Retrospective Comparison of Percutaneous Fixation and Volar Internal Fixation of Distal Radius Fractures

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Abstract A change in the practice of a single surgeon provided an opportunity for retrospective comparison of comparable cohorts treated with percutaneous fixation (17 patients) or a volar plate and screws (23 patients) an average of 30 months after surgery. The final evaluation was performed according to the Gartland and Werley and Mayo rating systems and the DASH questionnaire. There were no significant differences on the average scores for the percutaneous and volar plating groups, respectively: Gartland and Werley, 4 vs 5; Mayo, 82 vs 83; and DASH score 13 for both cohorts. Motion, grip, and radiographical parameters were likewise comparable. Volar internal plate and screw fixation can achieve results comparable to percutaneous fixation techniques in the treatment of fractures of the distal radius.

Keywords Distal radius fracture · Percutaneous pinning · External fixation · Open reduction and internal fixation · Plate and screws

Introduction

Dorsal internal fixation was advocated for the treatment of fractures of the distal radius on the basis that internal fixation of a periarticular fracture would allow early mobilization leading to improved results. [4, 25] Unfortunately, dorsal internal fixation has been slightly inferior to percutaneous fixation methods in prospective randomized

comparisons. [11, 24] In addition, dorsal plates have been associated with tendon irritation, tendon rupture, and other problems. [6, 32–35]

It has been suggested that volar internal fixation (which has become more appealing with the advent of plates with fixed-angle screws) has several advantages over dorsal internal fixation including more space between the bone and the tendons resulting in less tendon irritation and relatively straightforward reduction of the relatively stout volar cortex. Data from non-comparative retrospective cohorts [6, 32, 34, 35] and retrospective cohort comparisons [53] have supported the contention that volar internal fixation may achieve results equivalent to percutaneous treatment methods with relatively few complications related to the exposure or internal fixation device. This paper contributes data from another retrospective cohort comparison to further address these issues.

Materials and Methods

One surgeon changed practice from percutaneous fixation techniques to volar plate and screw fixation of distal radius fractures without changing practice setting, indications, or any other aspect of treatment. Percutaneous fixation was defined as stabilization of the fracture with two or three smooth Kirschner wires, with the wires protected (or neutralized) with either an external fixator, percutaneously injected calcium phosphate bone cement, or a cast. Inclusion criteria included (1) unstable dorsally displaced and angulated fractures and (2) articular fracture limited to no more than a simple sagittal split between the scaphoid and lunate facets based upon interpretation of standard radiographs. Exclusion criteria included (1) open fractures, (2) complex articular fractures (coronal fracture lines,

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central articular impaction, shearing fractures, and any kind of fragmentation), (3) associated carpal fracture or ligament injury, and (4) neurovascular injury. An unstable dorsally displaced fracture was defined as a fracture with 10° or greater dorsal angulation on radiographs obtained at the first office visit after closed manipulative reduction and splint immobilization in the emergency room.

A protocol for clinical and radiographic evaluation of these patients was approved by our Human Research Committee. Between 1999 and 2001, 33 patients satisfying the inclusion criteria were treated with percutaneous fixation techniques. Nine patients opted out of the study and seven could not be located, leaving a total of 17 patients (52%) for evaluation (Table 1). Between 2001 and 2003, 37 patients satisfying the inclusion criteria were treated with a volar plate and screws. Seven patients opted out and seven could not be contacted, leaving a total of twenty-three patients (62%) for evaluation (Table 2).

Percutaneous Fixation Cohort

The percutaneous fixation cohort consisted of 10 women and 7 men with an average age of 55 years (range, 27 to 77 years). The right wrist was fractured in eight patients (five dominant) and the left wrist was fractured in eight (six dominant). Three patients were retired and fourteen worked at desk-based work. Nine patients were injured in a fall from a standing height, one in a fall from a greater height, and seven in a fall during sports.

One patient had multiple traumatic injuries, and one had an ipsilateral humerus fracture. According to the classification of Fernandez, [22] there were 5 type 1 and 12 type 3 fractures. According to the comprehensive classification of fractures, there were 3 A.2.2 fractures, 2 A.3.2, 4 C 1.2, 7 C.2.1, and one C.2.3 type.

The variations in treatment in the percutaneous fixation cohort reflect the lack of a prospective protocol. During the study period, the surgeon occasionally used bone cement or cast immobilization rather than bridging external fixation to support (or neutralize) the Kirschner wires placed across the fracture, and occasionally used a non-bridging external fixator. These techniques are all variations of percutaneous fixation—similar to one another and distinct from open reduction and internal fixation with a volar plate. There were too few patients with bone cement, casting, or non-bridging external fixation to do sub-group analyses.

Fourteen patients in the percutaneous treatment cohort had closed reduction and stabilization of the fracture with percutaneously inserted smooth 0.062-in Kirschner wires using the Clancy technique or a modification thereof. Eleven of these patients had additional stabilization with an external fixator that crossed the wrist joint (Synthes,

Table 1 Seventeen patients treated with percutaneous fixation techniques.

Case	Gender	Age	Limb (Dominant)	Time of Follow-up (months)	Mayo Wrist Score	Mayo Categorical	Gartland and Wreley Score	Gartland and Wreley Categorical	DASH	Grip Strength	Percent Grip Strength	Post-operative Ulnar Inclination	Post-operative Volar Tilt	Post-operative Ulnar Variance
1	M	27	R	33	100	Excellent	1	Excellent	0	105	100%	22	11	1
2	F	58	R	46	95	Excellent	5	Good	4	18	109%	22	14	0
3	F	63	(L)	19	95	Excellent	2	Excellent	1	26	112.50%	17	15	0
4	F	63	(R)	24	95	Excellent	7	Good	13	52	100%	19	15	2
5	M	77	(R)	14	95	Excellent	2	Excellent	0	65	100%	20	11	0
6	F	70	L	57	85	Good	2	Excellent	30	27	89%	14	11	2
7	F	60	(L)	41	85	Good	2	Excellent	3	15	83%	23	7	1
8	M	46	(R)	54	85	Good	6	Good	20	118	90%	21	11	0
9	M	46	L	18	85	Good	3	Good	0	50	96%	23	11	2
10	F	52	(L)	54	85	Good	7	Good	14	84	75%	21	5	2
11	F	64	R	54	85	Good	7	Good	9	53	125%	23	2	4
12	F	39	(R)	49	80	Good	6	Good	12	25	83%	30	9	1
13	M	59	(L)	44	80	Good	2	Excellent	1	35	87%	28	7	5
14	F	46	(L)	24	75	Fair	8	Good	32	27	91%	19	15	-2
15	M	54	(L)	24	75	Fair	1	Excellent	0	20	82%	19	8	0
16	F	53	R	48	70	Fair	8	Good	16	18	82%	21	8	0
17	M	57	(R)	22	15	Poor	14	Fair	80	24	22%	19	-15	-1

Table 2 Twenty-three patients treated with volar plate fixation.

Case	Gender	Age	Limb (dominant)	Time of Follow-up (months)	Mayo Wrist Score	Mayo Categorical	Gartland and Wereley Score	Gartland and Wereley Categorical	DASH	Grip Strength	Percent Grip Strength	Post-operative Ulnar Inclination	Post-operative Volar Tilt	Post-operative Ulnar Variance
1	F	46	L	22	95	Excellent	1	Excellent	0	60	96%	18	17	4
2	M	29	(R)	24	95	Excellent	4	Good	2	105	100%	14	2	2
3	F	61	(R)	30	90	Excellent	2	Excellent	0	65	100%	21	14	4
4	F	54	L	22	90	Excellent	3	Good	14	44	113%	18	11	-1
5	F	40	(R)	19	90	Excellent	1	Excellent	0	18	83%	21	13	2
6	M	58	(R)	24	90	Excellent	5	Good	18	120	100%	28	19	1
7	M	44	(L)	27	90	Excellent	3	Good	3	55	81%	13	-10	1
8	F	59	(R)	26	90	Excellent	1	Excellent	1	65	100%	19	5	-2
9	M	38	(R)	18	85	Good	2	Excellent	0	55	90%	20	12	1
10	F	59	L	22	85	Good	5	Good	28	38	79%	23	11	-1
11	F	23	(R)	23	85	Good	0	Excellent	35	75	100%	20	-7	0
12	F	54	L	24	85	Good	1	Excellent	4	80	75%	12	8	0
13	F	41	L	28	85	Good	1	Excellent	0	42	90%	18	3	0
14	F	48	L	24	85	Good	5	Good	3	38	84%	20	13	3
15	F	65	L	22	80	Good	3	Good	13	60	92%	38	9	0
16	M	46	L	30	80	Good	5	Good	6	75	86%	19	19	1
17	F	77	(R)	24	75	Fair	8	Good	89	18	83%	21	11	0
18	F	48	(R)	14	75	Fair	5	Good	14	40	75%	14	8	0
19	F	55	R	15	75	Fair	4	Good	8	55	82%	13	13	1
20	M	77	(R)	45	70	Fair	10	Fair	7	32	107%	10	-8	3
21	F	50	(L)	16	70	Fair	6	Good	10	35	54%	20	13	3
22	M	45	L	22	70	Fair	10	Fair	37	63	100%	13	5	3
23	F	63	(R)	25	60	Poor	6	Good	2	25	80%	20	8	2

Paoli, PA), and three were immobilized in a short arm cast—two of whom had ancillary treatment with Norian bone cement (Synthes). In three patients, two percutaneous Schantz screws (large tip-threaded Kirschner wires) in the distal fracture fragment were incorporated into a small external fixator—creating a so-called non-bridging external fixator, meaning that the distal fracture fragments were stabilized with Schantz screws incorporated into the external fixator (Synthes). All superficial implants and casts were discontinued between 6 and 8 weeks after the index surgery. External fixators were removed in the office.

One patient had a severe pin track infection requiring pin removal. One patient had loosening of the fixator requiring removal 1 week earlier than initially planned. One patient had radial sensory nerve dysfunction that completely recovered. One patient had pain and restriction of motion treated with a Sauvé-Kapandji procedure. One patient had ulnar sided wrist pain and some instability of the distal radioulnar joint and had a second surgery for repair of the triangular fibrocartilage complex.

Volar Plate Cohort

The volar plate fixation cohort consisted of 16 women and 7 men with an average age of 51 years (range 23 to 77 years). The right wrist was fractured in 12 patients (11 dominant), and 11 fractured the left (2 dominant). Seventeen patients did desk-based work, three were laborers, and three were homemakers. Three patients had multiple traumatic injuries. One patient had an ipsilateral fracture of the ulnar diaphysis.

According to the classification of Fernandez, 6 patients had type 1 fractures and 17 type 3 fractures. According to the comprehensive classification of fractures, 5 patients had A.2.2 fractures, 2 A.3.2, 3 C.1.2, 13 C.2.1 fractures.

Volar internal fixation was performed through Henry's exposure at the wrist. [19] Nineteen patients were treated with the volar T-shaped plate that is included with the pi-plate (Synthes), two patients with DVR plates (Hand Innovations, Miami, FL), and one patient each with a 3.5- and 2.4-mm locking plate (Synthes).

The wrist was supported in a volar splint for 2 to 6 weeks after surgery depending on comfort level. Active forearm and digit motion was initiated and encouraged immediately. Active wrist motion was initiated once full or near full forearm and digit motion was achieved and the patient was sufficiently comfortable. Use of the arm for light functional activities was encouraged. Strengthening and resistance exercises were delayed until healing was apparent on radiographs—at least 6 weeks.

Three patients with flexor tendon irritation requested plate removal an average of 10 months after the index procedure. The plates included one volar T-shaped plate

from the Pi-plate set, one 3.5-mm locking compression plate, and one 2.4 mm distal radius locking compression plate (All Synthes). In each case, the tendon irritation was related to implant prominence, something that is much less common with newer plate designs. One patient was reoperated to remove a loose screw.

Evaluation

The final evaluation was performed by a single examiner not involved in the patient's care an average of 30 months (Range, 14 to 57 months) after the index surgery. The average follow-up was 37 months (14 to 57 months) in the percutaneous fixation cohort and 23 months (Range, 14 to 45 months) in the volar plating cohort.

The final evaluation was performed according to the Modified Garland and Werley score [45] and the Modified Mayo Wrist Score [8]. Grip strength of the injured and opposite arms were measured as the average of three attempts using a Jamar dynamometer (Asimov Engineering, Los Angeles, California) set at the third station with the elbow at 90° of flexion and the wrist and forearm in neutral. Patients also completed the Disabilities of the Arm, Shoulder, and Hand questionnaire (DASH). [21] Postero-anterior and lateral radiographs of the wrist were obtained.

Comparisons of dichotomous variables were performed with Fisher's Exact Test. Comparisons of continuous variables were performed with Student's *t* test (SPSS; Chicago, IL).

Results

There were no statistically significant differences between the two cohorts for any clinical or radiographic parameters. (Tables 3 and 4)

Percutaneous Fixation Cohort

The Modified Gartland and Werley Score averaged 5 points (range, 1 to 14 points) with 7 excellent, 10 good, and 1 fair result. The Modified Mayo Wrist Score averaged 82 points (range, 15 to 100 points), with 5 excellent, 8 good, 3 fair and 1 poor result. The average DASH score was 13 points (range, 0 to 80 points).

Volar Plate Cohort

The Modified Gartland and Werley Score averaged 4 points (range, 0 to 10 points) with 8 excellent, 13 good, and 2 fair results. The Modified Mayo Wrist Score averaged 83 points (range, 60 to 95 points), with 8 excellent, 8 good, 6 fair and

Table 3 Statistical comparison of the characteristics of the two cohorts.

Characteristics	Open Reduction and Internal Fixation Group, Volar Plate Group	Close Reduction and Percutaneous Fixation Group, Percutaneous Fixation Group	Significance, <i>p</i> value	Significance
Gender				
Males	7	7	0.52 (Fischer's Test)	No significant Difference
Females	16	10		
Age				
Mean	51 years	55 years	0.37 (T test)	No significant Difference
Range	23–77 years	27–77 years		
Occupation			0.74 (Chi Square)	
White collar	17	14	No significant Difference	No significant Difference
Laborers	3	0		
Retired	0	3		
Homemaker	3	0		
Hand dominance				
Right handed	21	8	0.03 (Fischer's Test)	Significant Difference ^a
Left handed	2	9		
Involved hand				
Right	12	9	1 (Fischer's Test)	No significant Difference
Left	11	8		
Dominant hands affected	13	11		
Mechanism of injury			0.46 (Chi Square)	
Sports related	5	7	No significant Difference	No significant Difference
Standing height fall	12	9		
Fall from a greater height	2	1		
MVC	3	0		
Assault	1	0		
Classification of injuries				
Fernandez system			0.74 (Chi Square)	
1	6	5	No significant Difference	No significant Difference
2	(–)	(–)		
3	17	12		
4	(–)	(–)		
5	(–)	(–)		
AO classification				
A.2.1.	(–)	(–)	0.46 (Chi Square)	
A.2.2.	5	3		
A.2.3.	(–)	(–)		
A.3.1.	(–)	(–)		
A.3.2.	2	2		
A.3.3.	(–)	(–)	No significant Difference	No significant Difference
C.1.1.	1	4		
C.1.2.	1	(–)		
C.1.3.	1	(–)		
C.2.1.	9	5		
C.2.2.	1	2		
C.2.3.	(–)	1		
C.3.1.	3	(–)		
C.3.2.	(–)	(–)		
C.3.3.	(–)	(–)		

^a Higher proportion of Right Handed patients in the volar plate group.

Table 4 Statistical comparison of the results in the two cohorts.

Outcomes	Open Reduction and Internal Fixation Group, Volar Plate Group	Close Reduction and Percutaneous Fixation Group, Percutaneous Fixation Group	<i>t</i> test, <i>p</i> value	Significance	95%, Confidence Interval
Follow up time					
Mean	23 Months	37 Months	<0.05	Significant	0.01–010
Range	14–45 Months	14–57 Months		Difference ^a	
Gartland and Werley					
Mean	4 pts	5 pts	0.36	No significant	0.26–0.36
Range	0–10 pts	1–14 pts		Difference	
Modified Mayo wrist score					
Mean	83 pts	82 pts	0.84	No significant	0.75–0.90
Range	60–95 pts	15–100 pts		Difference	
DASH score					
Mean	13 pts	13 pts	0.97	No significant	0.91–0.99
Range	0–89 pts	0–80 pts		Difference	
Wrist flexion					
Mean	58.91	61.47	0.58	No significant	0.48–0.68
Range		30–80		Difference	
Wrist extension					
Mean	67.09	65.59	0.7	No significant	0.60–0.68
Range		25–93		Difference	
Pronation					
Mean	82.83	85.88	0.26	No significant	0.18–0.36
Range		35–95		Difference	
Supination					
Mean	85.87	85	0.78	No significant	0.69–0.86
Range		50–85		Difference	
Radial deviation					
Mean	36.52	36.76	0.95	No significant	0.89–0.98
Range		10–50		Difference	
Ulnar deviation					
Mean	26.57	23.53	0.38	No significant	0.28–0.48
Range		20–35		Difference	
Grip strength					
Mean	55 Kg (89% Contralateral limb)	45 Kg (90% Contralateral Limb)	0.47	No significant	0.37–0.57
Range	18–120 Kg	18–130 Kg		Difference	

^a Follow up was longer in the percutaneous fixation group.

1 poor result. The average DASH score was 13 points (range, 0 to 89 points).

Comparative Results

Measurements of motion, grip, and radiographic measurements were comparable between the cohorts with no statisti-

cally significant differences. Mean grip strength was 55 kg in the volar plate group (89% of the opposite arm) and 45 kg in the percutaneous fixation group (90% of the opposite arm).

The average radiographic parameters for the percutaneous fixation and volar plate cohorts, respectively, were as follows: 21° vs 19° of ulnar inclination, and 8° of volar tilt and 1 mm of ulnar positive variance in both cohorts. Four patients in each

cohort had postoperative intraarticular incongruity averaging 1.5 mm (range 1 to 3 mm) in the percutaneous group and 1.2 mm (range 1 to 2 mm) in the volar plating cohort.

Discussion

This study addresses the results of treatment of relatively simple fractures of the distal radius: dorsally displaced and angulated extra-articular or simple intra-articular fractures (no more than a simple split between the scaphoid and lunate facets). The variety of treatment options in current use for relatively simple dorsally displaced unstable fractures of the distal radius reflects the lack of a single preferred treatment as well as the lack of good data to guide treatment.

In 2001, a Cochrane review concluded that there was not enough evidence in the published literature to suggest or recommend any specific treatment for distal radius fractures. [13] In fact, it was not possible to conclude that operative treatment is superior to non-operative treatment based upon available evidence. [12] Several other structured reviews have reached similar conclusions. [27, 38, 52]

The few available prospective randomized trials are inconclusive, show limited differences, or compare relatively similar treatments. McQueen reported limited difference between external fixation that crossed the wrist (bridging) and external fixation that leaves the wrist free to move (non-bridging), that were due primarily to better control of the distal fragment with the non-bridging fixator. [28] Comparisons of percutaneous pinning and plaster vs external fixation [17, 30], external fixation with or without supplemental K-wire fixation [26], bridging and non-bridging external fixation [50]; or volar vs dorsal plate fixation have also shown limited differences. [43] Prospective and retrospective cohorts support volar plate fixation [35–37], dorsal plate fixation [39–41, 47], combined dorsal and volar plate fixation [41, 42], various types of external fixators [1, 2, 5, 7, 9, 10, 17, 18, 20, 26, 29, 30, 44, 48, 50, 51], and fragment specific fixation [46]. However, it is difficult to make scientifically valid conclusions based upon these data. [14–16]

Prospective randomized comparisons of percutaneous and volar internal fixation methods are currently underway, but in the meantime, our retrospective cohort and those of others provide data that support the contention that the results of volar plate fixation are comparable to those of percutaneous treatment methods relatively simple distal radius fractures. Our findings are similar to those of Wright and colleagues, who also studied retrospective cohorts. [10] The strength of this study is the thorough evaluation by an independent evaluator and including outcomes instruments. The weakness of this study is the heterogeneity of the

percutaneous fixation cohort and the high number of patients that either declined participation or were lost. The complications were few in both groups, but slightly different. The reoperations in the volar plating group were related to problems associated with the implant such as tendon irritation and a loose screw, whereas the reoperations in the percutaneous fixation group were related to problems with the distal radioulnar joint. As expected, the percutaneous group had some problems with the pins including infection, loosening, and radial sensory nerve injury. We could not reliably track minor pin infections—although they are a nuisance, they rarely affect the final result. Tendon irritation and tendon rupture are well described for volar plate fixation of the distal radius [49, 3, 31, 23] and may have been somewhat greater with the volar T-shaped plate that accompanied the pi-plate.

Although not the focus of our study, it is the author's opinion that patients are more troubled by external wires and pins than they are by a more extensive volar incision and scar. In other words, part of the recent growth in the popularity of volar plating techniques is related to patient and surgeon preferences for internal rather than external fixation. External fixation devices are cumbersome, bothersome, and prone to pin problems (although usually minor). Current evidence suggests that volar plate fixation achieves results comparable to percutaneous treatment methods with few additional operations or complications—at least for relatively simple fractures—and can be considered a useful alternative in the treatment of fractures of the distal radius.

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