Volar Collapse After Dorsal Plating of Comminuted Distal Radius Fractures

Gamal A. Elsaidi, DO, Nicole Deal, MD, Beth P. Smith, PhD, and David S. Ruch, MD

Abstract

Between 1997 and 2001, 58 patients received dorsal plating for comminuted distal radius fractures. In 8 of these patients, subsequent collapse led to palmar flexion deformity, loss of rotation, and hardware prominence. In retrospectively reviewing this subgroup's range of motion, radiographic volar tilt, and complications, including tenosynovitis and extensor tendon rupture, we found that (1) with both palmar and dorsal comminution of distal radius fractures, dorsal plating may not prevent palmar cortex collapse; (2) deformity of the distal radius fragment causes palmar displacement of the radius relative to the intact ulna; (3) resultant incongruity at the distal radioulnar joint causes a significant loss of supination; and (4) palmar distal radius displacement leads to dorsal hardware prominence and may contribute to tenosynovitis and attritional extensor tendon ruptures.

Care for comminuted fractures of the distal radius has undergone a tremendous shift over the past 30 years. Results from epidemiologic studies indicate a higher incidence of distal radius fractures secondary to higher-energy mechanisms of injury in young adults.[1-3] The possible consequences of high-energy articular injuries—prolonged immobilization, restricted function, and subsequent early degenerative changes—have led surgeons to take a more aggressive approach in treating these injuries. Coincident with this approach is a dramatic increase in our understanding of the complexity of the osseous and ligamentous anatomy of the radiocarpal and the radioulnar joints.[4,5] The resulting trend has been to use open reduction and internal fixation (ORIF) to try to improve the accuracy of anatomy restoration and to reduce the early and late sequelae of these fractures.[1,6-11] Although reports of series of patients treated with dorsal plating have been numerous, there have also been sporadic reports of tenosynovitis and tendon rupture caused by the pressure of the plates on the dorsum of the wrist.

Dr. Elsaidi and Dr. Deal are Residents, and Dr. Smith and Dr. Ruch are Associate Professors, Department of Orthopaedic Surgery, Wake Forest University School of Medicine, Winston-Salem, North Carolina.

Requests for reprints: Gamal A. Elsaidi, DO, Department of Orthopaedic Surgery, Wake Forest University School of Medicine, Medical Center Boulevard, Winston-Salem, NC 27157 (tel, 336-716-3949; fax, 336-716-7310; e-mail, gelsaidi@wfubmc.edu).

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Between 1997 and 2001, 58 patients with comminuted distal radius fractures underwent ORIF and received a dorsal plate (Synthes USA, Paoli, Pa; Wright Medical, Arlington, Tenn). (Dr. Ruch was the surgeon in all cases.) Eight of these patients subsequently experienced palmar collapse of the distal fragment. The collapse deformity resulted in a clinical spectrum of loss of supination, dorsal hardware prominence, and tenosynovitis with attritional tendon rupture.

We also performed a biomechanical correlation study with cadaveric specimens. Our goals were to compare findings from the clinical study with those from the biomechanical study, to identify factors associated with the complication of palmar collapse of the distal fragment, and to elucidate the effect of distal radius volar and dorsal cortical collapse on forearm rotation.

Materials and Methods

Clinical

Between 1997 and 2001, 192 patients underwent operative treatment for unstable, comminuted fractures of the distal radius. Ninety-eight of these patients underwent ORIF and received a dorsal plate. Patients with incomplete data at different time points were excluded from the study, as were patients with ipsilateral extremity fractures, ipsilateral nerve injuries, or ipsilateral vascular injuries (given the confounding effect of these additional injuries). Fifty-eight patients were left in the study.

Of the 98 patients who underwent ORIF and received a dorsal plate, 19 were female, 79 male. Eighty fractures were AO (Arbeitsgemeinschaft für Osteosynthesefragen) type C2 or C3, and 18 were type A3. At initial diagnosis, all 98 fractures were treated with closed reduction and splinting. Within the next 10 days, the majority (68) were treated operatively for articular incongruity; the other 30 received delayed treatment (up to 6 weeks) for residual displacement or collapse after casting. Of the 58 patients included in the study, 49 (84.5%) had AO type C2 or C3 fractures, and 9 (15.5%) had type A3. At follow-up, 8 of these 58 patients were found to have volar collapse.

The operative approach used was a dorsal incision immediately ulnar to the Lister tubercle. The dorsal retinaculum was opened with a Z-incision, and the proximal 75% of the retinaculum was elevated from the second to the fifth dorsal compartment. The extensor pollicis longus was unroofed and the tendon retracted radially. The contents of the fourth compartment were retracted with the retinaculum ulnarly. The fracture was provisionally

stabilized with a single pin-bar external fixator extending from the long-finger metacarpal to the junction of the middle and distal thirds of the radius. For intra-articular fractures, an oblique arthrotomy was performed in line with the dorsal radiocarpal ligaments to assess reduction. For all patients, the metaphyseal fragment was elevated, and adjunctive cancellous allograft or iliac crest autograft was packed into the defect. Provisional reduction of the articular surface was obtained and maintained with Kirschner wires. The plate was then contoured, and any residual noncritical segments were cut and beveled. The articular surface was then stabilized with small (2.4-mm) screws; the proximal segment was fixed with 2.7-mm screws. Screw length was confirmed fluoroscopically. The retinaculum was brought back over the plate and approximated under the tendons using 2.0 Vicryl® suture. Radiographs were obtained postoperatively in the operating room.

After obtaining Institutional Review Board approval, we reviewed all patients' data, which included findings from physical examinations, plain radiographs, and clinical assessments as well as Disabilities of the Arm, Shoulder, and Hand (DASH) scale scores. Data were from the 3-month, 6-month, 1-year, and 2-year follow-ups. We present the data from the 2-year follow-up.

The DASH scale is used to rate disabilities/symptoms/ability to perform normal daily activities. Thirty items are rated on a 5-point scale ranging from *no difficulty* to *unable;* responses are added and then subtracted by 30; and the resulting value is divided by 1.2 for a final score on a 0-to-100 scale. Higher scores indicate more disability and symptoms that are more severe.

Biomechanical

A transverse osteotomy was performed at the Lister tubercle in 4 cadaveric specimens with intact hand, wrist, and elbow joints. An external fixator was used to control the degree of volar and dorsal tilt of the fracture fragment. Supination and pronation were tested for normal wrist; normal wrist with external fixator; osteotomy with external fixator (no tilt); osteotomy with external fixator with dorsal tilt (20°, 30°, 40°); and osteotomy with external fixator with volar tilt (20°, 30°, 40°).

Means and standard deviations were calculated. Statistical analysis was performed with the Tukey standard *T* test, and *P*s were calculated.

Results

Clinical

All Patients. At 2-year follow-up, the radiocarpal articular incongruity was less than 1 mm in 40 patients, 2 to 3 mm in 10 patients, and 4 mm or more in 8 patients. As measured on postoperative films at 2-year follow-up, radial shortening was less than 2 mm in 45 patients, 3 to 4 mm in 3 patients, and more than 4 mm in 10 patients. Palmar tilt was 10° to 12° in 20 patients, 12° to 15° in 25 patients, 15° to 18° in 3 patients, and more than 20° in 10 patients. Eighteen patients had radiocarpal narrowing with sclerosis at 2-year follow-up; the other 40 patients had no radiographic evidence of arthrosis. Mean total arc of wrist motion after dorsal plate fixation at 2-year follow-up was as follows: 78° extension, 75° flexion, 72° supination, and 90° pronation. Mean grip strength was only 78% that of the contralateral hand, even at 2-year follow-up. Mean DASH score at 2 years was 12.

Patients With Volar Collapse. For these 8 patients, the radiocarpal articular incongruity averaged 4 mm at 2-year follow-up. Radial shortening measured against postoperative radiographs averaged 4 mm. Mean radiographic volar tilt was 20°. Mean total arc of wrist motion after collapse at 2-year follow-up was as follows: 68° extension (range, 35°–90°), 62° flexion (range, 40°–85°), 57° supination (range, 40°–85°), and 90° pronation (all 8 patients had 90° pronation) (Table I). Mean DASH score at 2 years was 14.

Patients With Tenosynovitis and Tendon Rupture. These 10 patients (all 8 patients with volar collapse plus 2 other patients) presented at follow-up with increased swelling and pain despite fracture union. Two of these patients lacked index-finger extension, and 2 lacked thumb extension; the other 6 had a weak grip but no loss of finger or thumb motion. All 10 patients underwent hardware removal and tenosynovectomy. Ruptured thumb and digital extensors were treated with transfer (n = 2) or side-to-side tenorrhaphy (n = 2).

Table I. Volar Collapse After Dorsal Plating (N = 8 Patients)

Patient No.	DASH Score*	Degree				
		Volar Tilt	Supination	Pronation	Flexion	Extension
1	29.17	25	45	90	65	90
2	1.67	25	60	90	60	70
3	19.17	30	40	90	45	65
4	35	15	50	90	70	80
5	4.17	10	65	90	80	85
6	0.83	18	85	90	50	75
7	0.00	10	55	90	85	35
8	20.83	30	60	90	40	45
Mean	**13.85**	**20**	**57**	**90**	**62**	**68**
SD	**13.95**	**8.26**	**13.89**	**0.00**	**16.24**	**19.26**

*Score on Disabilities of the Arm, Shoulder, and Hand (DASH) scale.

Biomechanical

Mean supination was significantly (P = .0104) decreased in palmarly tilted (20°– 40°) versus dorsally tilted (20°– 40°) fragments (80% and 100% of prefracture tilt, respectively). Neither volar nor dorsal displacement affected pronation (Table II).

Discussion

Distal radius fractures are among the most common fractures encountered in clinical practice. Complications that arise from distal radius fractures and their treatment are numerous. Compressive neuropathy, postfracture arthrosis, malunion, tendon rupture, pin loosening, pin-tract infection, Volkman ischemic contracture, shoulder–hand syndrome, and stiff hands were among the complications (of the fracture or its treatment) reported by Cooney and colleagues[12] in their study of 565 patients with distal radius fractures. It is generally accepted that anatomic restoration results in improved functional result. In 1814, Abraham Colles reported that loss of integrity of the distal radioulnar joint is the cause of instability and poor results after distal radius fractures. The literature indicates that changes in the normal volar tilt of the distal radius result in midcarpal changes and disturbances in radiocarpal function and that abnormal radial inclination and length interfere with the function of the distal radioulnar joint and cause painful or limited forearm rotation.[13] The literature also indicates that residual dorsal tilt creates a distal radioulnar joint incongruity, which in turn limits supination and tightens the interosseous membrane.[14] In their biomechanical study, Short and colleagues[15] concluded that distal radius fractures that lead to loss of normal palmar tilt place a progressive load on the ulnocarpal and radioscaphoid articulations. Radial collapse after distal radius fractures has been well documented.[12,16-20] Altissimi and colleagues[20] identified severity of initial radial shortening as the most reliable indicator of instability, as it was directly related to frequency of redisplacement and amount of final shortening. Several investigators[21-24] have documented that, despite external fixation, a significant number of patients experienced some degree of radial shortening. Aro and Koivunen[25] reported that even minor modification of the precise anatomic relations between the distal radius and the ulna led to significant load-pattern changes. Results from anatomic and clinical studies have indicated that radial collapse results in load-pattern changes that have a deleterious effect on joint congruity and functional outcome.[13-15,25-27] In a study of 90 patients with Colles fracture, Villar and colleagues[16] reported that persistent dorsal tilt after 1 week was associated with late loss of flexion and supination. In a study of 2000 cases of Colles fracture, Bacorn and Kurtzke[19] found a direct correlation between residual deformity and disability, decreased wrist flexion in 94.5% of patients, and limitation in forearm rotation in one third of patients.

Use of ORIF to prevent dorsal angulation and radial shortening after distal radius fractures, particularly in younger patients, has been the subject of increasing attention.[1,4,7-10] As reported, results with ORIF have been good or excellent in 82% to 92% of cases.[4,7-11,28] Results from several other studies have shown that this technique may result in tenosynovitis and even tendon rupture.[28] Although several authors have reported tendon rupture, no one knows if this complication is the result of plate design, location, metallurgy, or an unknown factor. Cooney and colleagues[12] stated that tendon rupture was primarily related to bone fragments from displaced fractures that abraded the tendon after fracture healing.

The patients in our study underwent operative management involving standard techniques for the dorsal approach, including a z-plasty of the retinaculum with subperiosteal dissection of the dorsal compartments and coverage of the plate with either the floor of the dorsal compartments or the proximal slip of the retinaculum. In addition, for the 10 patients with tenosynovitis or tendon rupture, plates from 2 different manufacturers (Synthes USA, Wright Medical) were used. Seven plates were titanium, and 3 were stainless steel. Our results are consistent with other tenosynovitis findings. In our study, 8 (14%) of 58 patients who received dorsal plating for comminuted distal radius fractures experienced subsequent volar collapse. At 2-year follow-up, these 8 patients had a marked decrease in mean total arc of motion (wrist flexion, wrist extension, forearm supination); pronation did not change. Ten (17%) of the 58 patients showed evidence of tenosynovitis or extensor tendon rupture.

Table II. Biomechanical Study Data

Fracture Displacement	Mean (% of Prefracture)	
	Supination	Pronation
Volar tilt		
20°	83	100
30°	80	100
40°	78	100
Dorsal tilt		
20°	98	99
30°	98	99
40°	97	99

Conclusions

Our combined clinical and biomechanical study data indicate that (1) with both palmar and dorsal comminution of distal radius fractures, dorsal plating may not prevent palmar cortex collapse; (2) deformity of the distal radius fragment causes palmar displacement of the radius relative to the intact ulna; (3) resultant incongruity at the distal radioulnar joint causes a significant loss of supination; and (4) palmar distal radius displacement leads to dorsal hardware prominence and may contribute to tenosynovitis and attritional extensor tendon ruptures.

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This paper will be judged for the Resident Writer's Award.