Chapter 1
Treatment of Metaphyseal Distal Radius Fractures with a Volar Locking Plate

Rachel S. Rohde

Case

This 72-year-old right-hand dominant female fell onto her outstretched right hand. She was evaluated at a hospital based emergency center where she underwent closed reduction and splinting of a right distal radius fracture. At time of presentation, 10 days later, she denied any numbness or tingling and complained only of wrist pain and some pruritis from the cast material.

On physical examination, her right upper extremity was immobilized in a by then ill-fitting plaster splint extending to her proximal interphalangeal joints and encompassing her thumb in her palm. No neurovascular deficits were noted. Radiographs (Fig. 1.1) demonstrated a metaphyseal fracture of the right distal radius with complete dorsal displacement on the lateral view.

The chronicity of this fracture precluded an attempt at repeated closed reduction in the office. A discussion was had with the patient and her son regarding the risks and benefits of nonoperative and operative management, and a decision was made to proceed

R.S. Rohde, MD (✉)
Department of Orthopaedic Surgery, Oakland University William Beaumont School of Medicine, Michigan Orthopaedic Institute, P.C., 26025 Lahser Road, Southfield, MI 48033, USA
e-mail: rachel.rohde@beaumont.org

J.N. Lawton (ed.), *Distal Radius Fractures*,
DOI 10.1007/978-3-319-27489-8_1

Fig. 1.1 Extra-articular distal radius fracture with poor alignment at first visit following closed reduction

with surgical management of the fracture. The patient underwent open reduction and internal fixation of the distal radius fracture using a volar distal radius locking plate the following day. Radiographs during her postoperative care demonstrated maintained alignment of her hardware and fracture (Fig. 1.2). She was issued a cock-up wrist splint and a prescription to start occupational hand therapy; she gradually pursued activities as tolerated.

The Literature

Indications

Management of distal radius fractures depends on fracture characteristics, patient factors, and surgeon preference. Although some extra-articular fractures can be reduced and maintained in the appropriate position until healing occurs, others are less stable and apt to lose reduction, prompting consideration of operative management.

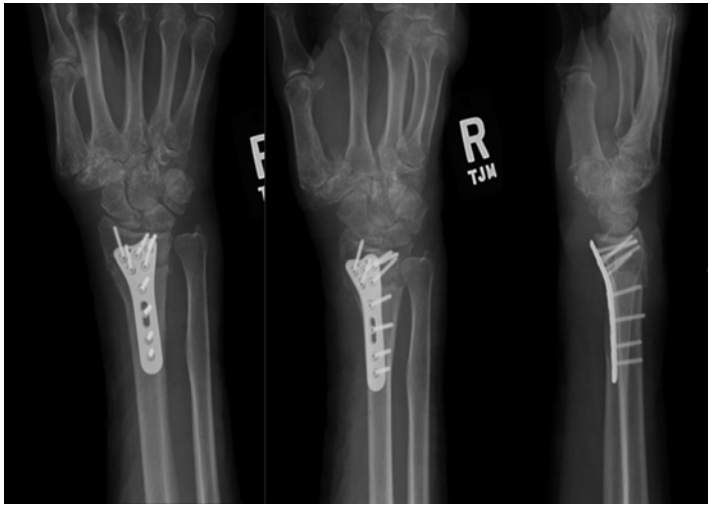

Fig. 1.2 Status post-ORIF distal radius fracture

Patient factors play a key role in determining management of metaphyseal distal radius fractures. Certainly, concomitant pathology such as multiple traumatic injuries and additional ipsilateral upper extremity soft tissue or bone injuries are potential indications for surgical treatment. Patients who are unable to tolerate prolonged immobilization for personal or professional reasons might benefit from the early mobilization allowed by internal fixation; although clinical outcomes are similar between many methods of treatment, internal fixation allows earlier discontinuation of immobilization, a requirement for certain occupational and avocational activities. With regard to its influence on fracture characteristics, patient age is one of the most reliable predictors of instability of these fractures [1]; early studies by McQueen et al. demonstrated that closed reduction of distal radius fractures in elderly patients failed in 53 of 60 wrists, 75 % within the first week after reduction [2]. It has been shown that distal radial fractures through osteopenic or osteoporotic bone are more likely to result in instability, malunion, and carpal malalignment [3]. Whether and when restoration of radiographic parameters is necessary for optimal functional outcome is

beyond the scope of this chapter. Suffice it to say, that if between the surgeon and the patient, it is determined that maintained alignment is desired, then consideration should be given to open reduction and internal fixation. Finally, because closed treatment requires more frequent follow-up visits [4], patients for whom access to physicians for weekly follow-up is problematic might benefit from early surgical stabilization of the fracture.

Biomechanical Considerations

Much of the initial literature regarding the use of volar locking plates to treat distal radius fractures involved assessment of the biomechanics in extra-articular fractures created in cadaver specimens. Several studies have described the optimal approach to fixation. These screws are to be placed in a subchondral position [5] to support the articular surface. Penetration of the dorsal cortex can result in irritation and rupture of the extensor tendons, hence, the subchondral screws should not extend beyond the dorsal cortex; Liu et al. reported that using a screw that traverses 75 % of the depth of the distal radius is acceptable [6]. Although most volar locking plates have many holes for screw placement in the distal fragment, it has been shown that biomechanically, it is acceptable to use only half the screws [7, 8]; Mehling, however, reported that the construct is stronger with more screws [9].

Volar Plating Versus Other Surgical Options

The volar plate has been compared to other fixation methods for treatment of extra-articular and simple intra-articular distal radius fractures.

The use of external fixation and percutaneous pinning of these fractures preceded the introduction of the volar plate. A randomized trial of patients treated with volar locked plating versus external fixation for these fractures demonstrated improved outcomes of volar plating in the first 6 months; the discrepancy was minimal at

12 months [10]. Similarly, percutaneous Kirschner wire fixation demonstrated clinically and radiographically inferior results to volar plating for at least 6 months [11]; the follow-up was limited, so it is not known if the clinical differences persisted long term. Investigations comparing the outcomes following use of various techniques are ongoing.

More recently, the use of an intramedullary nail versus a volar plate led to better short-term (6 week) clinical outcomes, but no difference by 3 months; the nail use was associated with a risk of injury to the superficial branch of the radial nerve [12]. A different intramedullary device was investigated in a pilot study and demonstrated no differences from the volar plate; it is suggested that this might involve less soft tissue dissection than plate use [13]. In contrast, worse results were noted with the use of an intramedullary device versus a volar plate by another group [14]. The fractures for which intramedullary devices might be useful are more limited than those amenable to treatment with the volar plate, but this alternate device continues to be explored as an option to treat these extra-articular fractures.

Potential Complications

As with any surgery, open reduction and internal fixation using a volar plate is not without the standard risks of infection, nerve or blood vessel injury, malunion, nonunion, stiffness, and need for further procedures. Reported risks specific to the use of this hardware primarily address potential for tendon irritation and/or rupture. Extensor tendons can be irritated dorsally by even slightly prominent screws and tendon rupture can occur (Fig. 1.3) [15–20]. Flexor pollicis longus and flexor carpi radialis irritation or rupture also can occur secondary to irritation by the plate volarly [20–24]. Intra-articular screw placement, loss of reduction, extensor tenosynovitis, carpal tunnel syndrome, complex regional pain syndrome, screw loosening, and delayed union all have been observed [25]. The complication rate for volar plating of unstable distal radius fractures has been noted to range from less than 5 % [26] to as high as 48 % [27].

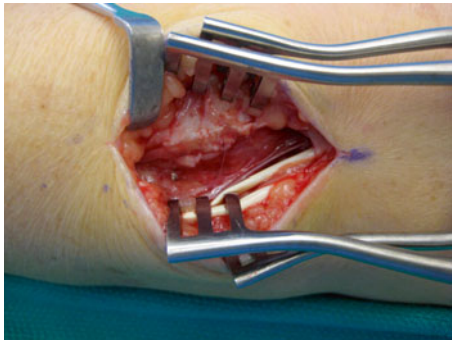

Fig. 1.3 Prominent dorsal screw tip that resulted in rupture of the extensor indicis proprius tendon

Postoperative Treatment

A benefit of the volar plate is that stable internal fixation can be achieved and early range of motion instituted. Although earlier range of motion does not appear to correlate with better long-term outcomes [28], this can be valuable to those who stand to lose significant productivity during the early months of recovery.

Case Review

Following loss of reduction in plaster immobilization, the fracture was not aligned appropriately to expect acceptable function. Therefore, a discussion was had with the patient regarding options for treatment. Although a second closed reduction could have been attempted in the operating room, the relative instability of this fracture already had been demonstrated. Closed reduction and percutaneous fixation was entertained as an option, but the patient had had difficulty tolerating the casting material already. In the author's hands, open reduction and internal fixation with a volar plate offered the most reliable opportunity to restore

anatomy and function while minimizing complications. This also allowed early transition to a removable splint and initiation of range of motion exercises.

Tips/Tricks: Author's Opinion

A patient with a well-reduced extra-articular distal radius fracture should be counseled regarding the options for management. Maintenance of fracture position is monitored weekly for 3 weeks and then at 6 weeks post-fracture. If the reduction is not maintained, consideration is given to surgery. A frank discussion about the risks and benefits of operative and nonoperative treatment guides the patient and the surgeon to a mutually agreeable plan. Loss of reduction and intolerance of prolonged immobilization are the most common reasons for fixation to be recommended. Patients early in their treatment for whom prolonged immobilization poses a significant compromise to livelihood are considered for early fixation as well.

This surgery can be performed on an outpatient basis under a regional anesthetic for intra- and post-operative pain control. Alternatively, A general anesthetic may be a more appropriate option in some patients. In my experience, the use of an indwelling "pain pump" through which anesthesia is administered decreases post-operative pain and narcotic requirements.

I utilize the flexor carpi radialis tendon sheath approach and aim to align the volar cortex. When the fracture is difficult to maintain in a reduced position (as is usually the case in unstable fractures meriting fixation), a 0.0625 inch Kirschner wire can be inserted under fluoroscopic guidance through the radial styloid, across the fracture site, and into the metadiaphyseal bone. This provides provisional fixation for confirmation of reduction and then the plate is applied volarly. This often precludes styloid screw placement, so the K-wire is removed to complete fixation. I choose the implant according to specific needs of the fracture and the patient, and secondarily by my comfort with the system. I use screws to fix these fractures and am careful to aim the most ulnar distal screw slightly radially to avoid DRUJ penetration.

I generally use absorbable sutures and skin adhesive, both for cosmesis and because this alleviates any patient anxiety about having to have sutures removed at the first post-operative visit. Immobilization following surgery is primarily directed at comfort. A well-padded volar plaster splint is placed for comfort; this is discontinued approximately 1 week post-operatively and a pre-fabricated wrist cock-up splint is applied for comfort. The patient is allowed to remove this for motion exercises—with or without guidance of a hand therapist—and to shower.

Patients are advised that bones usually take 6–8 weeks to heal. They receive a prescription for hand therapy at the first postoperative visit and return in approximately 1 month for clinical and radiographic evaluation. Strengthening and gradual resumption of activities as tolerated begin if healing is progressing well at that time.

I do not routinely remove the hardware. Plate removal is considered if the patient experiences tendon irritation (or rupture) or other symptomatic hardware or if s/he has a peri-plate fracture and revision ORIF is performed.

References

1. Mackenney PJ, McQueen MM, Elton R. Prediction of instability in distal radial fractures. J Bone Joint Surg Am. 2006;88(9):1944–51.
2. Beumer A, McQueen MM. Fractures of the distal radius in low-demand elderly patients: closed reduction of no value in 53 of 60 wrists. Acta Orthop Scand. 2003;74(1):98–100.
3. Clayton RA, Gaston MS, Ralston SH, Court-Brown CM, Mcqueen MM. Association between decreased bone mineral density and severity of distal radial fractures. J Bone Joint Surg Am. 2009;91(3):613–9.
4. Lichtman DM, Bindra RR, Boyer MI, Putnam MD, Ring D, Slutsky DJ, Taras JS, Watters WC, Goldberg MJ, Keith M, Turkelson CM, Wies JL, Haralson RH, Boyer KM, Hitchcock K, Raymond L. AAOS clinical practice guideline summary: treatment of distal radius fractures. J Am Acad Orthop Surg. 2010;18:180–9.
5. Drobetz H, Bryant AL, Pokorny T, Spitaler R, Leixnering M, Jupiter JB. Volar fixed-angle plating of distal radius extension fractures: influence of plate position on secondary loss of reduction—a biomechanic study in a cadaveric model. J Hand Surg Am. 2006;31(4):615–22.

6. Liu X, Wu WD, Fang YF, Zhang MC, Huang WH. Biomechanical comparison of osteoporotic distal radius fractures fixed by distal locking screws with different length. PLoS One. 2014;9(7), e103371.
7. Crosby SN, Fletcher ND, Yap ER, Lee DH. The mechanical stability of extra-articular distal radius fractures with respect to the number of screws securing the distal fragment. J Hand Surg Am. 2013;38(6):1097–105.
8. Moss DP, Means Jr KR, Parks BG, Forthman CL. A biomechanical comparison of volar locked plating of intra-articular distal radius fractures: use of 4 versus 7 screws for distal fixation. J Hand Surg Am. 2011;36(12): 1907–11.
9. Mehling I, Müller LP, Delinsky K, Mehler D, Burkhart KJ, Rommens PM. Number and locations of screw fixation for volar fixed-angle plating of distal radius fractures: biomechanical study. J Hand Surg Am. 2010;35(6):885–91.
10. Wilcke MK, Abbaszadegan H, Adolphson PY. Wrist function recovers more rapidly after volar locked plating than after external fixation but the outcomes are similar after 1 year. Acta Orthop. 2011;82(1):76–81.
11. McFadyen I, Field J, McCann P, Ward J, Nicol S, Curwen C. Should unstable extra-articular distal radial fractures be treated with fixed-angle volar-locked plates or percutaneous Kirschner wires? A prospective randomised controlled trial. Injury. 2011;42(2):162–6.
12. Safi A, Hart R, Těknědžjan B, Kozák T. Treatment of extra-articular and simple articular distal radial fractures with intramedullary nail versus volar locking plate. J Hand Surg Eur. 2013;38(7):774–9.
13. Zehir S, Calbiyik M, Zehir R, Ipek D. Intramedullary repair device against volar plating in the reconstruction of extra-articular and simple articular distal radius fractures; a randomized pilot study. Int Orthop. 2014;38(8): 1655–60.
14. Chappuis J, Bouté P, Putz P. Dorsally displaced extra-articular distal radius fractures fixation: Dorsal IM nailing versus volar plating. A randomized controlled trial. Orthop Traumatol Surg Res. 2011;97(5): 471–8.
15. Al-Rashid M, Theivendran K, Craigen MA. Delayed ruptures of the extensor tendon secondary to the use of volar locking compression plates for distal radial fractures. J Bone Joint Surg Br. 2006;88:1610–2.
16. Benson EC, DeCarvalho A, Mikola EA, Veitch JM, Moneim MS. Two potential causes of EPL rupture after distal radius volar plate fixation. Clin Orthop Relat Res. 2006;451:218–22.
17. Engkvist O, Lundborg G. Rupture of the extensor pollicis longus tendon after fracture of the lower end of the radius: a clinical and microangiographic study. Hand. 1979;11:76–86.
18. Failla JM, Koniuch MP, Moed BR. Extensor pollicis longus rupture at the tip of a prominent fixation screw: report of three cases. J Hand Surg Am. 1993;18:648–51.
19. Wong-Chung J, Quinlan W. Rupture of extensor pollicis longus following fixation of a distal radius fracture. Injury. 1989;20:375–6.

20. Rozental TD, Beredjiklian PK, Bozentka DJ. Functional outcome and complications following two types of dorsal plating for unstable fractures of the distal part of the radius. J Bone Joint Surg Am. 2003;85:1956–60.
21. Bell JS, Wollstein R, Citron ND. Rupture of flexor pollicis longus tendon: a complication of volar plating of the distal radius. J Bone Joint Surg Br. 1998;80:225–6.
22. DiMatteo L, Wolf JM. Flexor carpi radialis tendon rupture as a complication of a closed distal radius fracture: a case report. J Hand Surg Am. 2007;32: 818–20.
23. Klug RA, Press CM, Gonzalez MH. Rupture of the flexor pollicis longus tendon after volar fixed-angle plating of a distal radius fracture: a case report. J Hand Surg Am. 2007;32:984–8.
24. Koo SC, Ho ST. Delayed rupture of the flexor pollicis longus tendon after volar plating of the distal radius. Hand Surg. 2006;11:67–70.
25. Arora R, Lutz M, Hennerbichler A, Krappinger D, Espen D, Gabi M. Complications following internal fixation of unstable distal radius fracture with a palmar locking-plate. J Orthop Trauma. 2007;21(5):316–22.
26. Fok MWM, Klausmeyer MA, Fernandez DL, Orbay JL, Bergada AL. Volar plate fixation of intra-articular distal radius fractures: a retrospective study. J Wrist Surg. 2013;2(3):247–54.
27. Knight D, Hajducka C, Will E, McQueen M. Locked volar plating for unstable distal radial fractures: clinical and radiological outcomes. Injury. 2010;41(2):184–9.
28. Lozano-Calderon SA, Souer S, Mudgal C, Jupiter JB, Ring D. Wrist mobilization following volar plate fixation of fractures of the distal part of the radius. J Bone Joint Surg Am. 2008;90:1297–304.