Immobilization following Distal Radius Fractures: A Randomized Clinical Trial

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Abstract

Background No consensus exists regarding postoperative splinting position following volar plate fixation of distal radius fractures.

Purpose The purpose of this study was to determine whether immobilization in supination would result in superior outcomes compared with no restriction of forearm range of motion.

Patients and Methods All patients >18 years of age with distal radius fractures indicated for volar plate fixation were eligible. Exclusion criteria were open fracture and concomitant injury to, or functional deficit of, either upper extremity. Patients were randomized to immobilization in (1) maximal supination with a sugar-tong splint or (2) no restriction of supination with a volar splint. Patient-Rated Wrist Evaluation (PRWE), Disabilities of the Arm, Shoulder, and Hand (DASH) score, and visual analog scale (VAS) score; wrist range of motion; and grip strength were recorded at 2 and 6 weeks postoperatively. A Student's *t*-test was used to compare mean values of all outcome measures at each time point.

Results A total of 46 patients enrolled in the study; 28 were immobilized with a volar splint and 18 were immobilized with a sugar-tong splint. Six-week follow-up data were obtained for 32 patients. There was no significant difference in PRWE, DASH, and VAS scores; or range of motion; or grip strength between the two groups postoperatively.

Conclusion Range of motion, grip strength, and patient-rated outcome measures were similar regardless of postoperative immobilization technique in patients with a distal radius fractures stabilized with a volar plate. Surgeons can elect to use the standard-of-care postoperative immobilization modality of their preference following volar plate fixation without compromising short-term return to function.

Level of Evidence This is a Level II, therapeutic study.

Keywords

- ▶ distal radius
- ▶ immobilization
- ▶ splint

The distal radius is the most common fracture site in the upper extremity and accounts for approximately one-sixth of fractures treated in emergency departments in the United States.¹ Distal radius fractures occur in a bimodal distribution, caused by high-energy injuries in youths and ground-level falls in elderly patients with osteoporotic bone.

Open reduction and internal fixation (ORIF) is the mainstay of treatment for unstable distal radius fractures, with volar plating being the most common method of fixation.^{2–5}

While postoperative immobilization is standard practice, there is no consensus regarding the optimal splinting position to expedite return to function following this procedure. As a result, immobilization practices vary between institutions and are based largely on surgeon preference.

Postreduction immobilization in supination was first studied by Sarmiento et al.⁶ The authors demonstrated that functional bracing in supination following closed reduction of Colles' fractures produced superior anatomic and

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functional outcomes when compared with immobilization in pronation.⁶ These findings were substantiated by Bnger et al several years later.⁷

Two studies have evaluated the efficacy of immobilizing the wrist and forearm in supination following closed reduction of distal forearm fractures in the pediatric population, with conflicting results.^{8,9} In addition, Park et al found no difference in outcomes between patients immobilized in neutral position or supination following surgical fixation of Galeazzi fracture–dislocations with a stable distal radioulnar joint.¹⁰ However, optimal protocols for immobilization following operative fixation of isolated distal radius fractures have not been established.¹¹

As the most common fracture of the upper extremity, distal radius fractures represent a significant injury burden.¹² Delayed return of function following operative fixation of these fractures can have both financial and quality-of-life implications for many patients. Although the postoperative recovery period is influenced by a multitude of factors, proper splint positioning may optimize soft tissue healing, and thereby reduce stiffness and decrease recovery time.

The purpose of this study was to determine whether immobilization of the distal radius in supination following volar plate fixation of distal radius fractures would result in superior early clinical outcomes compared with immobilization without restriction of forearm range of motion.

Patients and Methods

This randomized controlled trial was performed at a Level I Trauma Center. Approval from the Institutional Review Board was obtained prior to study initiation. All patients provided written informed consent prior to participation in the study. Eligible patients (see criteria later) undergoing volar plate fixation for a distal radius fracture were randomized to one of two postoperative immobilization techniques: no restriction of pronation/supination using a volar splint distal to the elbow, or maximal supination using a sugar-tong splint.

Inclusion criteria were (1) patient age ≥ 18 years, (2) an isolated distal radius fracture confirmed by radiographs, and (3) patient indicated for ORIF of distal radius fracture with a volar plate. Exclusion criteria were (1) patient age < 18 years, (2) presence of open fracture, (3) concomitant injury to either upper extremity, (4) functional deficit to either upper extremity, and/or (5) history of injury to either upper extremity. Patients were also excluded if supplemental fixation in addition to volar plate fixation was deemed necessary at the time of surgery.

Outcome Measures and Data Collection

Outcome measures included range of motion at the wrist; grip strength; Patient-Rated Wrist Evaluation (PRWE) score; Disabilities of the Arm, Shoulder, and Hand (DASH) score; and visual analog scale (VAS) pain score.

During preoperative evaluation, all patients completed the DASH, PRWE, and VAS surveys. These surveys were repeated at each postoperative visit. Standardized bilateral

measurements of wrist range of motion using a calibrated hand dynamometer (Hydraulic Hand Dynamometer, Model J00105 [Lafayette Instrument Company, Lafayette, IN]) were also recorded at each postoperative visit. Grip strength was measured three times in the injured and uninjured hands, then averaged. Relative range of motion and grip strength values were calculated as a percentage of the uninjured contralateral extremity. All measurements were conducted by a physician blinded to the patient's splint assignment.

Randomization

A random number generator was used to assign enrolled participants to postoperative immobilization in either a sugar-tong splint with the forearm in supination or a volar splint. Immobilization status was recorded by a research coordinator and was then communicated to the operative team at the time of splint application. Thus, the operating surgeons remained blinded to the patient's study assignment prior to and during the operative procedure.

Operative Treatment

All procedures were performed by one of two fellowship-trained attending hand surgeons. Each case was performed under general anesthesia with use of an upper extremity tourniquet. A modified Henry approach, including release of the pronator quadratus muscle, was used in all cases. Open reduction was performed with the assistance of fluoroscopy. Application of a volar fixed-angle plate (Volar Fixed Angle Plate [Trimed, Santa Clarita, CA] or Distal Radius Plate [CarboFix Orthopaedics, Ocean Isle Beach, NC]) was performed in standard fashion. The pronator quadratus muscle belly was repaired in each case.

Postoperative Immobilization

Upon completion of the procedure, patients were placed in the assigned splint. Splint application was standardized to minimize differences in plaster molding between providers. Volar splints were created using four-inch plaster extending from the metacarpophalangeal joints to the mid-forearm. Sugar-tong splints were created using four-inch plaster with the elbow in 90 degrees of flexion and the forearm in full supination. After splint placement, patients were instructed to perform digital range of motion exercises as tolerated.

Postoperative Follow-up

All patients followed our institution's standard postoperative protocol for volar plate fixation. Two weeks after surgery, sutures were removed and the wrist was placed in a removable wrist brace. Nonweightbearing restrictions of the upper extremity were maintained, except for grooming activities. Patients were instructed to perform pronation/supination range of motion exercises, but told to refrain from flexion/extension at the wrist. Patients returned to clinic during the sixth postoperative week, at which point plain radiographs were obtained and the removable wrist brace was discontinued. Patients were instructed to begin

performing wrist flexion/extension range of motion exercises and to bear weight on the upper extremity as tolerated. A final symptom check was performed 3 months after the procedure.

Sample Size Calculation

Prior to study initiation, a power analysis was performed. Calculations were based on the outcome of global upper extremity function, indicated by the DASH score. Prior studies have established a difference of 10 points as being clinically significant.¹³ Assuming an α error of 0.05, a sample size of at least 32 patients per group was calculated to detect a clinically significant difference in the DASH scores with 80% power.

Statistical Analysis

All data analysis were performed on Stata Data Analysis and Statistical Software 13 (College Station, TX). Wrist range of motion and grip strength percentages were analyzed using a Student's *t*-test comparing the volar immobilization splint to the sugar-tong immobilization splint at 2 and 6 weeks postoperatively (► **Table 1**). VAS, PRWE, and DASH scores were also analyzed using a Student's *t*-test comparing the two study groups preoperatively, and at 2 and 6 weeks postoperatively (► **Table 2**). Demographic data and injury characteristics were analyzed using a two-sample *t*-test

comparing the volar immobilization splint to the sugar-tong immobilization splint groups. American Orthopaedic Association (AO) classification between the two groups was compared using a Fisher's exact test.

Results

Between November 2015 and March 2017, 59 patients requiring surgical treatment for unstable displaced distal radius fractures presented to our institution. Forty-six patients agreed to participate in the study and were followed up prospectively during and after ORIF of a distal radius fracture with a volar fixed angled plate. Twenty-eight patients were randomized to the volar splint (neutral) immobilization group, and 18 patients were randomized to the sugar-tong (supination) immobilization group. Nine patients in the volar splint group and five patients in the sugar-tong group did not return to clinic and were lost to follow-up. There were no postoperative complications.

Thirty-two patients completed the study at 6-week postoperative follow-up, 19 in the volar splint group and 13 in the sugar-tong group. Patients in the volar splint group had an average age of 41.00 ± 13.7 years and were 52.6% male, while patients in the sugar-tong splint group had an average age of 45.62 ± 13.07 years. Concurrent diseases present in both groups can be found in ► **Table 1**. Injury characteristics

Table 1 Patient demographic data and injury characteristics

	Volar splint	Sugar-tong splint	p-Value
Demographic data			
Age	41.00 (13.7) y	45.62 (13.07) y	
Male	52.6%	69.2%	0.471
Asthma	5.3%	0%	1.000
Diabetes mellitus	10.5%	0%	0.502
Hyperlipidemia	5.3%	7.7%	1.000
Hypertension	15.8%	15.4%	1.000
Tobacco use	26.3%	23.1%	1.000
Injury characteristics			
Articular step-off	2.20 (1.36) mm	2.75 (1.32) mm	0.265
Dominant side injured	47.4%	30.8%	0.471
Intra-articular	57.9%	76.9%	0.450
Comminuted	84.2%	100%	0.253
Radial length	7.63 (3.35) mm	5.89 (3.35) mm	0.160
Ulnar styloid involvement	73.7%	76.9%	1.000
Volar tilt	− 7.26 (13.85) deg	− 3.31 (18.10) deg	0.489
AO classification			Fisher exact
A	6 (31.6%)	4 (30.8%)	0.634
B	4 (21.1%)	1 (7.7%)	
C	9 (47.4%)	8 (61.5%)	

Abbreviation: AO, American Orthopaedic Association.

Note: Mean (standard deviation).

Table 2 Wrist range of motion (mean % $\pm$ standard deviation)

	Volar splint (n = 19)	Sugar-tong splint (n = 13)	p-Value
2 wk postoperative			
Flexion (%) ^a	33.4 $\pm$ 16.4%	26.9 $\pm$ 22.7%	0.355
Extension (%) ^a	19.5 $\pm$ 14.7%	23.9 $\pm$ 20.3%	0.475
Pronation (%) ^a	45.4 $\pm$ 35.3%	48.8 $\pm$ 31.8%	0.782
Supination (%) ^a	40.8 $\pm$ 23.2%	41.4 $\pm$ 36.2%	0.955
Grip strength (%) ^a	12.5 $\pm$ 13.4%	7.4 $\pm$ 5.3%	0.210
6 wk postoperative			
Flexion (%) ^a	40.0 $\pm$ 23.6%	50.1 $\pm$ 18.5%	0.209
Extension (%) ^a	44.5 $\pm$ 26.2%	50.2 $\pm$ 21.0%	0.521
Pronation (%) ^a	68.8 $\pm$ 35.3%	72.1 $\pm$ 22.0%	0.765
Supination (%) ^a	59.2 $\pm$ 33.9%	63.3 $\pm$ 24.4%	0.716
Grip strength (%) ^a	31.3 $\pm$ 22.3%	25.4 $\pm$ 16.0%	0.425

^a% = injured/uninjured.

included whether the fracture occurred in the dominant forearm, ulnar styloid involvement, and fracture characteristics including AO classification, articular involvement, articular step-off, radial length, and presence of dorsal or volar angulation are presented in ►Table 1. Volar tilt is reported as degrees less than zero and dorsal tilt is reported as degrees more than zero. AO classification analysis using a Fisher's exact test showed no significance between the two groups ($p = 0.634$). There were no significant differences between the two groups with respect to demographic profile, concurrent disease, or fracture characteristics ($p > 0.05$).

An interim analysis revealed that the enrollment of additional subjects would not change our conclusions based on the obtained p -values. As a result, the study was ended before reaching our goal enrollment of 32 patients per immobilization group.

Wrist range of motion is represented as a percentage of the contralateral upper extremity for each follow-up visit (►Table 2). Range of motion in all planes demonstrated improvement at both 2 and 6 weeks postoperatively for both immobilization groups. Differences in wrist range of motion improvement between the two groups were not statistically significant at either postoperative time point.

Grip strength was also represented as a percentage of the contralateral upper extremity for each follow-up visit (►Table 2). Grip strength demonstrated improvement at both 2 and 6 weeks postoperatively for both immobilization groups. Differences in grip strength improvement between the two groups were not statistically significant at either postoperative time point.

All patient-rated outcome scores for the volar immobilization splint group improved between the preoperative and 2-week postoperative visits (►Table 3). PRWE and DASH

Table 3 Comparing outcome measures (mean $\pm$ standard deviation)

	Volar splint (n = 19)	Sugar-tong splint (n = 13)	p-Value
Preoperative			
VAS	4.3 $\pm$ 3.3	3.8 $\pm$ 3.2	0.675
PRWE	73.5 $\pm$ 18.7	78.7 $\pm$ 78.7	0.456
DASH	72.7 $\pm$ 19.1	82.6 $\pm$ 17.5	0.148
2 wk postoperative			
VAS	3.9 $\pm$ 2.9	3.9 $\pm$ 2.8	0.978
PRWE	67.8 $\pm$ 25.2	71.0 $\pm$ 14.1	0.677
DASH	65.9 $\pm$ 24.4	79.4 $\pm$ 10.6	0.070
6 wk postoperative			
VAS	2.6 $\pm$ 2.8	1.6 $\pm$ 2.0	0.288
PRWE	46.5 $\pm$ 26.3	46.5 $\pm$ 23.7	0.997
DASH	43.4 $\pm$ 24.8	53.5 $\pm$ 21.7	0.244

Abbreviations: DASH, Disabilities of the Arm, Shoulder, and Hand; PRWE, Patient-Rated Wrist Evaluation; VAS, visual analog scale.

scores in the sugar-tong group improved between the preoperative and 2-week postoperative visits. VAS score in the sugar-tong group did not improve between the preoperative and 2-week postoperative visits. All scores showed improvement within each immobilization group between 2- and 6-week postoperative follow-up visits. The difference in outcome scores between the two groups was not statistically significant during the preoperative, 2-, or 6-week visits.

Discussion

During the past two decades, treatment of displaced distal radius fractures has trended toward operative fixation using the volar approach. However, no consensus exists regarding the optimal postoperative splinting position to expedite return to function following volar plate fixation of distal radius fractures.¹⁴ The purpose of this study was to determine whether immobilization in supination would result in superior clinical outcomes compared with immobilization with no restriction to forearm range of motion. We found no difference in clinical outcomes at 2 and 6 weeks postoperatively between the two immobilization groups.

At present, there is a paucity of evidence regarding the optimal immobilization technique following surgical fixation of distal radius fractures. Pool examined and nonoperatively treated 239 patients with Colles' fractures in the 1970s with an average follow-up of 2 years and recommended that below-elbow plaster casts should be used for immobilization following reduction.¹⁵ A prospective, randomized study by Bong et al compared immobilization in a sugar-tong splint with immobilization in a short-arm radial gutter for maintaining reduction following distal radius fractures. The authors found that the two techniques were equally effective in maintaining reduction, but that short-arm radial gutter splints resulted in superior DASH scores.¹⁶ However, in patient managed nonoperatively, the primary concern is fracture reduction and healing. Following operative fixation, return to function is determined primarily by soft tissue healing. Thus, although these prior studies provide some insight into proper forearm immobilization following fractures of the distal radius, our understanding of this practice in the postoperative period is incomplete.

ORIF of unstable distal radius fractures with volar plates has been shown to improve range of motion and DASH scores during the early postoperative period,¹⁷⁻¹⁹ with the largest improvements in wrist range of motion occurring during the first several months.²⁰ Our findings are consistent with these prior reports, as both supination and pronation in the injured arm returned to more than 40% of the contralateral uninjured wrist at 2 weeks postoperatively.

We hypothesized that immobilization in supination would lead to superior functional outcomes in the early postoperative period. However, the data produced by this study indicate that there was no significant difference in any outcome measure between the two immobilization groups. We postulate that scar tissue formation in the wrist and forearm is not affected by the position of immobilization of the forearm following surgery.

The primary limitation of this study is that multiple patients were lost to follow-up. Similar low rates of compliance with postoperative follow-up visits have been previously reported at the same medical center.²¹ This was an unfunded study; therefore, patients were not compensated for returning to clinic. It is possible that patients returning after 2 weeks may have created a negative bias; patients who expected shorter time to return to normal function were more likely to return. In addition, patients who did not return are more likely to have experienced positive outcomes. We did not meet our initial power analysis of at least 32 patients per immobilization group due to ending the study early. This was because our results demonstrated that reaching the number of participants initially calculated would not have generated a difference in our conclusion based on the obtained *p*-values.

In conclusion, range of motion, grip strength, and patient-reported subjective outcome measures were similar regardless of postoperative immobilization technique in patients with a distal radius fracture treated with volar plate fixation. Surgeons can elect to use the postoperative immobilization modality of their preference following volar plate fixation without compromising return to function in the early postoperative period.

Ethical Approval

Approval from the Keck School of Medicine Institutional Review Board was obtained prior to study initiation.

Conflict of Interest

None.

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