Management of Intra-Articular Distal Radius Fractures: Volar or Dorsal Locking Plate—Which Has Fewer Complications?

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Abstract

Background: The aim of this study was to compare the functional outcomes and complications of volar and dorsal plating for the management of intra-articular distal radius fractures, with special regard to indications for dorsal plating. Furthermore, we examine the rationale for choosing dorsal plating and its frequency of use. **Methods:** Clinical assessments included range of motion measurements at the wrist; grip strength; the Quick Disabilities of the Arm, Shoulder, and Hand score; and the Gartland and Werley score. Clinical results were compared with those achieved using a volarly placed locking plate system. According to Lutsky's plate theory, the rationale for choosing dorsal plating was based on 4 types of pathologic fractures. **Results:** Of 112 patients, 38 patients were treated with open reduction internal fixation via a dorsal approach and 68 patients were treated using a volar approach. Except for wrist flexion, there were no other statistical differences in the clinical results between groups for both subjective and objective parameters. There were no statistically significant differences in the complication rates between the volar and dorsal plated groups. One serious complication occurred after volar plating. The most common reason for choosing dorsal plating was irreducible dorsal *die-punch* fractures. **Conclusions:** The treatment of displaced intra-articular distal radius fractures with a dorsally versus a volarly placed interlocking plate system demonstrated similar clinical results. Postoperative complications were not readily observed in the patients treated with a dorsal locking plate. Certain fracture patterns are more appropriately stabilized using a dorsal plate fixation.

Keywords: distal radius fracture, dorsal approach, locked plate fixation, intra-articular fracture, complications

Introduction

Despite the frequency of distal radius fractures, a consensus has not been reached on the optimal approach to treatment. Volar plating systems have changed the ease by which fractures can be treated compared with traditional methods such as fracture specific fixation, pinning, and external fixation, but they have not changed the indications for an operation. The need for surgery is largely dependent on the propensity for a fracture to collapse based on fracture patterns. Nevertheless, the volar plate is not a panacea for all distal radius fractures. Increasingly, it has been recognized that extensor and flexor tendon injury, loss of fixation, and secondary displacement can occur after volar fixed-angle plate osteosynthesis. Distal radius fractures with a complex disruption of the articular surface, and other fractures, are preferentially treated via a dorsal approach, but many surgeons have avoided dorsal plating. This preference might be attributed to the reportedly high

complication rates, which specifically involve extensor tendon irritation and rupture associated with dorsal plating.^{6,15,17,21} More recently, low-profile dorsal plates have been developed in an attempt to minimize these complications. Several case series have shown excellent results with these newer, low-profile plates.^{3,5,8,10,11,14,19,23} Lutsky and colleagues¹⁰ reported that certain pathologic fracture patterns are more appropriately stabilized using dorsal plate fixation, and these include: (1) dorsal shear fractures; (2) dorsal *die-punch* fractures, or fracture patterns in which an indirect reduction from the volar approach cannot be

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obtained, and (3) fractures with associated scapholunate ligament injury.

The aim of this study was to compare the functional outcomes and complications of volar versus dorsal plating for the management of intra-articular distal radius fractures, with special regard to the indications for dorsal plating. The rationale for choosing dorsal plating is covered and we discuss the frequency of its use among our cases.

Materials and Methods

This nonblinded, prospective, nonrandomized study was designed according to and approved by the local Medical Ethics Committee in January 2011. Between January 2011 and January 2014, we treated 217 wrists of 192 consecutive patients with displaced intra-articular fractures of the distal radius. Of these, 112 wrists with displaced intra-articular fractures were treated with an open reduction and internal fixation (ORIF) and we examined whether they had been treated via either a volar approach or a dorsal approach. We included secondary displacements that occurred within 1 month after conservative treatment. The exclusion criteria included patients with previous trauma distal to their upper limbs, or those individuals who had been treated for rheumatoid arthritis or osteoarthritis at their wrist.

All the operations were performed by the first author. According to the rule of our institute, decisions about which surgical approach to adopt—either volar or dorsal—were made after an internal discussion among colleagues for all cases.

Based on the theory of Lutsky,¹⁰ dorsal locking plates were selected for patients with any of the following fractures: (1) dorsal shear fractures; (2) dorsal *die-punch* fractures, or fracture patterns in which an indirect reduction from the volar approach cannot be obtained; (3) fractures with associated scapholunate ligament injury; and (4) fracture patterns in which the volar margin was distal to the watershed line with significant dorsal comminution requiring bone (substitute) grafting. If one of those criteria was met, treatment with dorsal plating was selected. Therefore, all volar plates were placed proximal to the watershed line.

In a case with severe metaphyseal comminution, scapholunate ligament injury, and/or joint depression, external fixation and/or bone grafts or substitutes were used with either volar or dorsal plate fixation, and the frequencies at which they occurred were also examined.

For postoperative management, active finger motion and forearm rotation were encouraged immediately after surgery in all cases. Except for the cases with associated scapholunate ligament injury, a short arm splint or external fixator was removed within 2 weeks after surgery (mean, 8.4 days) and then active wrist motion was started. In 2 patients with

Figure 1. Posteroanterior and lateral radiographs of a 46-year-old male who sustained a fracture with an associated scapholunate ligament injury.

Figure 2. Posteroanterior and lateral radiographs taken after the patient was treated using internal fixation with dorsal distal plating (Aptus 2.5 TriLock Distal Radius Plates; dorsal) and a radiocarpal external fixator.

Note. The scapholunate ligament was repaired with a suture anchor simultaneously via a dorsal approach.

associated scapholunate ligament injury (Figures 1 and 2), the external fixator was removed 2 weeks after surgery and a short forearm splint was applied for 6 weeks thereafter. Intercarpal Kirschner wires were removed 8 weeks after surgery and then active wrist motion was started.

At our institute, implant removal surgery 8 to 12 months after ORIF was routinely recommended for all of the patients. Clinical data were extracted from records just before a patient's visit for implant removal in those

who had consented to and underwent that surgical procedure. For the remaining patients who declined implant removal, their clinical data were extracted from their records at final follow-up (range, 8-28 months). Patients were divided into 2 groups: a dorsal plate group and a volar plate group.

Patient outcomes were evaluated using both objective and subjective parameters. Objective parameters included a physical examination of wrist range of motion (ROM), grip strength compared with the contralateral healthy wrist, and radiographic evaluation. Radiographic criteria for acceptable healing were defined as a less than or equal to 10° dorsal tilt, less than or equal to 3-mm radial shortening, and less than or equal to 2-mm articular incongruity.⁹ Subjective parameters included a patient-reported score using the Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) questionnaire and the Gartland and Werley score.⁴ The QuickDASH questionnaire was completed by 104 of 112 patients, either while at our clinic or returned by mail after follow-up. Union of the fracture was defined as radiographic healing within 6 months. Finally, complications including infection, complex regional pain syndrome (CRPS), tenosynovitis or tendon rupture, compression neuropathy (carpal tunnel syndrome), unacceptable healing (>10° dorsal tilt, >3-mm radial shortening, and/or >2-mm articular incongruity), and stiffness were recorded. Carpal tunnel syndrome was determined via nerve conduction studies that showed a distal motor latency of the abductor pollicis brevis of more than 4.5 milliseconds. Stiffness was defined as out of functional ROM, which was less than 40° flexion, less than 40° extension, or/and a less than 40° arc of radial-ulnar deviation.¹⁸

Statistical analyses were performed using statistical software (StatMate 5; Atoms, Tokyo, Japan). Cross-tabulations were used to analyze patient characteristics and wrist and forearm injury characteristics. Categorical data were analyzed using the Fisher exact test. All other data were analyzed using the Student *t* test. Statistical significance was set at *P* < .05.

Results

Of 112 patients, 38 patients (mean age, 57.7 years; 24 women, 14 men) were treated with ORIF via a dorsal approach and 74 patients (mean age, 59.0 years; 47 women, 27 men) were treated with a volar approach (74 = Aptus 2.5 TriLock distal Radius Fracture Plates; volar, Basel, Switzerland). A volar approach was used at twice the frequency of the dorsal approach. In the dorsally plated group, supplemental bone grafts or substitutes were used in 9 of 38 (23.7%) wrists. In the volar plating group, supplemental bone grafts or substitutes were used in 6 of 68 (8.8%) wrists. Demographic data for both patient cohorts are shown in Table 1.

Table 1. Demographic Data for the Dorsal Plating and the Volar Plating Groups.

	Dorsal plate n = 38	Volar plate n = 74	<i>P</i> value ^a
Mean age, y	53.7 ± 12.7	59.0 ± 13.8	.055
Female/male, n (ratio)	24/14 (0.43)	40/28 (1.43)	.68
Follow-up, months	13.0 ± 5.5	12.6 ± 5.5	.67
Bone graft or bone substitute, n	9	4	.096*
External fixation, n	6	5	.16
Right/left hand dominance, n	11/27	27/47	.53

Note. Data values are means ± standard deviations unless otherwise indicated.

^a*P* values are for comparisons between dorsal plating and volar plating.

*Statistically significant.

Based on the rationale established by Lutsky for choosing dorsal plating, we treated 3 wrists (7.9%) with dorsal shear fractures (Matrix-SmartLock; Stryker Osteosynthesis = 2); 22 wrists (57.9%) with dorsal *die-punch* fractures, or fracture patterns in which an indirect reduction from the volar approach cannot be obtained (Synthes 2.4-mm Locking Compression Plate Distal Radius System; dorso-radial and dorsoulnar = 22); 2 wrists (5.3%) with fractures that had an associated scapholunate ligament injury (Aptus 2.5 TriLock distal Radius Plates; dorsal = 1; Synthes 2.4-mm Locking Compression Plate Distal Radius System; dorso-radial and dorsoulnar = 1); and 11 wrists (28.9%) with fracture patterns in which the volar margin was distal to the watershed line and with significant dorsal comminution requiring bone (substitute) grafting (Matrix-SmartLock; Stryker Osteosynthesis = 11). The most common fracture pattern for which dorsal plating was chosen was an irreducible dorsal *die-punch* fracture. In contrast, a dorsal shear fracture with an associated scapholunate ligament injury was rarely the reason for using dorsal plating due to the relatively infrequent occurrence of that pathology.

Clinical results for both patient cohorts were compared and are shown in Table 2. The dorsal plated group demonstrated significantly less ROM in flexion than the volar plated group. There were no statistically significant differences in the subjective parameters that were assessed, which included the QuickDASH (9.7 vs 9.4, respectively) and the Gartland and Werley scores (2.7 vs 2.1).

The complications that occurred in both patient cohorts are compared in Table 3. There were no instances of non-union, infection, and/or CRPS. There were no statistically significant differences between groups in the overall complication rate.

Unacceptable healing was observed in 5 wrists in the volar plated group. Among them, an unacceptable healing

Table 2. Range of Motion and Outcome Data for Dorsal Plate and Volar Plate Groups.

	Dorsal plate n = 38	Volar plate n = 74	P value ^a
Extension	54.2° ± 14.9	58.1° ± 18.1	.26
Flexion	48.3° ± 11.3	57.0° ± 14.7	.002*
Supination	81.7° ± 7.0	75.9° ± 15.0	.20
Pronation	80.4° ± 7.2	79.1° ± 11.5	.25
Radial-ulnar deviation arc	43.7° ± 6.5	45.1° ± 9.6	.43
Grip strength (% of contralateral side)	61.7% ± 20.3	63.6% ± 18.8	.63
QuickDASH score	9.7 ± 6.3	9.4 ± 8.9	.85
Gartland and Werley score	2.7 ± 2.3	2.1 ± 1.6	.86

Note. Data are means ± standard deviation unless otherwise shown.

QuickDASH = Quick Disabilities of the Arm, Shoulder, and Hand.

^aP values are for comparisons between dorsal plating and volar plating.

*Statistically significant.

outcome in 5 of the 6 wrists was due to a more than 3-mm radial shortening compared with the contralateral wrist, and in the remaining wrist it was due to a more than 10° dorsal tilt.

In the dorsal plated group, 30 patients underwent implant removal surgery. Of these, no patients required hardware removal due to complications such as extensor tendon irritation or rupture. Intraoperatively, there was no evidence of tenosynovitis or tendon damage. One patient experienced pain and paresthesia in the distribution of the superficial sensory branch of the radial nerve due to radial nerve neuropathy; neurolysis was performed with hardware removal. Although the remaining 8 patients did not undergo hardware removal, no patient experienced postsurgical-related symptoms and/or complications such as extensor tendon irritation or rupture, for example.

In the volar plated group, 59 patients underwent implant removal surgery. Eight patients presented with median nerve neuropathy. Four patients were treated with corticosteroid injections. The remaining 4 patients required open carpal tunnel release concomitant with hardware removal. One patient had a flexor pollicis longus (FPL) tendon rupture and was treated with free tendon grafting concomitant with hardware removal. Partial tendon wearing was observed in 3 FPL tendons and one flexor digitorum profundus II tendon (Figure 3). Lateral radiographs represented grade 1 of the Soong classification in those 5 patients.²⁰

Hardware failure was observed in 4 of the volar plated wrists as a result of distal screw loosening. However, there were no instances of plate or screw breakage.

Discussion

The volar approach was initially believed to decrease the risk of tendon rupture, but there have been multiple reports of both flexor and extensor tendon irritation and rupture.^{1,2,7,12,13,16} In the present series, complications were proportionally, but not significantly, higher overall in the volar plated group (7.9% vs 17.6%). Of the complications, one was a serious FPL rupture. Our results are in discord with a retrospective study on complications of low-profile dorsal and volar locked plating, in which no major differences in tendon irritation or rupture for either of the techniques were identified, and in which a higher rate of neuropathic complications occurred using the volar approach.²³

There are 2 main types of dorsally placed interlocking plate systems, one is a buttress type plate and the other is a column plate. The main goal of buttress type plates is, in certain cases, to oppose dorsal displacement with the possibility of an *on the plate* reduction. The buttressing effect of the plate, if necessary, is augmented with locking screws in the distal fragments. Column plates are based on the 3-column theory of Rikli and Regazzoni.¹⁴ The 2 cortical bone columns of the radius injured by fractures must be reconstructed with one or several plates that may be more or less anatomic, and must be adapted to each of these columns. Those 2 instruments should be complementary, because preventing recurrent displacement and restoring the anatomy are 2 complementary goals. Therefore, we applied buttress type plates based on the following pathologies: (1) dorsal shear fractures and (4) fracture patterns in which the volar margin is distal to the watershed line with significant dorsal comminution requiring bone (substitute) grafting (Figures 4 and 5). Dual column plates were applied for (2) irreducible dorsal *die-punch* fractures with closed manipulation (Figures 6 and 7).

Although different systems were used, unacceptable healing was not observed in the dorsal plating group. This fact might validate the adequacy of our indication for dorsal plating. On the contrary, unacceptable healing was observed in 5 wrists in the volar plated group. Among them, 4 of the 5 were due to more than 3-mm radial shortening compared with the contralateral wrist and the remaining one was due to a more than 10° dorsal tilt. The reason for unsatisfactory healing may relate to less use of bone grafts or bone substitutes in the volar plated group (used in 4 of 74 wrists) than in the dorsal plated group (9 of 38 wrists). This approach may have prevented radial shortening in the dorsal plated group. A recent literature review concluded that grafting may improve radiographic alignment and/or short-term outcome, but no overall influence on the final result was observed.²²

Table 3. Complications of Wrist Plate Fixation in the Dorsal Plating and Volar Plating Groups.

	No. of wrists (%)		P value ^a	Odds ratio (95% CI)
	Dorsal plate n = 38	Volar plate n = 74		
Tendon rupture, flexor pollicis longus	0	1 (1.4%)	1.00	0.64 (0.03-1.6)
Tenosynovitis, partial tendon wearing	0	4 (5.4%)	.30	0.20 (0.01-3.93)
Neuropathy	1 (2.6%)	8 (11%)	.12	0.22 (0.03-1.8)
Hardware failure, distal screw loosening	0	5 (6.8%)	.16	0.16 (0.01-3.0)
Unacceptable healing	1 (2.6%)	5 (6.8%)	.66	0.37 (0.04-3.3)
Stiffness	3 (7.9%)	6 (8.1%)	1.0	0.97 (0.2-4.1)
Total complications	3 (7.9%)	13 (17.6%)	.25	0.4 (0.1-1.5)

Note. CI = confidence interval.

^aP values are for comparisons between dorsal plating and volar plating.

Figure 3. The case of a 69-year-old woman.

Note. The patient had implant removal surgery 10 months after open reduction and internal fixation for a distal radius fracture with volar plating (Aptus 2.5 TriLock Distal Radius Plates; volar). Intraoperative tendon damage was sustained by the flexor pollicis longus.

In the present series, flexion was significantly more limited in the dorsal plated group than in the volar plated group. Our results are compatible with previously reported studies comparing volar and dorsal plating.^{3,17} This finding may be the result of dorsal capsular contracture and/or adhesion of extensor tendons.

The present study had several limitations related to the nature of a nonblinded and nonrandomized study. First, the dorsally plated group consisted of a relatively small number of patients. This fact may reflect that the indication for dorsal plating is less frequently applicable than that for volar plating. Second, both groups were not matched in terms of receiving supplemental bone grafts. Although a prospective randomized controlled trial would seem to be ideal to compare the outcome of volar versus dorsal locking plating for the treatment of distal radius fractures, a certain number of

Figure 4. Posteroanterior and lateral radiographs of a 67-year-old female who sustained a fracture with secondary displacement and significant dorsal comminution in which a volar fracture margin was more distal to the watershed line.

fractures could not be appropriately stabilized using either a volar or a dorsal approach using such a study design. In contrast, our study is the first series to compare the outcome of volar versus dorsal interlocking plating for the treatment of distal radius fractures under the strict surgical indications in practice.

Our results revealed that the treatment of displaced intra-articular distal radius fractures with a dorsally placed interlocking plate system demonstrated similar objective and subjective clinical results, except for the loss of wrist flexion. Furthermore, the overall complication rate was not significantly higher in the dorsally placed interlocking plate group than in the volarly placed interlocking plate group.

Figure 5. Immediate postoperative, posteroanterior, and lateral radiographs of the same patient after internal fixation with a dorsal plate osteosynthesis (Matrix-SmartLock) and a radiocarpal external fixator: An iliac bone graft was applied into the resulting defect.

Figure 6. Posteroanterior and lateral radiographs of a 46-year-old male who sustained dorsal die-punch fractures.

Figure 7. Immediate postoperative, posteroanterior, and lateral radiographs of the same patient after internal fixation with column plates (Synthes 2.4-mm Locking Compression Plate Distal Radius System; dorsoradial and dorsoulnar).

Certain fracture patterns are more appropriately stabilized with dorsal plate fixation, but the indication is less frequently applicable than that for volar plate fixation.

Authors' Note

The authors alone are responsible for the content and writing of the article.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent

Informed consent was obtained from all individual participants included in the study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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