The Effects of Patient Age on the Radiographic and Functional Outcomes of Distal Radius Fractures: A Two-Study Review

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INTRODUCTION

The incidence of distal radius fractures increases with age[1-3], and due to improving life expectancy, these fractures will continue to be a common injury seen in the emergency department. Even though these fractures are more frequently seen in the female osteoporotic population, they are still prevalent in younger patient populations as well, both male and female[4,5]. Despite this prevalence, typical distal radius fracture studies often include patient cohorts comprising of only one age group. For those that do include patients of a wide age variety, the results are rarely stratified by age. Thus, without these comparative results, it becomes difficult to extract practical conclusions regarding the association of age and loss of fracture alignment after reduction and cast treatment.

Multiple fixation techniques – incorporating various splints, plates, and screws – have been developed with the goal of producing optimal anatomical results in distal radius fracture repair. While achieving adequate fracture alignment may be important, the actual functional significance of anatomic reduction is controversial. It has been shown that minimizing anatomical incongruity is of benefit to younger patient populations[6]; however, this benefit has not been definitively proven to exist among older patient cohorts.

Our group sought out to determine the influence of patient age on the radiographic and functional outcomes of distal radius fractures. We conducted two studies in order to do so. In Study I, a retrospective review, we examined radiographic outcomes in a cohort of patients that underwent conservative management following distal radius fracture. In Study II, a call-back study, we focused on a different cohort of patients with distal radius fractures that were all at least 55 years old, and we assessed both radiographic and functional outcomes in these patients. We hypothesized that increasing patient age would lead to increasing rates of radiographic displacement. We further predicted that despite these radiographic outcomes, functional outcomes in older patients would not be adversely affected.

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Criteria for Radiographic Displacement	
Parameter	Range
Dorsal Angulation	>10°
Volar Angulation	>25°
Radial Shortening	>5.0 mm
Articular Gap	>2.0 mm
Articular Step-off	>2.0 mm

Table 1: *Radiographic criteria for displacement of fractures in Studies I and II* – those fractures that met one or more of the above criteria were considered to be "displaced"

MATERIALS AND METHODS

Study I

All consecutive distal radius fractures seen in our Emergency Department from April 2002 to September 2004 were considered for this study. Patients were included if they underwent initial conservative management (casting immobilization only or closed reduction and cast), received all follow-up treatment at our institution, and were at least 18 years old. Patients with combined radial/ulnar shaft fractures were excluded, as were those patients that underwent initial operative fixation. The primary endpoint was evidence of "secondary displacement" – i.e. gradual fracture displacement that necessitated subsequent operative fixation or healing with evidence of radiographic deformity. A literature review[5-10] was conducted to identify parameters indicating adequate fracture alignment; those that healed outside any one or more of these parameters (Table 1) were considered to have been secondarily displaced.

Radiographs were assessed at initial fracture presentation, after reduction (if applicable), and at healing (8 or more weeks post-fracture). Each radiograph was assessed according to the parameters of Table 1 (i.e. angulation, articular incongruity, and radial shortening), and evidence of "radiographic displacement" was noted at each time point. Further, each patient was assigned to one of three age groups. Group I included patients between the ages of 18-44; Group II included patients 45-64 years old; and Group III included patients 65 or older. Rates of secondary displacement were compared according to patient age and treatment.

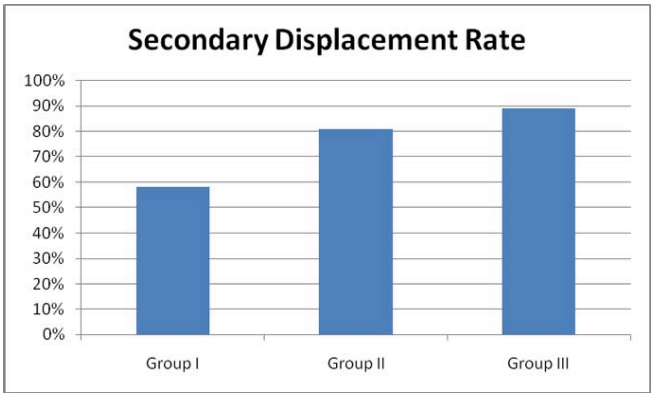

Figure 1: *Rates of secondary displacement among fractures undergoing closed reduction in Study* I- a correlation was found between increasing patient age and increasing rates of displacement ($p<0.05$).

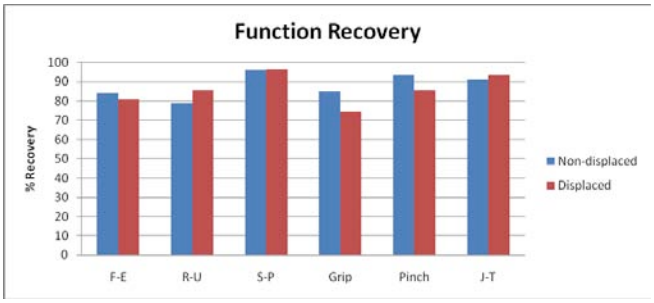

Figure 2: *Comparison of functional recovery among fractures with and without evidence of radiographic displacement from Study II* – no statistically significant differences were found in function between these two groups when comparing flexion-extension (F-E), radio-ulnar (R-U), and supination-pronation (S-P) arcs. Nor were there any differences found in grip strength, pinch strength, or Jebsen-Taylor test scores (J-T).

Study II

All distal radius fracture patients seen in clinic between January 2006 and February 2007 who were 55 years of age or older qualified for participation in Study II. Those that were at least six months from initial treatment and without significant medical co-morbidities (precluding completion of functional tasks) were called back to participate in the study. Whereas fractures in Study I were treated only by conservative, non-surgical methods, the patients in Study II had undergone a variety of fixation procedures, both conservative and surgical (i.e. closed reduction percutaneous pinning, open reduction internal fixation, and open reduction internal/external fixation).

All patients in Study II were assessed according to radiographic, subjective, and objective outcomes. Radiographic parameters were the same that were used in Study I (angulation, articular incongruity, and radial shortening), and fractures were considered to be "displaced" if they met the criteria set forth in **Table 1**. All radiographic assessment was done on films taken of the affected wrist after fracture/treatment healing. Subjective functional outcomes included surveys such as the DASH and PRWE. A new survey designed and validated by our group – the Modernized Activity Subjective Survey of 2007[11] (MASS07) – was also used. This survey incorporated activities more modern in scope than those featured in the DASH and PRWE (i.e. using a cell phone, working with a computer mouse, etc.). Objective measures included range of motion (flexion-extension, radio-ulnar, and supination-pronation arcs), strength (grip, pinch), and Gartland and Werley assessment. Finally, performance testing was also assessed using the Jebsen-Taylor test (with the writing section omitted because of concerns of patient performance variability inherent in such a task). These objective measures were reported as percentage recovery of the contralateral, unaffected wrist.

Statistical Methodology

Fisher's exact tests (2-tailed) were used to compare whole-number distributions between two different groups of patients, and a Chi Square test was used if there were three or more groups. ANOVA was used to compare continuous data (such as radiographic outcomes) between different patient sub-groups. All statistical analysis was conducted using SPSS software package (V 15.0, SPSS, Inc., Chicago, IL), and $p<0.05$ was considered statistically significant, while $p\leq0.10$ suggested a statistical trend.

RESULTS

Study I

As aforementioned, all patients from Study I underwent non-surgical treatment (either casting alone or closed reduction and cast). Those fractures that were casted only displayed less radiographic deformity than those requiring closed reduction. However, post-reduction analysis indicated that reduction was adequate, i.e. within the acceptable bounds set forth by **Table 1**. Our preliminary data suggests that, among all fractures, secondary displacement rates increased with increasing patient age, such that the rates of displacement were higher in Group II and Group III patients (45-64 and 65+ years old, respectively) compared to Group I patients (18-44 years old; $p<0.05$). When stratified by treatment, this effect was most pronounced among fractures undergoing closed reduction (**Figure 1**; $p<0.05$). There was no increase in displacement rates that correlated with patient age for those fractures that underwent casting alone. We also compared the rates of secondary displacement among fractures that presented with initial dorsal angulation compared to those that were volarly angulated on presentation and found no difference between the two groups.

Given that a correlation was found between age and radiographic outcomes in this set of distal radius fractures, it was important to investigate the contribution of any other variables that may affect the outcomes in these patients. We first investigated if fracture comminution conferred any additional risk of secondary displacement. The rate of secondary displacement among fractures consisting of four or more fragments was found to be slightly higher than that of fractures with two or three fragments; however, this difference was not statistically significant.

In addition to comminution, the radiographic status of fractures *on presentation* was assessed for any possible contribution to fracture outcome. We attempted to determine if initial radiographic displacement was also correlated with age, thus correlating it to radiographic outcome. Each fracture – on presentation – was assessed according to the parameters of **Table 1**, and those that met the criteria for displacement (i.e.

dorsal angulation greater than ten degrees, volar angulation greater than twenty-five degrees, etc.) were considered to have been *initially radiographically displaced*. According to this stratification, there was no correlation found between radiographic presentation and patient age ($p>0.05$).

Our final statistical consideration was that of gender and its effects on the radiographic outcomes of the distal radius fractures in our study cohort. Preliminary data suggests that the rates of secondary displacement for male and female patients were similar among patients in Groups I, II, and III (all $p>0.05$). Therefore, female gender was not shown to correlate with increased likelihood of secondary displacement, regardless of age.

Study II

The patients that enrolled in Study II all had previously sustained a uinlateral distal radius fracture and were at least 55 years old. These patients were treated both conservatively and surgically, as described in the Methodology section. Radiographic and functional (subjective, objective) outcomes were assessed in every patient and stratified according to treatment rendered and final radiographic outcomes.

All measured outcomes were first stratified according to the final radiographic results following fracture treatment, i.e., when they were called back for study participation. This was done by comparing functional outcomes of patients whose radiographs displayed evidence of displacement (according to the parameters of **Table 1**) to outcomes of those patients without such evidence of displacement. There were no statistically significant differences found between these two groups when considering any of the range of motion outcomes (flexion-extension, radio-ulnar, and supination-pronation arcs; all $p>0.05$). Similarly, there was no difference found in pinch strength; however, those patients with non-displaced fractures showed a trend towards increased grip strength when compared to displaced counterparts. The outcomes of the subjective measures were also compared. Survey outcomes – for the DASH, PRWE, and the MASS07 – were similar in both groups, as were the Gartland and Werley scores. Finally, hand performance outcomes were also tested using the Jebsen-Taylor test; again, no differences were found between patients with and without evidence of radiographic displacement (**Figure 2**; $p>0.05$).

Radiographic and functional outcomes were subsequently compared between fractures that underwent conservative management (casting alone or closed reduction and cast) and those that underwent operative fixation (closed reduction percutaneous pinning, open reduction internal fixation, or open reduction internal/external fixation). The radiographs of fractures that underwent surgical management displayed significantly less residual dorsal angulation than those treated non-operatively ($p<0.05$). There was also less radial shortening in these fractures. However, residual volar angulation and articular incongruity (gap, step-off) were similar between both treatment groups. In fact, the proportion of fractures that healed with evidence of radiographic displacement, according to the parameters of **Table 1**, were similar for both groups ($p>0.05$).

Subjective and objective functional outcomes were also assessed and compared between fractures that underwent conservative management and those that underwent surgical fixation. When considering range of motion, those fractures that underwent conservative management showed a trend towards increased supination-pronation arcs when compared to surgically managed counterparts. Radio-ulnar and flexion-extension arcs were similar in both groups, as were outcomes of grip strength and pinch strength. With regards to survey responses, no differences were noted for any of the three surveys used, nor were there any differences found in Gartland and Werley scores. Finally, hand performance/Jebsen testing revealed no statistically significant difference between these two treatment groups ($p>0.05$).

DISCUSSION

This review assessed two different studies designed to determine the effects of patient age on the radiographic and functional outcomes following distal radius fracture repair. Study I investigated radiographic outcomes of these fractures among patients who were managed conservatively and who comprised a wide age range. Results from this study indicated that increasing patient age led to increasing rates of secondary displacement, and that this was especially true for fractures undergoing closed reduction (compared to minimally displaced fractures that necessitated casting alone; **Figure 1**). In Study II, both radiographic and functional outcomes were assessed in patients 55 or older who had sustained a distal radius fracture; these patients were managed either conservatively or surgically. A particular strength of this study was the incorporation of the Jebsen-Taylor test, which provided truly objective outcomes assessment. Our preliminary data suggests that patients in this age group with healed fractures without evidence of radiographic displacement (**Table 1**) had similar functional outcomes to those patients whose fractures did have evidence of displacement. We found no differences in subjective outcomes (DASH, PRWE, MASS07), nor in objective measures (range of motion, strength, Gartland and Werley, and Jebsen performance testing) between the two sub-groups. When considering treatment methods in this age group, we found that surgically managed patients displayed less dorsal angulation and radial shortening than conservatively managed counterparts. However, no differences were found in subjective or objective functional outcomes in these two groups.

While age over 60 has been considered to be a risk factor[12] for secondary displacement after reduction, we found increased rates of such displacement existed among fractures from Study I who were in both Groups II and III (45-64 and 65+ years old, respectively). It is important to note that, despite high rates of secondary displacement among older patients (especially after closed reduction), it is unclear what the actual functional disabilities are from these radiographic outcomes. Several studies have attempted to determine this correlation but have produced conflicting results. For example, one study by Jaremko *et al.*[13] assessed 74 conservatively managed fractures in patients 50 or older and reported no statistical correlation between radio-

graphic outcomes and patient satisfaction (using DASH and SF-12 surveys). Another study by Ring and Jupiter[12] assessed radiographic and functional outcomes in twenty patients aged 60 or older who had undergone operative fixation following unsuccessful closed reduction. Similarly, PRWE scores were not found to correlate with the radiographic outcomes of these fractures.

In contrast, some studies have indicated that radiographic and functional outcomes of distal radius fractures may indeed be linked. One study by Trumble *et al.*[14] demonstrated a correlation between radiographic outcomes (post-operative gap, step-off, total articular incongruity, and radial shortening) and functional outcomes (range of motion, grip strength) in a series of 52 surgically managed displaced intra-articular fractures. Another study by Knirk and Jupiter[6] similarly demonstrated the importance of 2+ mm of articular displacement towards the progression of post-traumatic arthritis among young patients.

Conflicting studies, such as those mentioned above, served as motivation to conduct our own studies investigating the effects of radiographic outcomes on the functional outcomes following distal radius fracture in the elderly patient population. Further motivation was provided from the fact that current criteria used for radiographic assessment of distal radius fractures (i.e. those mentioned in **Table 1**) were extrapolated from previous studies that did not focus on the elderly patient population. Hence, Study II was conducted in an effort to address both of these areas of clinical uncertainty.

Our two-study review does have inherent limitations. Both studies were retrospective and thus lack the power of prospective trials. Further, patients comprising both study cohorts were from the same institution; thus, the results may not be generalizable to all patient populations. Finally, while bone mineral density would have been useful information to incorporate into these studies, the retrospective nature of our trials precluded obtaining such information.

In conclusion, our research group conducted two studies that sought to determine the impact of patient age on the radiographic and functional outcomes of distal radius fractures. Preliminary data from Study I indicates that increasing patient age does indeed lead to increased rates of secondary displacement among conservatively managed fractures, especially those displaced fractures undergoing closed reduction. However, results from Study II indicate that, among older patients, functional outcomes are largely independent of radiographic outcomes at healing. Moreover, no significant differences in functional outcomes were found between those fractures that were managed surgically and those that required only conservative management. These preliminary results indicate that closed reduction for displaced fractures may serve some alternative purpose in these patients besides fracture alignment, whether it be pain reduction, patient comfort, or prevention of secondary co-morbidities, e.g., traumatic carpal tunnel syndrome. Therefore, post-reduction radiographic assessment may no longer be necessary, assuming the patient has achieved adequate relief from the procedure.

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