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Radiographic Outcomes and Complications of Delayed Fixation of Distal Radius Fractures

Stella J. Lee[1,2], Derek S. Stenquist[1,2], Jamie E. Collins[1,2], Ariana N. Mora[1], Brett A. Teplitz[3], Philip E. Blazar[1,2], and Brandon E. Earp[2]

Abstract

Background: Surgeons are sometimes presented with patients with distal radius fractures who present in a delayed fashion or lose reduction after several weeks of attempted closed management. There are limited studies on delayed surgical treatment of distal radius fractures to assist providers in decision-making. **Methods:** We conducted a matched cohort study to compare radiographic outcomes and complications for patients with a distal radius fracture treated with delayed (3-5 weeks) or early (0-2 weeks) surgical fixation. Patients ages 18+ who underwent open reduction and internal fixation of distal radius fractures by a volar approach at 2 Level I trauma centers between 2003 and 2015 were eligible. We measured radiographic outcomes and reviewed medical records to determine operative approach and complications. **Results:** There were 25 cases and 50 controls matched for age (18-87), sex, and AO fracture type. The delayed group had surgery at a mean of 24.8 days from injury and the early group at 5.6 days. There was no statistically significant difference between the delayed and early cohorts in radiographic parameters on injury x-rays, in improvement in radiographic parameters on first postoperative x-rays, or in maintenance of radiographic parameters at union. **Conclusion:** We did not find significant differences in radiographic outcomes or complication rates between patients with delayed versus early surgical treatment for distal radius fracture. Providers treating patients with late presentation or late displacement have the option of surgical fixation beyond the first few weeks after injury.

Level of Evidence: III (Retrospective matched cohort study)

Keywords: distal radius fracture, late presentation, delayed fixation, outcomes, research & health outcomes, case-control, distal radius, fracture/dislocation, diagnosis

Introduction

Fractures of the distal radius are one of the most common fractures in all age groups and account for nearly 20% of fractures in the elderly population.[1] These fractures are increasing in prevalence, with more than 600,000 cases per year in the United States alone.[1] In 2007, Medicare spent $170 million on medical care related to distal radius fractures.[2] These high costs are partly due to the growing elderly population but also reflect a trend toward operative management.[3,4] The trend toward increasing operative management has paralleled the use of volar locked plating, which has been found to be an effective treatment for unstable dorsally displaced distal radius fractures,[5] and has now become a common surgical treatment for this injury.

A treatment conundrum occurs when a patient presents in a delayed fashion with a displaced distal radius fracture or when loss of reduction occurs during attempted non-operative treatment.[6] When this occurs more than 3 weeks after injury, the surgeon's ability to achieve an acceptable reduction with this degree of healing has been a concern. Traditionally, surgeons have allowed the fracture to unite and then performed a corrective osteotomy in delayed fashion.[7] However, corrective osteotomy is associated with complications such as extensor pollicis longus (EPL) tendon rupture, pain at the site of iliac crest bone graft harvest, and delayed osteotomy healing, as well as additional time of disability.[7] It is currently unclear if delayed surgical treatment of acute distal radius fractures

[1]Brigham and Women's Hospital, Boston, MA, USA
[2]Harvard Medical School, Boston, MA, USA
[3]University of Rochester, NY, USA

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Corresponding Author:
Brandon E. Earp, Department of Orthopedic Surgery, Brigham and Women's Hospital, 75 Francis Street, Boston, MA 02215, USA.
Email: bearp@bwh.harvard.edu

produces equivalent radiographic outcomes and complications compared to early surgery.[8] If so, delayed fixation could avoid the potential morbidity and duration of total treatment time associated with later osteotomy.

Given the paucity of studies on delayed fixation of distal radius fractures, we compared radiographic outcomes and complications for patients treated with delayed (3-6 weeks) versus early (0-2 weeks) open reduction internal fixation (ORIF) of a distal radius fracture. We hypothesized that there would be no difference in radiographic outcomes or complication rates between the 2 groups.

Methods

We conducted an institutional review board–approved retrospective matched cohort study at 2 Level I trauma centers for patients with distal radius fractures treated with ORIF with a volar approach between 2003 and 2015 with a delay of 22 to 46 days from reported date of injury to date of surgery. Our billing database was queried for the following Current Procedural Terminology codes: 25620 (open treatment of distal radial fracture or epiphyseal separation, with or without fracture of ulnar styloid, with or without internal or external fixation), 25607 (open treatment of extraarticular distal radial fracture or epiphyseal separation, with or without fracture of ulnar styloid, with or without internal or external fixation), 25608 (open treatment of intraarticular distal radial fracture or epiphyseal separation with internal fixation of 2 fragments), and 25609 (open treatment of intraarticular distal radial fracture or epiphyseal separation with internal fixation of 3 or more fragments). Cases were defined as patients who had surgery between 3 and 6 weeks after injury. Controls had surgery within 0 to 2 weeks of injury. A billing database of all orthopedic patients treated at these institutions from 2003 to 2015 was queried for ORIF of intra-articular or extra-articular distal radius fractures. Patients were excluded for age less than 18 years, prior ipsilateral distal radius fracture, open fracture, ipsilateral carpal fractures, prior surgical treatment (bridge plate or ex-fix), dorsal plating, unknown date of injury, incomplete radiographs, radiographic follow-up less than 4 weeks, or surgical treatment between 2 and 3 weeks or beyond 6 weeks following injury.

A total of 119 patient records were included; 50 patients were excluded at the outset for duplicate records (multiple encounters for the same patient), diagnoses other than distal radius fractures, and procedures other than open reduction and internal fixation, leaving 69 patients. Another 28 patients were excluded due to prior ipsilateral distal radius fracture, ipsilateral carpal fractures, prior surgical treatment (bridge plate or ex-fix), dorsal plating, unknown date of injury, and radiographic follow-up less than 4 weeks, leaving 41 patients. Another 16 patients were then excluded due to incomplete set of radiographs, unclear date of injury, or fewer than 2 matched controls available for that case. This resulted in a set of 25 cases.

To obtain a matched control group, we performed a query of our institutional database for open reduction and internal fixation of distal radius fractures within 0 to 14 days of injury. The full query using the above criteria revealed 953 patients who matched to 1 or more case patients. This produced a list of eligible controls for each case patient.

Controls were matched to each case for AO fracture type, sex, and age within 3 years, and then assessed for adequate radiographic follow-up. There were enough controls with adequate radiographic follow-up for a 2:1 match. For cases with $>$ 2 eligible controls, we randomly selected 2 controls from among the matched options using a random number generator.

We examined medical records for demographic characteristics, date of injury, date of surgery, tourniquet time, and postoperative complications. We analyzed operative notes for operative approach, number of incisions, and surgical technique including soft tissue releases and surgical implant utilized. A single author who was blinded to all patient demographics and timing of surgery performed all radiographic assessments which included radial height, radial inclination, volar tilt, implant complication, intra-articular step-off, and loss of fixation. The same author classified the fractures into AO fracture type based on plain x-rays. Three sets of radiographs were analyzed: initial injury radiographs, immediate postoperative radiographs, and radiographs at union (defined as radiographic evidence of union and minimum 4 weeks postoperatively). Union was determined on plain radiographs when bridging bone was seen on 2 of 3 or all 3 images. If initial injury radiographs were not available, the most recent preoperative radiographs were used. Demographic characteristics for cases and controls are summarized in Table 1.

The exposure variable for our matched cohort study was time to surgery (0-2 weeks vs 3-6 weeks). The dependent variables were clinical metrics and radiographic parameters. We evaluated the association between exposure and radiographic outcomes using the *t*-test. In adjusted analysis, we used linear regression to assess the association, adjusting for institution and time of x-ray. We adhered to STROBE guidelines.

Results

The final case control match included 25 cases and 50 controls matched for age, sex, and AO fracture type (Table 1). The delayed group had surgery at a mean of 24.8 days (range: 22-31, SD: 2.4) from injury and the early control group had surgery at 5.6 days (range: 0-12, SD: 3.5). The mean radiographic follow-up was 188 days (SD: 352; range: 26-1791) in the delayed group and 126 days (SD: 111; range: 35-669) in the early group. The mean clinical follow-up was 324 days (SD: 738; range: 26-3792) in the delayed group and 324 days (SD: 559; range: 35-2889) in the early group. In the delayed group,

Table 1. Baseline Demographics in the Case and Control Groups.

Characteristic	Early surgery, n = 50	Delayed surgery, n = 25	*P* value
Age (range)	49.5 (18-87)	49.6 (18-87)	.9781
Sex			1.0000
Male	20 (40%)	10 (40%)	
Female	30 (60%)	15 (60%)	
Injury on dominant side			.4542
Yes	20 (40%)	8 (32%)	
No	19 (38%)	8 (32%)	
Not recorded	11 (22%)	9 (36%)	
Mechanism of injury			.0633
Fall from standing	22 (44%)	14 (56%)	
Fall from height	12 (24%)	1 (4%)	
MVC or pedestrian struck	4 (8%)	6 (24%)	
Sports	10 (20%)	4 (16%)	
Other	2 (4%)		
AO classification			.9088
23A	30 (60%)	16 (64%)	
23B	2 (4%)	1 (4%)	
23C	18 (36%)	8 (32%)	

Note. MVC = motor vehicle collision; AO = arbeitsgemeinschaft für osteosynthesefragen.

16 out of 25 patients (64%) had surgery due to loss of reduction, while the remaining 9 patients (36%) had surgery due to late presentation or other factors such as polytrauma or other active medical conditions. At union the average radial height in the early group was 10.9 and in the delayed group 11.2 (P = .6050), radial inclination was 22.5 in the early and 22.3 in the delayed (P = .85), and volar tilt was 4.6 in the early and 2.9 in the delayed (P = .451). In the early group, the complication was 10% and in the delayed, it was 12% (P = .791).

Radiographic parameters of x-rays taken at injury, first postoperative visit, and at union are displayed in Figure 1. A review of operative notes revealed that an extended surgical approach and invasive dissection techniques were utilized more frequently in the delayed group (Table 2). We found no significant differences between radiographic parameters at union or complications in a case controlled study of distal radius fractures treated at 0 to 2 weeks after injury compared to those treated 3 to 6 weeks after injury (Table S1, 3, 4).

Outcomes for intra-articular step-off were similar between the 2 groups (Table S2), with an average of 65.5 minutes in the delayed group compared to 55.8 minutes in the early group.

Discussion

Surgeons then face the dilemma of attempting delayed surgical fixation or waiting to perform a formal osteotomy for reconstruction when patients present in a delayed fashion or lose reduction during closed management.[8,9] We compared radiographic outcomes and complications to assess the ability to safely achieve and maintain an acceptable radiographic reduction with surgical fixation of distal radius fractures at a time from injury that is less commonly investigated.

Despite an extensive body of literature, surgeons are currently unable to accurately predict which distal radius fractures will lose reduction during closed management.[10,11] Surgeons and patients may choose earlier surgical fixation for potentially unstable fractures to diminish the risk and potential morbidity of late fixation or malunion.[12–14] Our results offer some evidence that non-operative treatment with close monitoring of unstable fractures may be appropriate, with the knowledge that ORIF can be performed safely even after 3 weeks. The majority of case patients (64%) in this study had delayed surgery due to late loss of reduction after attempted closed management.

Jupiter and Ring challenged the traditional "late" osteotomy approach for distal radius malunions. In their study of osteotomies, similar subjective outcomes, grip strength, and complication rates were found in patients treated early (average 8 weeks) versus late (average 40 weeks) between the 2 groups. They concluded that early osteotomy should be favored since it was technically easier and reduced the overall period of functional disability.[7] Delayed surgical fixation between 3 and 5 weeks after injury offers the same radiographic improvements as early osteotomy with an even shorter overall period of dysfunction between injury and ultimate surgical treatment.[15]

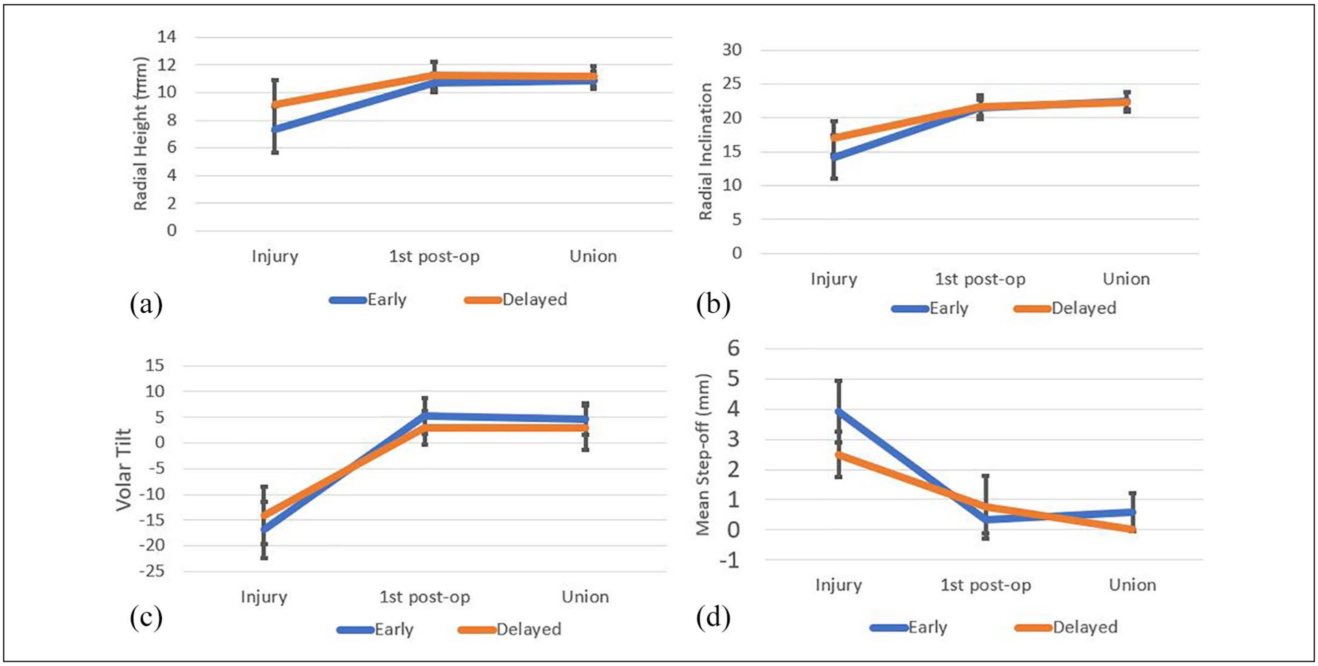

Figure 1. Radiographic parameters over time: mean radial height (a), radial inclination (b), volar tilt (c), and articular step-off (d) with 95% CI on injury x-rays, first postoperative x-rays, and final x-rays in the early group (blue) and delayed group (red).
Note. There was no statistically significant difference between any of the parameters at any time points.

Table 2. Operative Technique.

	Early, n = 50	Delayed, n = 25	*P* value
Extended FCR approach	0 (0%)	6 (24%)	.0009
Use of osteotome	0 (0%)	9 (36%)	**<.0001**
Brachioradialis release	5 (10%)	7 (28%)	.0906
Dorsal periosteal release	0 (0%)	5 (20%)	.0031
Pronation of proximal fragment	0 (0%)	1 (4%)	.3333

Note. FCR = flexor carpi radialis.
Bold denotes significance.

Table 3. Complications.

Complications	Delayed	Early	*P* value
None	22 (88%)	45 (90%)	
Implant removal	1 (4%)	3 (6%)	
Infection	1 (4%)	0	
Nerve injury	1 (4%)	0	
Loss of fixation/malunion	0	2 (4%)	
Total	3 (12%)	5 (10%)	.791

Table 4. Tourniquet Time.

Delayed (minute)	Early (minute)	*P* value
65.5 (SD: 25.5)	55.8 (SD: 27.4)	.151

Weil et al[8] compared radiographic parameters and outcomes for 40 patients treated with delayed fixation of a distal radius fracture (mean delay 30 days) with 75 patients undergoing acute fixation (mean delay 8 days). Their study differed from ours as matching was only by age and not fracture type, their early fixation group had more AO "type C" fractures than the delayed group (91.5% vs 67.5%). The authors found no difference in radiographic outcomes, but there was a statistically significant difference in Disabilities of the Arm, Shoulder and Hand outcome scores, with the delayed treatment group reporting worse function.[8] This difference was no longer significant when 2 outliers were excluded.

Wijffels et al[16] reported on the use of an extended flexor carpi radialis (FCR) approach for volar locked plating of nascent malunions of the distal radius. They reported significant improvement in radiographic parameters without any complications, and concluded that ORIF using the extended FCR approach was a safe and effective treatment method for nascent malunions of the distal radius. In our study, only 24% of the delayed group required an extended FCR approach and 28% had a BR release and 20% documented a dorsal periosteal release.

Our results suggest that surgical fixation is a safe option between 3 and 5 weeks after injury for patients with delayed initial presentation or late displacement of a distal radius fracture. Restoration of radiographic parameters was similar between early and delayed surgery in this study. In their systematic review and meta-analysis including 1961 patients from 16 studies, Mulders et al[17] found that an unacceptable radiological reduction of displaced distal radius fractures is significantly associated with worse patient-reported outcomes in adults. Ali et al[13] found that radiographic malunion of the distal radius defined as dorsal angulation of ≥10°, ulnar variance of ≥ 3 mm, and/or radial inclination of ≤ 15° was associated with significantly worse functional outcome, pain, and satisfaction scores at long-term follow-up.

Our study has several limitations. This study is retrospective in nature and includes a relatively small number of patients. The study was powered to detect moderate to large effects, therefore it is possible that we failed to detect small to modest effects between the groups. This is a study assessing only radiographic outcomes and early complications, so it does not address clinical outcomes, patient-reported outcomes, patient satisfaction, and late complications outside our study period. Since this study matched patients by age, we cannot specifically comment on the effect of age on treatment and outcomes. We did not measure the technical complexity of the surgery so are unable to compare the 2 groups rigorously in this regard. This study cannot address if there is a role for bone graft or bone graft substitute in the surgical treatment for a subset of these injuries. Finally, most of these delayed surgeries were performed by experienced distal radius fracture surgeons with academic interest in these injuries.

A strength of our study is that the delayed and early fixation groups were matched for AO fracture type. We were able to control for differences in preoperative radiographic alignment and compare alignment between initial postoperative films and x-rays at union. Our findings demonstrate that delayed fixation of distal radius fractures within 5 weeks of injury is an option to decrease the period of dysfunction associated with waiting to perform a formal osteotomy and reconstruction. This work indicates delayed surgery is safe and effective at restoring radiographic parameters in the hands of experienced surgeons, but future studies are needed to examine differences in functional outcomes and patient satisfaction.

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 (5). This study did not obtain informed consent and was approved by the Partners Human Research Committee. This article does not contain any studies with animal subjects.

Statement of Informed Consent

Informed consent was not obtained in this study. Informed consent was also not required to obtain information from the medical record.

Declaration of Conflicting Interests

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ORCID iDs

Stella J. Lee https://orcid.org/0000-0001-9945-6988
Brett A. Teplitz https://orcid.org/0000-0002-6532-8168
Philip E. Blazar https://orcid.org/0000-0002-2156-0053
Brandon E. Earp https://orcid.org/0000-0002-7983-3325

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