Summary: Open reduction and internal fixation is the mainstay of treatment for most unstable, intra-articular distal radius fractures. Anatomical reduction and maintenance of the reduction can be challenging in the setting of injuries with multiple fracture fragments and complex intra-articular fracture patterns. Although common, volar locking plates cannot adequately address every fracture pattern. Fragment-specific fracture fixation methods are technically demanding, but can be used alone or in conjunction with other fixation methods to obtain reliable reduction and fixation in complex fracture patterns. The aim of this report is to illustrate the use of the fragment-specific technique for intra-articular distal radius fracture fixation.

Key Words: distal radius fracture, fragment-specific fixation, intra-articular fracture

INTRODUCTION

Distal radius fractures are one of the most common skeletal injuries, with an estimated annual US incidence of more than 600,000, second only to hip fractures.1–3 Understanding the mechanism of injury and the fracture pattern is critical to avoid complications. Most fractures are stable, extra-articular, and may be treated with closed reduction and immobilization. Those that are unstable and intra-articularly typically warrant surgical fixation.4 Historically, dorsal plating was used when operative fixation with a plate was performed given the advantages of a direct articular reduction and the avoidance of potential damage to the median nerve and radial artery.5,6 Due to complications involving extensor tendon attrition and rupture and the introduction of volar locked plating, dorsal plating has become less common.5,7 Corresponding to the introduction of volar plating was a rapid increase in the rate of internal fixation for distal radius fractures, with 1 study of Medicare claims data finding a five-fold increase in the rate of internal fixation over a 10-year period.7–9 Benefits of locked volar plating include direct fracture visualization and neutralization of forces as a fixed angle construct by transmitting forces from the distal fragments to the volar cortex of the radial shaft.10,11 The locking screw construct allows for improved fixation in osteoporotic, short segments, and metaphyseal bone by not relying on the bone quality for purchase. Although increasingly common, volar locked plating is not a panacea for distal radius fractures. High-energy injury mechanisms may result in articular comminution and complex fracture patterns that produce fragments too distal or too small to be adequately captured by volar locked plating alone, presenting unique challenges to the surgeon. For example, in a retrospective review of 77 AO C3 (articular multifragmentary) distal radius fractures treated with only a volar locked plate, at an average of 120-day follow-up, Earp et al12 found a 10.4% rate of loss of reduction. Beck et al,13 in reviewing 52 AO B3 (volar shearing) distal radius fractures operatively treated with volar locking plates, found that fractures in which the lunate facet fragment had less than 15 mm in length of the volar cortex available for fixation and lunate facet fragments with greater than 5 mm of initial subsidence were at risk of failure despite proper volar plate placement. Volar locking plates are often placed distally to capture small and distal fragments; however, studies have shown that placing these plates distal to the watershed line may lead to flexor tendon irritation and rupture.11,14–16

Fragment-specific fracture fixation is a technically demanding adjunct with a steep learning curve17,18 that uses low-profile,
individualized implants to rigidly restore anatomy. By using tailored implants and fixation techniques to address specific fragments, success relies on preoperative assessment and understanding of the fracture pattern. Fragment-specific fixation can be used alone or in conjunction with other fixation methods and may require more than one surgical approach. The purpose of this report is to illustrate the use of the fragment-specific technique for intra-articular distal radius fracture fixation.

Patient Information
A 42-year-old woman sustained an intra-articular distal radius fracture after falling off a bike. This was a closed injury, and she was neurovasculally intact. There was no evidence of acute median nerve compression. The fracture was reduced in the emergency department, and a short arm splint was placed. Her preoperative radiographs revealed a three-part intra-articular fracture including a lunate facet/volar ulnar corner fragment, a scaphoid facet fragment, and a radial styloid fragment. There was no carpal fracture or instability noted on preoperative imaging, nor was there an ulnar styloid fracture (Fig. 1).

Surgical Technique
Preoperative imaging revealed a comminuted intra-articular distal radius fracture with a shearing type fracture in the sagittal plane involving the volar ulnar corner. In the operating room, the patient was placed supine on the operating room table with the upper extremity on a hand table. A nonsterile tourniquet was used on the upper arm. A mini c-arm was prepared and was placed at the side of the hand table. The upper extremity was prepped and draped in usual sterile fashion. We used a modified Henry approach, as we felt it would allow for visualization of both the radial and intermediate columns and allow for direct visualization of the fracture reduction. We made a 5-cm longitudinal incision over the flexor carpi radialis (FCR). The epidermis and dermis were sharply dissected, and blunt dissection with Littler scissors was used to dissect through the subcutaneous tissue to the level of the FCR fascia. Care was taken to avoid the radial artery. Any branches crossing the field were cauterized with a bipolar. The FCR sheath was incised, the FCR was retracted ulnarily, and the FCR subsheath was incised revealing the flexor pollicis longus. The flexor pollicis longus was retracted ulnarily revealing the pronator quadratus (PQ). A surgical sponge was unfolded and placed into the space of Parona to improve visualization of the PQ. We sharply incised the PQ creating a proximal and ulnarly based flap. The incision started just distal to the watershed line and was carried radially and then proximal to the proximal aspect of the PQ. This was bluntly elevated with a surgical elevator. Dissecting along the radial aspect of the distal radius, we identified brachioradialis. This was released sharply off of its attachment to the radial styloid to allow for improved fracture reduction, as it is often a deforming force pulling the distal radial styloid fragment radially. At this point, we had good visualization of the fracture. The fracture site was cleared of soft tissue to allow for improved reduction. We identified 3 main articular volar fragments, including the lunate facet and volar ulnar fragment, the volar margin of the scaphoid facet, and the radial styloid fragment. Due to comminution within the lunate facet and concern it would not be reliably captured by screws from the volar plate, we opted for a surgical technique described by Moore and Dennison17 where k-wires are used for fragment-specific fixation of the lunate facet. A dental pick was used to directly reduce the lunate facet fragment, and this was held with two 0.054 in k-wires that were placed from distal to proximal. The volar scaphoid facet fragment was reduced in a similar manner and secured with one 0.035 in k-wire also from distal to proximal. Reduction was confirmed with fluoroscopy. A 0.062 in k-wire was placed through the skin and into the radial styloid fragment from distal to proximal, and this wire was used to joystick the fragment under direct visualization. This wire was passed proximally into the radius. Adequate reduction was again confirmed with fluoroscopy. The wires (excluding the radial styloid wire) were cut and bent to contour to the volar distal radius. Attention was then turned to selection of a volar locking distal radius plate placed over the k-wires. The plate (Acu-loc 2 volar Distal Radius Plate; Acumed, Hillsboro, OR) was placed onto the distal radius such that it would not be too distal or too radial, the distal screws would not be intra-articular, and it would cover the K-wires. A 2.8-mm hole was drilled into the oblong hole and a 3.5-mm nonlocking screw was placed to hold the plate onto the radius. After the proximal to distal and ulnar to radial location of the plate was confirmed on fluoroscopy, locking screws were placed distally with the use of a locking guide. One screw was placed into the lunate facet fragment and a second into the scaphoid facet fragment. After 2 locking screws were placed into the radial styloid fragment, the radial styloid wire was removed. Two locking screws were placed just proximal and distal to the initial nonlocking proximal screw. The reduction and screw lengths were deemed appropriate on 10° tilted posterior-anterior (PA) and 20° tilted lateral. The tourniquet was deflated, and

**FIGURE 1.** Injury radiographs. PA (A), oblique (B), and lateral (C) demonstrating an intra-articular volar shear type fracture of the distal radius.
bipolar cautery was used to achieve hemostasis. The distal radial ulnar joint was evaluated in neutral, full supination, and full pronation. This was found to be stable in comparison with the contralateral side. The wound was irrigated and closed. The patient was placed in a volar resting splint, which was maintained for 10 days. Ten-day postoperative imaging showed maintained fracture and hardware alignment (Fig. 2). She was instructed to not bear weight through the operative upper extremity for 2 weeks. After 10 days, the splint was removed, and the patient began hand therapy 2 weeks postoperatively. Three-month postoperative imaging shows a healed fracture with maintained alignment and hardware positioning (Fig. 3).

**DISCUSSION**

Although a wide variety of fracture patterns and classification systems exist, the basic principles of surgical treatment remain to minimize complications and promote early return of wrist function. Fragment-specific distal radius fixation, either alone or in conjunction with conventional techniques, allows for rigid fixation and early range of motion with restoration of articular congruity, length, alignment, and rotation with minimal soft-tissue trauma. With several mini-fragment plate and screw options available to treat other articular fractures (eg, radial styloid, volar ulnar corner, and dorsal ulnar corner), the current fragment-specific fixation technique is versatile and effective in achieving a stable reduction in the many complex fracture patterns.

Good to excellent outcomes at mid-term follow-up have been reported for fragment-specific fracture fixation in the literature.\(^{19-21}\) In a review of 81 patients with 85 distal radius fractures treated with fragment-specific fixation, no patients had loss of reduction or tendon rupture; however, 6% required a second procedure for hardware removal.\(^{19}\) Sammer et al,\(^{22}\) in a comparative study of 99 patients with distal radius fractures treated with
fragment-specific and volar locking plate fixation, noted improved radiographic outcomes of volar locked plating (regarding volar tilt and radial length) at 1 year. Although they noted superior grip and pinch strength, range of motion, and Michigan Hand Outcomes Questionnaire Scores at 6 months with volar locked plating, the differences between fixation techniques were smaller at 1-year follow-up.22 Importantly, they noted a 57% complication rate associated with fragment-specific fixation, stemming largely from hardware removal and tendon or nerve irritation. Although this study matched patients by AO type for their functional and patient-reported outcome analysis, it was not randomized, and one may argue that a higher AO type (AO type C: 79% in the fragment-specific cohort, compared with 46% in the volar locked plating cohort) may result in more soft-tissue injury, slower recovery, and more complications. Landgren et al23 conducted a randomized controlled study of 50 patients with AO types A and C distal radius fractures to evaluate differences between fragment-specific fixation and a volar locking plate. This study was powered to detect a difference in grip strength of 20% compared with the contralateral side. The authors found no difference in grip strength, range of motion, or functional outcome scores between the 2 cohorts. They did note a significantly higher rate of complications in the fragment-specific fixation group, primarily attributable to transient radial neuropaxia. These studies consistently suggest an increased complication rate with fragment-specific fixation; however, there is a need for adequately powered studies to help better recognize the advantages and disadvantages as well as indications for fragment-specific fixation instead of or in conjunction with volar locked plating.

In comminuted and intra-articular fracture patterns, the importance of preoperative imaging and planning should not be overlooked. Standard and adequate PA, oblique, and lateral radiographs taken before and after reduction should be evaluated. The use of intraoperative fluoroscopy can be a valuable aid to evaluate adequacy of reduction. Thiart et al24 arthroscopically evaluated 44 intra-articular distal radius fractures treated with fragment-specific fixation and fluoroscopy and were unable to detect an articular gap in 37 patients or a step-off in 33 patients. A 10-degree tilt PA or 45-degree pronated oblique view can help to evaluate the articular surface of the scaphoid fossa, while a 10-degree tilt lateral may help evaluate the volar rim.25,26

Orthogonal or 10-degree tilt PA and lateral views may assist in visualizing intra-articular fragments.27 Computed tomography scans thinly sliced and reformatted can provide valuable information regarding fracture pattern and fragment dimensions. An understanding of the fracture pattern and appropriate fixation technique (eg, buttress plate for a sheared partial articular fracture) is critical to prevent intraoperative and postoperative complications.

There are several methods, not described above, by which to achieve adequate fixation with the fragment-specific technique, including lower profile plates that can be placed more distally on the radius to avoid tendon irritation and plates that incorporate suture holes to capture small articular fragments not amenable to screw or pin fixation. Understanding the principles of fracture fixation, the nature of the fracture at hand, and the fixation options available is critical. The few studies evaluating fragment-specific fixation techniques consistently demonstrate an increased rate of complications, primarily attributable to transient neuropraxias and the need for hardware removal.19,22,23 The learning curve for this technically demanding fixation method has been described,17,18 and with experience, the complication profile may change. Future randomized controlled trials, adequately powered for various outcome measures, are needed to better evaluate the indications for fragment-specific fixation techniques as well as risks and benefits of this technique instead of or in conjunction with volar locked plating.

CONCLUSIONS

The present case illustrates that a fragment-specific technique may be successfully used for intra-articular distal radius fracture fixation. The fragment-specific technique may be a valuable adjunct or alternative to volar locked plating and other fixation techniques for fixation of comminuted and intra-articular distal radius fractures. Fragment-specific fixation allows for individualized fixation of small and distal fracture fragments that are critical to maintenance of the reduction and may not be amenable to other types of fixation.

REFERENCES


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