Long-term Results of Dorsally Displaced Distal Radius Fractures Treated With the Pi-Plate: Is Hardware Removal Necessary?

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abstract

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The purpose of this study was to evaluate the outcome of patients treated with open reduction and internal fixation (ORIF) using dorsal plates and screws (AO/ASIF pi-plate) for dorsally displaced fractures of the distal radius. Although extensor tendon rupture is a recognized complication of all distal radial fractures, there appears to be an increased risk of this using dorsal plating. In addition, there is the added complication of extensor tendon irritation and dorsal wrist pain, which may necessitate plate removal. The low-profile pi-plates intended to overcome this problem have not done so, with quoted rates ranged from 19% to 55%.

We treated 32 completely evaluated patients (13 men and 19 women) in our department between 2000 and 2004, with an average age of 46 years. They underwent ORIF of dorsally displaced fractures of the distal radius using the specially designed pi-plate. Bone graft was used in 18 patients who had significant metaphyseal defect. Clinical examination, plain radiographs, and functional assessments using the modified Mayo Wrist Score were performed at an average follow-up of 86 months (range, 56-115 months). Satisfactory reduction was achieved in all 32 fractures at the time of operative fixation with no instances of loss of fracture reduction during the study period. According to the Mayo Wrist Score, 23 patients (72%) had excellent or very good results, 7 (22%) had fair results, and 2 (6%) had poor results. Two cases (6.25%) of extensor tendon rupture were noted during the first postoperative month, and 2 other patients showed progressive weakness of index finger extension 6 months postoperatively. The remaining 28 patients had no soft tissue problems.

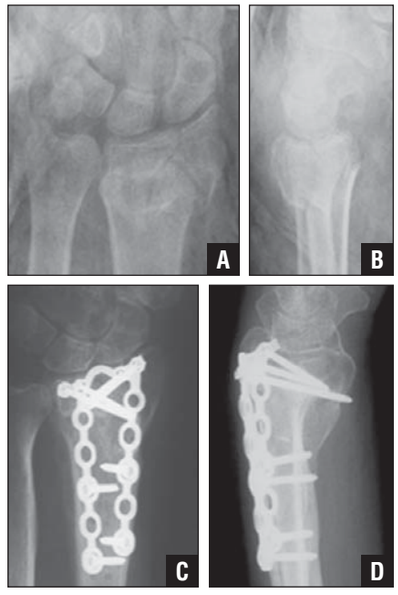

Figure: Preoperative AP (A) and lateral (B) radiographs of a type II fracture in a 42-year-old woman who sustained the fracture after a fall from a height. AP (C) and lateral (D) radiographs at last follow-up 91 months postoperatively. The Mayo score was 94.

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One of the most common injuries in orthopedics is the distal radius fracture. Some of these fractures are caused by severe high-energy trauma, resulting in intra-articular involvement and comminution. Treatment of such injuries is difficult. These fractures often are unstable, difficult to reduce anatomically, and associated with a high prevalence of complications. Restoration of radial shortening, radial inclination, and sagittal tilt, as well as articular congruency, is required for the best chance of good functional outcome.[1,2] Displaced, unstable fractures left untreated may lead to instability,[3,4] posttraumatic osteoarthritis,[5,6] or residual disability.[7] The fixation method of choice is the one that can maintain a satisfactory reduction and allow early motion to avoid joint stiffness and disuse atrophy.[8]

While dorsal plates have yielded good results in dorsally comminuted or displaced fractures through osseous synthesis using a dorsal 3.5-mm T-plate, they were largely abandoned because of unfavorable experiences with the extensor tendons.[9] With the anatomically precontoured AO/ASIF pi-plate, extensor tendon problems can be lessened, and despite various authors advocating volar fixed-angle plate for dorsally displaced fractures,[10,11] there are some fractures that are problematic to reduce and stabilize from the palmar side in which dorsal reduction may be easier to perform.[12]

This article describes our experience treating these dorsally displaced fractures of the distal radius with dorsally applied pi-plates and early mobilization. The study group was homogeneous with respect to fracture as well as fixation type. Removal of pi-plates has been recommended after fracture healing to avoid late tendon problems.[13] However, in our department, plate removal is not regularly performed because of lack of adequate operating time. We present the long-term clinical outcome of the distal radius treated with pi-plate that was not routinely removed. It appears that if there is no tendon irritation in the immediate postoperative period (up to 6 months), it will not occur in the long term; thus, scheduled plate removal is not necessary.

MATERIALS AND METHODS

During a 4-year period (2000-2004), 95 patients underwent surgical treatment for a distal radius fracture in our department. Forty-nine patients were treated with external fixation and 34 patients with the pi-plate. Thirty-two were available at the last follow-up. Thirteen men and 19 women had a mean age of 46.1 years (range, 20-73 years).

Inclusion criteria were dorsally displaced fractures with failure of initial reduction to restore: radial inclination $\geqslant 15°$ on posteroanterior radiographs; sagittal tilt on lateral projection between 15° dorsal tilt and 20° volar tilt; radial shortening of <5 mm at the distal radial ulnar joint compared with the contralateral wrist; and incongruity of the intra-articular fracture <2 mm at the radiocarpal joint.

All fractures were operated within 48 hours of admission. In 4 cases, surgery was performed after a week because of late redisplacement of the fracture. All fractures were dorsally displaced, and 1 had both dorsal and volar displacement. According to AO classification,[14] four fractures were type A2 (extra-articular simple and impacted), 16 were type A3 (extra-articular multifragmentary), 4 were type B1 (partial articular, sagittal), 4 were type B2 (partial articular, dorsal rim), 3 were C1 (articular simple, metaphyseal simple), and 1 was type C2 (articular simple, metaphyseal multifragmentary). By definition, C3 (complete articular fracture, multifragmentary) and B3 (partial articular, volar rim) fractures were excluded from the study. Associated injuries included 1 scaphoid fracture, 1 tibial fracture, and 1 multiple injured patient. All fractures were closed, and no associated ligamentous injuries of the wrist were noted.

The surgical treatment method of choice was open reduction and internal fixation (ORIF) with pi-plate unless severe intra-articular fragmentation excluded the use of the method. The latter cases were treated with external fixation, augmented or not, and were excluded from the study. The decision on the method of treatment was made intraoperatively by the senior author (M.E.T.) based on fluoroscopic images under traction. Once the decision was made, no intraoperative shift from 1 method to the other was done.

SURGICAL TECHNIQUE

All procedures were performed by the same surgeon (M.E.T). Under general anesthesia and tourniquet use, a dorsal incision was made over Lister's tubercle. The third extensor compartment was opened, leaving the extensor pollicis longus tendon free. With subperiosteal dissection toward the radial and ulnar site, the dorsal cortex of the distal radius was then exposed. The fragments were reduced with gentle maneuvers and temporarily stabilized with 1- or 1.25-mm K-wires when necessary.

After fluoroscopic guidance, the pi-plate was applied. Three or four 2.7-mm screws were used in the proximal part. In cases with intact opposite volar cortex, $\geqslant 3$ screws were used; otherwise, pegs were preferred. No posterior interosseous nerve resection was routinely performed in any case. Bone graft was inserted after pi-plate application in 18 patients who had significant metaphyseal defect. Autografts were used in 11 patients and autografts and allografts in 7 patients. Although the pi-plate was anatomically designed in 3 cases, we had to precontour the vertical part of the plate with special guides to match anatomic variations of the dorsal cortex. Holes from the radial or ulnar edge or both of the vertical part of the plate were cut off in 5 cases because the plate intervened with smooth extensor tendon gliding. The third compartment was left open, and after a final fluoroscopic examination, the wound was closed. Carpal tunnel decompression was performed if there was preoperative clinical evidence of median

nerve compression (5 cases). The mean operative time was 67 minutes.

A short forearm cast was used in all patients for 1 to 2 weeks postoperatively. Once in a removable splint, patients commenced weekly hand therapy sessions, starting with early active movement and progressing to passive movement by 4 to 6 weeks.

RESULTS

All patients were examined clinically and radiologically at 2, 4, and 8 weeks and 6 months postoperatively. The mean time to union was 5.3 weeks (range, 4.5-8 weeks). At 6-month follow-up, no radiological differences were noted compared to immediately postoperatively. There was no clinical evidence of carpal instability or any fracture subsidence. For the purpose of the present study, the patients were evaluated by 2 independent medical students an average of 86 months postoperatively (range, 56-115 months).

At most recent follow-up, patients were given the modified Mayo Wrist Score questionnaire to subjectively evaluate their pain (25 points) and satisfaction with the final outcome (25 points), whereas objective evaluation included measurement of grip strength (25 points) with a Jamar dynamometer and range of motion (25 points) with a standard goniometer. There was no other communication in the meantime except the cases mentioned below. According to Mayo Wrist Score, 34% of the patients had excellent results, 38% good, 22% fair, and 6% poor. No patient had reflex sympathetic dystrophy, nonunion, infection, or material failure.

Radiological parameters (radial inclination, radial shortening, sagittal tilt, and intra-articular step) were among the normal values, and no case had statistically different values between postoperative and last follow-up radiographs (Figures 1, 2). At the last follow-up, there was a mean sagittal tilt of 8°, radial inclination of 17°, and radial shortening of 11° (Table). In terms of intra-articular congruity, 2 patients had steps of 0 to 1 mm and one of 1 to 2 mm at the radiocarpal joint. These 3 patients also revealed evidence of grade 1 Knirk and Jupiter[5] osteoarthritic change at the radiocarpal joint.

Three patients were reoperated 6 weeks postoperatively due to wrist stiffness attributed to material protrusion into the joint. All 3 had been under physiotherapy for at least 1 month with little improvement. Intraoperatively, the tip of 1 screw was found to penetrate the cartilage and abrade the scaphoid or lunate articular surface. No substantial improvement in range of wrist motion was noted postoperatively after plate removal.

Two cases of extensor tendons rupture were noted during the first postoperative month. The ruptured tendons were repaired side-to-side with the remaining

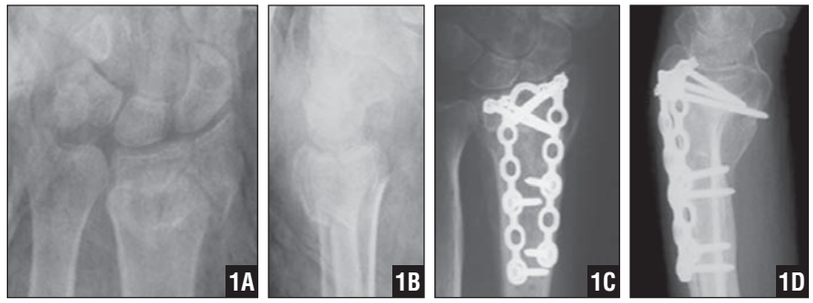

Figure 1: Preoperative AP (A) and lateral (B) radiographs of a type II fracture in a 42-year-old woman who sustained the fracture after a fall from a height. AP (C) and lateral (D) radiographs at last follow-up 91 months postoperatively. The Mayo score was 94.

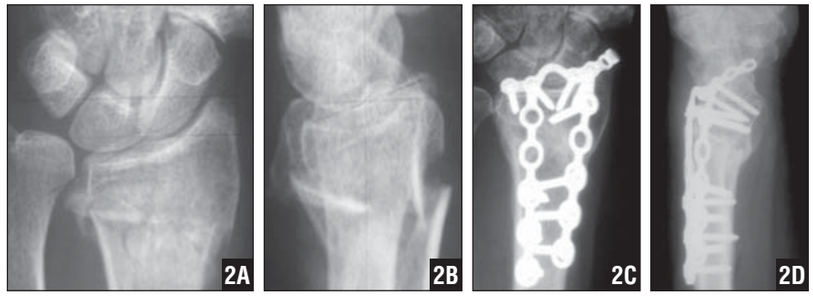

Figure 2: Preoperative AP (A) and lateral (B) radiographs of an extra-articular fracture in a 57-year-old woman who sustained the fracture after a fall from a height. AP (C) and lateral (D) radiographs at last follow-up 78 months postoperatively. The Mayo score was 92.

Table

Radiographic Measurements

	Median (range)			
	Radial Shortening, mm	Sagittal Tilt, deg	Radial Inclination, deg	Intra-articular Step, mm
Preoperatively	5 (−5 to 14)	−18 (−45 to 26)	10 (−20 to 21)	5 (0-9)
Postoperatively	12 (8-16)	8 (−2 to 18)	18 (15-24)	0.5 (0-2)
Last follow-up	11 (7-16)	8 (−3 to 19)	17 (14-24)	0.5 (0-2)
Normal wrist	13 (10-14)	11 (8-14)	22 (16-27)	0

Abbreviation: deg, degrees.

intact tendons and the plate was removed because callus formation was already present. A plaster cast was applied for 4 weeks. Intraoperatively in both cases, the head of a distal screw was found slightly protruding from the plate at the point where the rupture had occurred. In 2 other cases, the patients reported progressive weakness of index finger extension 6 months postoperatively. The tendons were found frayed, and no cause could be identified. The overall rate of reoperation was 21.8% (7/32 patients). Six patients (19%) reported dorsal wrist pain. At final clinical assessment, all patients reported gradual diminishing of the pain within 1 year postoperatively.

DISCUSSION

The treatment of distal radius fractures remains controversial. In 48 international randomized studies cited in the Cochrane database, we found no evidence of superior, long-term, functional advantages from any surgical procedure, including external fixation, K-wire osteosynthesis, and open reduction and plate osteosynthesis.[15] Controversy also exists about various surgical methods. Results of 4 randomized controlled trials comparing external fixation with ORIF for the treatment of intra-articular distal radius fractures describe no consistent benefit of 1 treatment over another.[16]

Locked volar plates for dorsally displaced fractures have been proposed to address problems of the dorsal plates. The former are better covered under soft tissues and do not interfere with the extensor mechanism. However, Rein et al[17] found no statistically significant difference between patients operated with dorsal or volar approach for distal radius fractures, and in 4 retrospective cohort studies, there is insufficient evidence to infer the advantage of either the volar or dorsal plating approach for treatment of distal radius fractures.[16] Willis et al,[18] in a biomechanical model of dorsally comminuted extra-articular distal radial fractures, demonstrated that the dorsal pi-plate had better resistance to fracture gap motion than did the 4 types of volar plate fixation. In this particular model, the presence of a volar gap is not addressed, and the pi-plate would likely become more unstable as the other types of volar plating do. However, Kandemir et al[19] showed that the fixation obtained with volar locking plates is as stable as fixation with a dorsal plate in acute healing period and can withstand the functional demands of the immediate postoperative period in dorsally comminuted unstable extra-articular distal radius fractures.

Initial studies with low-profile plates report good results. Using the Gartland and Werley scoring system, Campbell[20] reported 4 very good, 11 good, and 10 satisfactory results in 25 patients; Ring and Jupiter[21] reported 6 very good, 7 good, and 9 satisfactory results; and Rozental et al[22] reported 19 excellent and 9 very good results. Using the New York Orthopaedic Hospital wrist rating scale, Suckel et al[12] reported 17 very good and 25 good results in 42 patients. In our series, we used the Mayo Wrist Score and had excellent or very good results in 23 patients (72%), fair in 7 (22%) and poor in 2 (6%).

Some authors suggest early implant removal to avoid possible complications. In previous studies, dorsal hardware was removed in 18% to 36% of cases.[9,21,23] Sánchez et al,[24] in a retrospective review of 389 patients with distal intra-articular fractures of the radius treated with the dorsal pi-plate, reported a complication rate of only 6.7% within the first 2 postoperative months. Hardware was removed in 75.5% of patients after 6 to 8 months. In the remaining 24.5% of patients, the plates were left in situ for >33 months, and 89% of these patients were pain free and had excellent movement in the wrist.

Materials are not ordinarily removed in our department due to lack of adequate surgical time. That allowed us to observe the potential problems related to low-profile pi-plates when they remain in situ for years. To our knowledge, this is the longest series in the literature of nonremoved pi-plates.

Incidence of posttraumatic arthritis in our series was low, as most of the fractures (28/32) were extra- or partially intra-articular.

The most common complaint in our study was dorsal wrist pain (19% of the patients), and the same is found in other studies.[21] Kambouroglou and Axelrod[25] reported 5 cases of extensor tenosynovitis and 2 cases of extensor tendon rupture in 8 patients who had been treated with a titanium pi-plate. Khanduja et al[26] reported removal of plate in 4 of 19 patients (23%) due to extensor tenosynovitis and restriction of flexion. Chiang et al[13] attempted to avert pain by creating a retinacular flap with limited success. In their series of 20 consecutive patients, there was a 60% incidence of dorsal wrist pain and the need for plate removal in 45% of them. Possible explanations for dorsal pain could be the chronic gliding of the tendons on a hard surface. Since in our series we did not routinely ligate the terminal articular branch of the posterior interosseous nerve, irritation of that nerve under the plate could have also been a contributing factor.

The close contact of the extensor tendon mechanism to the head of the distal screws is a matter of concern because of possible tendon attrition. In the 2 cases with early rupture of the extensor tendon mechanism, the site of lesion was found right over the head of 1 of the distal screws that was slightly loose and protruding. The cause for the 2 late ruptures was not clear. There was no malposition of the distal fragment that could have led to frictional stress of the overlying tendons, nor was there any head screw protrusion at the site of tendon fraying. In both cases the lesion was at the extensor tendon of the index finger of patients working heavily on a computer.

The second-generation pi-plate with larger flanges introduced to facilitate tendon gliding obscured the articular line of the radius in the radiographs. This was a significant drawback, and in 3 cases the tips of distal screws were found in post-

operative computed tomography scans to protrude 1 to 2 mm within the joint. Implant removal only slightly improved wrist motion. Other authors have also failed to find any significant decrease in wrist pain after plate removal.[13]

Conclusion

Displaced and/or comminuted fractures of the distal radius yield predictably poor results unless accurately reconstructed, especially in young and more active patients. In addition, due to the natural tendency for posttraumatic stiffness in these fractures, results may still be poor unless measures, such as early mobilization, are taken. In the subgroup of dorsally displaced fractures, we found that the dorsal approach allowed good restoration and maintenance of both extra- and intra-articular parameters. Although extensor tendon rupture is a recognized complication of all distal radial fractures, there appears to be an increased risk of this using dorsal plating. In addition, there is the added complication of extensor tendon irritation and dorsal wrist pain, which may necessitate plate removal. The low-profile pi-plates intended to overcome this problem have not done so, with quoted rates ranging from 19% to 55%.[21,23-25]

However, our study found that if patients are not having dorsal problems in the early stages, they probably will not have a problem later. Therefore, routine removal of this device may not be warranted. There are times when dorsal hardware is a better option for some fracture patterns than the volar approach and fixation. Knowing that long-term dorsal soft tissue problems are unlikely in the absence of short-term ruptures may be helpful.

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