compression fractures of the distal radius. *J Orthop Trauma* 2004;18(1):28-33
- 16 Moore AM, Dennison DG. Distal radius fractures and the volar lunate facet fragment: Kirschner wire fixation in addition to volar-locked plating. *Hand (NY)* 2014;9(2):230-236
- 17 Marcano A, Taormina DP, Karia R, Paksima N, Posner M, Egol KA. Displaced intra-articular fractures involving the volar rim of the distal radius. *J Hand Surg Am* 2015;40(1):42-48
- 18 Waters MJ, Ruchelsman DE, Belsky MR, Leibman MI. Headless bone screw fixation for combined volar lunate facet distal radius fracture and capitate fracture: case report. *J Hand Surg Am* 2014;39(8):1489-1493
- 19 Wiesler ER, Chloros GD, Lucas RM, Kuzma GR. Arthroscopic management of volar lunate facet fractures of the distal radius. *Tech Hand Up Extrem Surg* 2006;10(3):139-144
- 20 Kreder HJ, Hanel DP, McKee M, Jupiter J, McGilivray G, Swiontkowski MF. Consistency of AO fracture classification for the distal radius. *J Bone Joint Surg Br* 1996;78(5):726-731