SCIENTIFIC ARTICLE

Surgical Outcomes Following Fixation of Peri-Implant Distal Radius Fractures: A Case Series

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Purpose The purpose of this study was to evaluate surgical outcomes following fixation of peri-implant distal radius fractures.

Methods A retrospective chart review was conducted of peri-implant distal radius fractures treated surgically at a large academic practice over 18 years. Patients were included if they had previously undergone open reduction and internal fixation of a distal radius fracture; subsequently sustained a fracture at, or adjacent to, the existing hardware; and then undergone revision fixation with the removal of hardware. Fractures were categorized into 3 groups: type A (distal to the implant), type B (at the level of the implant), and type C (proximal to the implant). Outcomes, including range of motion, Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire scores, and radiographic alignment, were recorded at the latest follow-up visit.

Results Twelve peri-implant distal radius fractures that had undergone revision surgical fixation were identified. At the time of injury, the average patient age was 63 years. Ten occurred around a volar plate, 1 occurred around an intramedullary device, and 1 occurred around a dorsal plate. One fracture occurred proximal to previous hardware (type C), 9 fractures occurred at the level of previous hardware (type B), and 2 fractures occurred distal to previous hardware (type A). The median time from initial fixation to peri-implant fracture was 2.7 years. At a mean follow-up of 6 months after the removal of the hardware and revision fixation, radiographic alignment was within acceptable parameters for all injuries. At the final follow-up, the average wrist motion for flexion, extension, supination, and pronation were 66°, 66°, 83°, and 86°, respectively. The average DASH score was 6.7. Three patients experienced complications.

Conclusions Although peri-implant fractures are infrequent complications following distal radius fracture internal fixation, outcomes of surgically treated peri-implant distal radius fractures are satisfactory with respect to radiographic alignment, range of motion, and function. *(J Hand Surg Am. 2022;47(2):192.e1-e6. Copyright © 2022 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Therapeutic IV.

Key words Distal radius, fracture, hardware, outcomes, peri-implant.

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Received for publication May 14, 2020; accepted in revised form April 15, 2021.

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

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0363-5023/22/4702-0018$36.00/0
https://doi.org/10.1016/j.jhsa.2021.04.016

DISTAL RADIUS FRACTURES ARE the most common fracture of the upper extremity and comprise one-sixth of all fractures evaluated in the emergency department.[1–3] Most distal radius fractures can be treated nonsurgically; however, displaced or unstable fractures often require surgery. Although various surgical options exist, including closed reduction and percutaneous pinning, external fixation, and open reduction internal fixation (ORIF), there has been a steady increase in the rate of ORIF

over the past 20 years.[4] Because of faster recovery times and better radiographic alignment, volar plates have become the mainstay of treatment.[5,6] Though generally considered to be a safe procedure, complication rates with ORIF have been found to be as high as 22% to 27%.[7]

Reported complications following distal radius fracture ORIF include infection, nerve/vessel injury, tendon irritation/rupture, stiffness, malunion, nonunion, and hardware prominence.[5,7] As with any procedure involving retained hardware, there is also the potential for peri-implant fracture. However, despite the frequency of distal radius fracture ORIF, this complication has rarely been reported. To date, we are aware of only 1 case report in the literature.[8] Therefore, the purpose of our study was to present a series of peri-implant distal radius fractures requiring surgical treatment and to review the outcomes following surgical intervention.

MATERIALS AND METHODS

Institutional review board approval was obtained with a waiver of informed consent per institutional protocol (Thomas Jefferson University). We performed a retrospective review of the surgical billing database from a large academic institution with a total of 22 hand surgeons. We identified all patients with Current Procedural Terminology codes indicating concomitant removal of hardware (ROH) and ORIF of a radius fracture between January 1, 2002, and January 31, 2020. Patients were identified using the Current Procedural Terminology codes associated with ROH (20670, 20680, 25250, or 25251) and ORIF (25607, 25608, 25609, 25515, 25525, 25526, 25574, or 25575) on the same surgical date and setting. A hand surgery fellow (JMK) reviewed all preoperative radiographs to ensure appropriate designation of distal radius peri-implant fracture, which was subsequently confirmed by 2 fellowship-trained, orthopedic hand surgeons (KFL, JLM). Inclusion criteria included fractures around a previously fixed distal radius fracture with retained hardware in skeletally mature individuals. Exclusion criteria included previous radial shaft fracture ORIF, previous distal radius ORIF with early loss of fixation unrelated to peri-implant fracture, and revision for a cause other than peri-implant fracture (ie, lunate facet escape or early hardware failure/loss of reduction).

Given the lack of a widely accepted classification system for peri-implant fractures, we categorized the fractures into 3 groups: type A (distal to the implant), type B (at the level of the implant), and type C (proximal to the implant). We adapted our classification from the Unified Classification System that was intended for use with prosthetic implants and not specifically for internal fixation devices.[9] Patients' electronic medical records were reviewed to obtain demographic data, medical comorbidities, date of initial distal radius ORIF surgery (when available), mechanism of reinjury, date of peri-implant fracture ORIF with ROH, range of motion (ROM), Disabilities of the Arm, Shoulder, and Hand (DASH) score, complications, and final follow-up time. Radiographs at the final follow-up appointment were evaluated to determine implants used and to measure the distal radius alignment, including radial inclination, radial height, volar tilt, and ulnar variance. The overall data were analyzed by descriptive statistics.

The revision fixation algorithm was not standardized. In general, the previously placed hardware was removed. Then, the fracture was reduced and provisionally stabilized. A revision implant was selected that would allow for adequate fixation into the distal segment. This often required choosing an implant from a different manufacturer that would allow for redirection of locking screws to avoid prior hardware or fracture defects. Proximal to the fracture, the goal was to obtain at least 6 cortices of fixation.

RESULTS

Based on our initial query, 55 patients were identified who underwent concomitant ROH and ORIF. Of this group, 12 patients were confirmed to have peri-implant fractures and were included in the final analysis (Table 1). The mean age at the time of injury resulting in peri-implant fracture was 63 years (range, 17−91 years). The most common mechanism of reinjury was a low energy fall from standing (n = 10, 83%). The median time from initial fracture fixation to injury causing peri-implant fracture was 2.7 years (range, 0.5−16 years). Initial distal radius fracture fixation was with a volar plate in 10 patients (83%), with a dorsal plate in 1 patient (8%), and with an intramedullary device in 1 patient (8%). According to our classification, there were 2 type A fractures (17%), 9 type B fractures (75%), and 1 type C fracture (8%), (Figs. 1−3). In 2 patients with type B fractures, there was a failure of the hardware. One volar plate was bent at the shaft, and the other volar plate was bent at the distal screws and broken at the shaft. These were both titanium implants from the same manufacturer. In the sole type C fracture, initial

TABLE 1. Summary of Patient Demographics

Patient	Age (Years)	Sex	Smoker	Diabetes	Fracture Type (UCS)	Mechanism	Laterality	Initial Fixation	Revision Fixation
1	91	F	N	N	B	Fall from standing	R	Volar plate	Long volar DR plate
2	65	F	N	N	B	Fall from standing	R	Volar plate	Long volar DR plate
3	63	F	N	N	B	Fall from standing	L	Volar plate	Volar LCP plate
4	75	F	N	N	C	Fall from standing	L	IM device	Long volar DR plate
5	63	F	N	N	B	Fall from standing	R	Volar plate	Volar LCP plate
6	77	F	N	N	B	Fall from standing	L	Volar plate	Volar recon plate
7	70	F	N	Y	A	Fall from standing	R	Volar plate	Dorsal wrist spanning plate
8	22	M	N	N	B	Bicycle accident	R	Volar plate	Long volar DR plate
9	85	F	N	Y	B	Fall from standing	R	Volar plate	Long volar DR plate
10	56	M	N	N	B	Skiing accident	R	Volar plate	Volar DR plate
11	66	F	N	N	B	Fall from standing	L	Dorsal plate	Long volar DR plate
12	17	M	N	N	A	Fall from standing	R	Volar plate	K-wires

DR, distal radius; IM, intramedullary; LCP, locking compression plate; N, no; UCS, Unified Classification System; Y, yes.

fixation was performed with an intramedullary device.

All patients underwent removal of existing hardware and revision ORIF. Eleven of the patients (92%) had removal of all existing hardware. For the patient with the intramedullary device, the intention was to remove the entire implant. However, stripping of 2 screw heads required that part of the device be left in place and that fixation proceed around it. Seven patients (58%) with peri-implant fractures (1 type C and 6 type B) were fixed using a contoured volar distal radius plate. Fractures in 3 patients (25%), all with type B fractures, were fixed volarly with a small fragment plate (1 with a reconstruction plate and 2 with a locking compression plate). One patient with a type A fracture was fixed dorsally with a wrist spanning plate because of the comminution and distal extent of the fracture. Finally, 1 skeletally mature, adolescent patient with a type A fracture was stabilized with Kirschner wires because of preexisting deformity from the previous fracture that would have made revision plate fixation technically difficult. Overall, 10 patients (83%) had revision fixation with a different plate type and/or manufacturer than what was used for the initial fixation. No patients had ulnar fractures that required fixation. No patients required any additional treatment for distal radioulnar joint instability.

The mean final follow-up was 6 months (range, 2−19 months). The patient with 2 months of follow-up had a metaphyseal fracture that was both clinically and radiographically healed. Overall, the mean final DASH score was 6.7 (range, 0−18). The mean final ROM measurements including wrist flexion, wrist extension, forearm supination, and forearm pronation were 66° (range, 28° to 90°), 66° (range, 60° to 70°), 83° (range, 50° to 90°), and 86° (range, 70° to 90°), respectively. Final radiographic measurements after revision fixation were all within acceptable parameters per the American Academy of Orthopaedic Surgeons Clinical Practice Guidelines (dorsal tilt, <10° dorsal; articular stepoff, <2 mm; radial height, <3 mm shortening): average volar tilt was 3° (range, −9° to 12°), average radial inclination was 23° (range, 16° to 30°), average radial height was 11 mm (range, 8−15 mm), and average ulnar variance was neutral (range, −4−3 mm).[10] There were 3 patients who experienced postoperative complications (25%). Complications included 1 incisional cellulitis that resolved with oral antibiotics, 1 delayed union that healed at 7.5 months, and 1 loss of fixation (the distal portion of plate pulled slightly off the bone) that resulted in a loss of volar tilt but did not require additional surgery and healed within acceptable

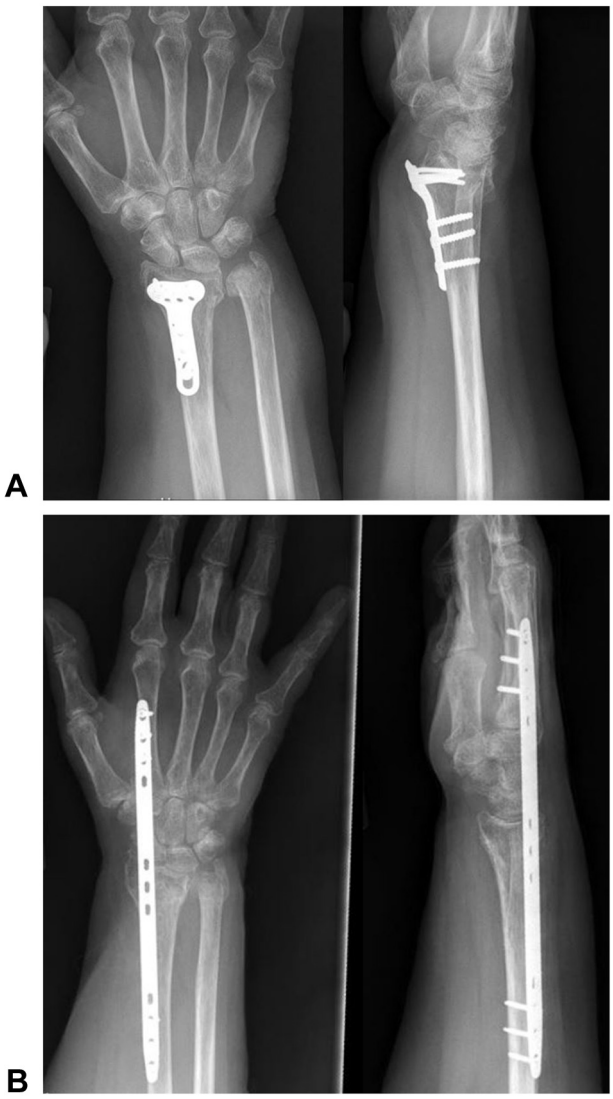

FIGURE 1: A 70-year-old woman with a type A peri-implant distal radius fracture at the distal extent of a previously placed volar plate. **B** Revision fixation with a dorsal wrist spanning plate given the distal extent of the fracture.

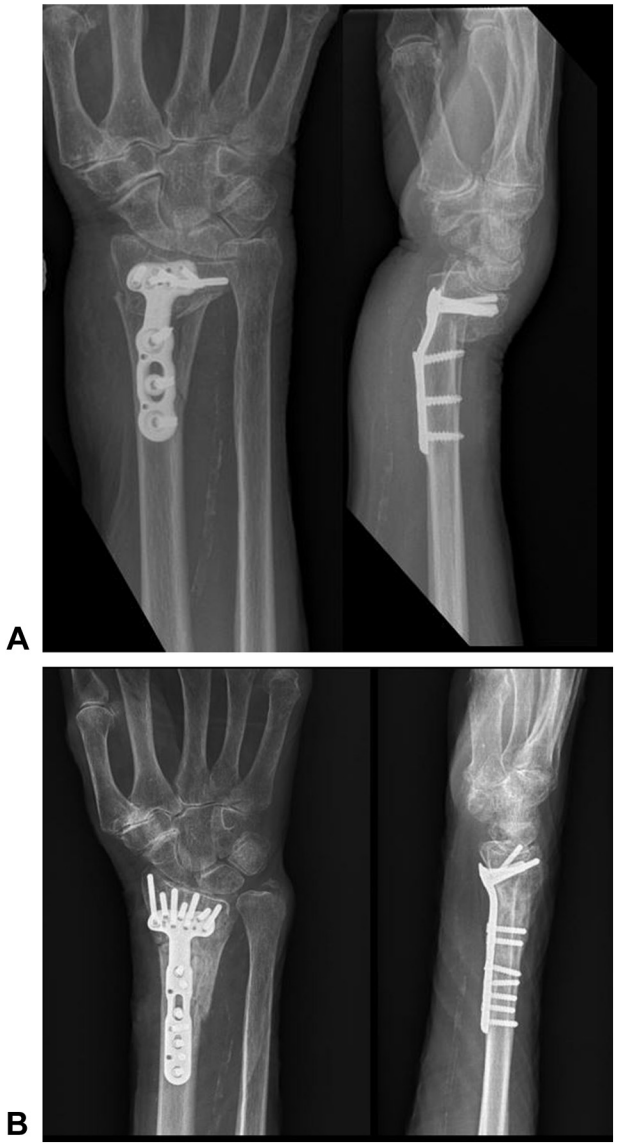

FIGURE 2: A 91-year-old woman with a type B peri-implant fracture around a previously placed volar plate. **B** Revision fixation with a long, precontoured, volar distal radius plate.

radiographic parameters per American Academy of Orthopaedic Surgeons Clinical Practice Guideline. No patient required another revision surgery or readmission to the hospital after surgery.

DISCUSSION

Surgical fixation of distal radius fractures, although generally considered safe and beneficial, is associated with some risk. Common complications include tendon irritation/rupture, nerve irritation, and malunion or loss of reduction.[5] Our study presents a complication that we believe is uncommon and rarely reported. Given the limited data available on this complication and the infrequency with which it is encountered, surgeons may not feel compelled to counsel patients about this risk. Furthermore, when presented with this scenario, surgeons have little information upon which to guide patients regarding outcomes after revision fixation.

In 2018, Barrera-Ochoa et al[8] published a case report of a patient who sustained peri-implant radial and ulnar shaft fractures after volar locking plate fixation of the distal radius. The patient was injured during a high-energy traffic accident and ultimately was successfully treated. To our knowledge, this is the only description of such an injury currently in the literature. In 2015, Snoddy et al[11] published a retrospective review of 33 patients who underwent ROH following distal radius

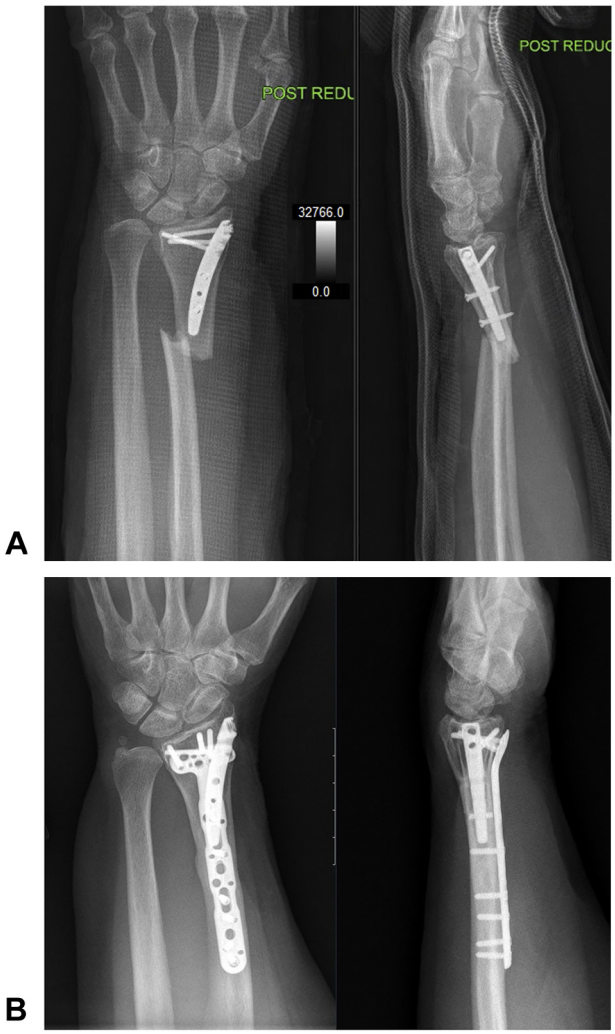

FIGURE 3: A 75-year-old man with a type C peri-implant distal radius fracture proximal to a previously placed intramedullary device. **B** Revision fixation with a long, precontoured, volar distal radius plate with retention of some of the initial hardware.

fracture ORIF to determine reasons for removal. None of these patients had hardware removed to treat a peri-implant fracture. In an evaluation of volar plating of 616 distal radius fractures, Wilson et al[12] found an overall 17% complication rate. The most common complications were loss of reduction (25%) and postoperative carpal tunnel syndrome (17%). They did not specifically report any incidences of peri-implant fractures, though 10 patients in their study had unspecified complications listed as "other."

With the increasingly high rates of distal radius fracture ORIF and the relatively low rates of routine distal radius ROH, we suspect that peri-implant distal radius fractures will become a more recognized entity over time.[5,13,14] In general, plate and screw constructs function as load-bearing devices and are stiffer than native bone. This biomechanical principle creates a potential stress riser at the bone/plate interface of the plate's proximal extent or at the most proximal screw hole (with the proximal screw hole being the weakest point), which can lead to peri-implant fractures.[15] Surgeons should be aware of this complication when discussing surgical risks with patients, while also recognizing that the incidence of peri-implant fracture appears to be extremely low.

In our practice, we treat nondisplaced peri-implant distal radius fractures that have not compromised the existing hardware with immobilization and close clinical/radiographic follow-up to monitor for instability and ensure adequate healing. Fractures that are displaced or have resulted in loosening of the hardware are treated with revision surgery. We remove the previous hardware and generally fix the fracture with a longer implant, ensuring that 3 bicortical screws have purchase proximal to the peri-implant fracture. However, some adaptability is required, given that prior fracture and fixation can alter the local anatomy. In this study, this was noted in the patient with deformity from the previous fracture that required revision fixation with Kirschner wires and in the patient who required partial retention of an intramedullary device. Our typical postoperative protocol, provided that stable plate fixation is obtained, is similar to that of primary distal radius ORIF with early ROM and a removable orthosis.

Our current study has several limitations. Most of these are attributable to its retrospective design. First, we relied on the accuracy and completeness of the medical record for outcome data. Specifically, we did not have preoperative DASH scores or ROM measurements, so we were unable to assess change after revision fixation. Second, we may not have captured every peri-implant fracture treated surgically at our institution. It is possible that the surgeons did not use the Current Procedural Terminology codes we identified and/or that there were peri-implant fractures that were fixed during the study period without ROH. However, we believe that this is relatively unlikely given that it is not our typical treatment approach to retain initial hardware. Third, we only included peri-implant distal radius fractures that required surgical intervention, and therefore, the incidences and outcomes of peri-implant fractures treated without surgery are not determined by our study. Fourth, the time to follow-up is relatively short for some of the patients. Although it is possible that additional outcome data would be available with longer follow-up, all patients were followed until their fractures were healed, and they were doing well enough to be discharged by their treating surgeon. Fifth, there may

be technical factors (eccentric plate/screw positioning, screw size or type, etc) that can predispose to peri-implant fractures. The nature of our study does not allow for an assessment of this possibility; however, surgeons should be aware to maintain appropriate plate and screw positioning, type, and length. Sixth, we are unable to comment on the decision-making related to the selection of revision hardware.

Overall, peri-implant fracture is an uncommon and rarely reported complication following surgical fixation of the distal radius. If treated with ROH and revision ORIF, these injuries have the potential for good outcomes. Surgeons should be aware that this complication can occur and be prepared with a treatment strategy if presented with this scenario.

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