

Distal Radius Fractures in Older Patients

Is Anatomic Reduction Necessary?

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Abstract The relationship between radiographic and functional outcomes in older patients with distal radius fractures is controversial. We explored this relationship by assessing the influence of radiographic displacement and fracture comminution on the functional outcomes of these fractures. We also asked whether operative intervention and demographic factors (age, gender, duration of followup) influenced outcome. We examined 53 patients older than 55 years with distal radius fractures with various functional assessments: range of motion (ROM) and strength measurements, three subjective surveys (Disabilities of the Arm, Shoulder, and Hand; Patient-rated Wrist Evaluation; Modernized Activity Subjective Survey of 2007), a Gartland and Werley score, and an objective, standardized hand performance test (Jebsen-Taylor). We measured angulation, articular gap/stepoff, and radial shortening on final radiographs and fracture comminution of preoperative radiographs. We observed no effect of radiographic displacement on subjective or objective outcome assessments, including standardized hand performance timed testing. Surgically treated fractures

were less likely to display residual dorsal angulation and radial shortening, but surgical intervention did not independently predict functional outcome. Fracture comminution, patient gender, and months of followup similarly had no effect on outcome. We found no relationship between anatomic reduction as evidenced by radiographic outcomes and subjective or objective functional outcomes in this older patient cohort.

Level of Evidence: Level II, diagnostic study. See the Guidelines for Authors for a complete description of levels of evidence.

Introduction

Before the plate and screw era for bony fixation, distal radius fractures traditionally were treated by closed reduction and casting or by pins and plaster [11]. Many physicians who used these techniques claimed patients attained functionally good outcomes despite visible wrist deformities, and multiple studies showed minimal or no improvement of functional outcome with improved radiographic reduction [13, 16, 19, 27, 28, 35, 40, 41, 49]. However, with the advent of frequent internal fixation, other studies have suggested radiographic reduction does offer better functional outcomes [1, 9, 14, 21, 23–25, 30, 37, 40, 44]. These data support the trend toward surgical fixation as the definitive treatment of a distal radius fracture with deformity. Despite this shift, in a recent review of the literature it is argued, in the absence of a large, long-term, prospective, randomized, controlled trial, there is no definitive clinical evidence arguing for the superiority of any treatment modality over another, particularly regarding different modalities of surgical intervention [5]. Moreover, age-specific data regarding older patient populations that

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Each author certifies that his or her institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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correlate radiographic and functional outcomes are insufficient, with most data tailored to younger populations [24].

We sought to determine whether (1) anatomic alignment (as measured by radiographic displacement and comminution) after distal radius fracture repair influenced standardized motion and strength measurements, functional outcome assessments, and objective, standardized, timed hand performance testing in an older cohort; and whether (2) operative intervention or (3) demographic information (age, gender, length of followup) influenced either the radiographic or functional outcome.

Materials and Methods

Using the International Classification of Diseases, 9th Revision, codes [18], we identified and contacted by phone 64 potential patients with intraarticular and extraarticular distal radius fracture who initially presented to our center from January 2006 to February 2007. All patients were seen by one of two orthopaedic hand surgeons (CSD, TDR). We included only patients 55 years or older, patients followed at least 6 months after initial treatment, and patients with isolated/unilateral distal radius fractures. We excluded patients with multiple medical comorbidities (precluding them from completing functional tasks; $n = 16$) or patients who had moved away ($n = 17$) or were no longer living ($n = 5$). All remaining (64) participants were called back for a 30-minute visit to measure their outcome parameters. Eleven of the 64 patients (17%) declined to participate. All 53 remaining patients completed the subjective questionnaires and functional outcomes testing in followup. The mean age of our study population ($n = 53$) was 69 years (range, 55–90 years), and 46 patients (87%) were female. The minimum followup from fracture treatment was 6 months (average, 17 months; range, 6–45 months). Twenty fractures (38%) were of the dominant hand. All treatment decisions were made according to the clinical judgment of the treating surgeon before study enrollment; nonoperative and operative treatments were used. Nonoperative treatment ($n = 26$) entailed closed reduction and immobilization. Operative treatment ($n = 27$) included closed reduction percutaneous pinning ($n = 4$), open reduction and internal fixation ($n = 20$), and open reduction and internal/external fixation ($n = 3$). Institutional Review Board approval was granted before initiation of this study, and strict confidentiality guidelines were followed.

Each patient in this study was assessed according to a battery of functional and radiographic outcomes. Outcomes assessed in the study included radiographic displacement parameters, radiographic comminution assessment, ROM and strength measurements, subjective functional outcome

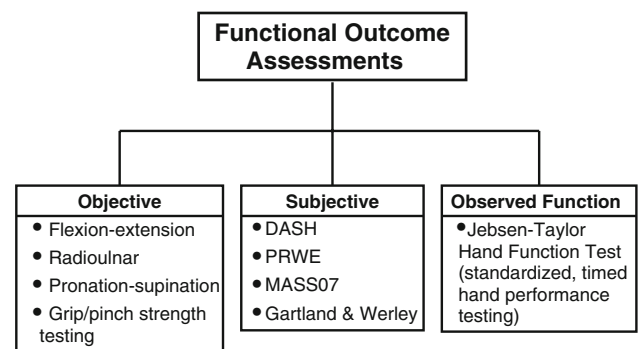


Fig. 1 The different assessments of functional outcome used in this study are shown. These tools can be classified into three general categories: objective, subjective, and observed function assessments.

assessments, and objective, standardized hand performance testing (Fig. 1). All of these end points were measured at the time of the study visit. Treatment modality rendered and demographic information (age, gender, duration of followup) also were collected.

For each patient, one of the authors (AJS, who was not the treating surgeon) measured three ROM parameters of the affected wrist: the flexion-extension, radioulnar, and supination-pronation arcs with a standard goniometer. All measurements were obtained using the same model goniometer and the same measurement technique. These values were compared with the contralateral, unaffected side and reported as the corresponding percentage of recovery of this unaffected side. Additional bilateral measurements included grip strength (using a Jamar dynamometer) and lateral pinch strength (using a thumb press). These also were reported as a percentage of the contralateral, unaffected side.

We used four subjective assessments/surveys to assess functional outcomes. Two of these were the Disabilities of the Arm, Shoulder, and Hand (DASH) [15] and the Patient-rated Wrist Evaluation (PRWE) [33] surveys. A third survey, the Modernized Activity Subjective Survey of 2007 (MASS07), is a novel, modern wrist and hand functional assessment recently developed and validated by our group [2]. The tasks used in the MASS07 are more technologically applicable to modern daily activities than those found in either the DASH or the PRWE. Examples of these tasks include using a computer mouse, operating a cellular telephone, and so on (Table 1). We also assigned a Gartland and Werley [10] score to each of the affected wrists. This score is an older method of evaluating healed distal radius fractures and assigns points based on criteria including residual deformity, subjective evaluation, objective evaluation, and complications. Based on the number of points accrued, the fracture is classified into four outcomes groups (excellent, good, fair, and poor). The

Table 1. The Modernized Activity Subjective Survey of 2007

Functional task		No difficulty										Unable to do
1. Type on a keyboard	NA	0	1	2	3	4	5	6	7	8	9	10
2. Use a computer mouse	NA	0	1	2	3	4	5	6	7	8	9	10
3. Dial a cell phone/telephone	NA	0	1	2	3	4	5	6	7	8	9	10
4. Take a photograph with a camera	NA	0	1	2	3	4	5	6	7	8	9	10
5. Pull an item from a pocket/purse	NA	0	1	2	3	4	5	6	7	8	9	10
6. Write a check	NA	0	1	2	3	4	5	6	7	8	9	10
7. Take a dollar bill out of a wallet	NA	0	1	2	3	4	5	6	7	8	9	10
8. Plug a cord into a power outlet	NA	0	1	2	3	4	5	6	7	8	9	10
9. Do laundry/fold clothes	NA	0	1	2	3	4	5	6	7	8	9	10
10. Type on a handheld device	NA	0	1	2	3	4	5	6	7	8	9	10

NA = not applicable; indicates the patient has never performed the task in question (eg, some people have never typed on a handheld device) and thus is unable to comment on the relative difficulty compared with before the fracture.

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Gartland and Werley score, which is an unvalidated scale and uses somewhat arbitrary classification groups, has been largely supplanted by more modern subjective assessments. However, its inclusion allowed comparisons with previous studies that used this score as a primary end point and thus is of some historical relevance.

Finally, we assessed each wrist with an objective, standardized, timed performance test, the Jebsen-Taylor hand function test [20], which measured performance through manipulation of everyday items such as spoons, cans, pencils, and paper clips. Each patient completed these tasks with the affected and the unaffected wrists, and results were reported as a ratio (in percent form) of the two values. For this study, we used a modified Jebsen-Taylor test; the writing section was excluded because this task is highly dependent on hand dominance and therefore is difficult to interpret [6]. Because of its ability to assess true functional outcome, we believe the Jebsen-Taylor test of hand function is a particularly representative assessment of the final outcome in our analysis.

Radiographs were assessed by two study investigators (AJS, ECM). Any disputed radiographs were referred for resolution to the senior author (CSD), who was blinded to all identifying information of the patient (name, demographics, treatment modality, and so on). Radiographs of the healed distal radius fractures were assessed by the investigators and analyzed with respect to five different radiographic displacement parameters: dorsal/volar tilt, radial shortening, and articular gap/stepoff. Fractures were considered radiographically displaced if they contained one

Table 2. Criteria for radiographic displacement*

Parameter	Range
Dorsal angulation [8, 11]	> 10°
Volar angulation [11, 39]	> 25°
Radial shortening [8, 36, 38]	> 5.0 mm
Articular gap [24, 36]	> 2.0 mm
Articular stepoff [24, 36, 38]	> 2.0 mm

* Any fracture that healed with any one or more radiographic parameters in this range was considered to have been radiographically displaced.

or more radiographic parameters in the bounds for dorsal tilt, volar tilt, radial shortening, articular gap, and articular stepoff (Table 2; Fig. 2) [8, 11, 24, 36, 38, 39]. Moreover, comminution was assessed by categorizing as having two, three, and four or more parts. All measurements were made using Centricity® Web software (GE Healthcare, Chalfont St Giles, UK) and the included length and angulation tools packaged in the software.

The statistical analyses were geared to address the questions of our study. Our primary question was the determination of a relationship between anatomic alignment as measured by radiographic displacement and fracture comminution; two-tailed Student's t tests and analysis of variance were used to compare the means of two or more groups of data (ie, comparing radiographic outcomes data for two groups consisting of displaced and nondisplaced fractures). Multivariate regression analysis

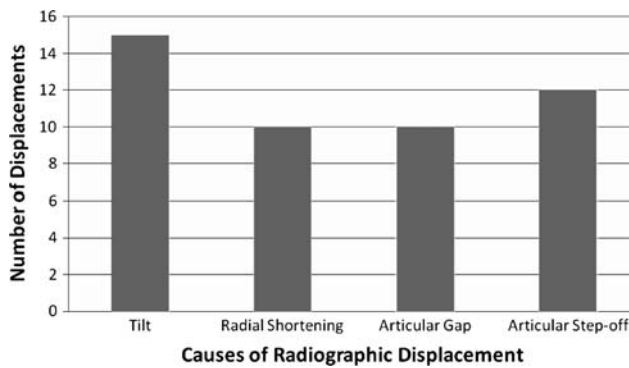


Fig. 2 We assessed the radiographic outcome of 53 patients with distal radius fractures. Twenty-six (49%) of the patients in this cohort showed evidence of radiographic displacement in at least one of four general displacement categories: tilt, radial shortening, and articular gap/stepoff. Thirteen (25%) of the fractures showed displacement of two or more parameters.

was performed when determining the independent predictive value of radiographic data as continuous data on functional, subjective, and objective outcomes. For the analysis of our second question, the influence of operative intervention on the radiographic and functional outcomes, two-tailed Student's *t* tests were used to compare the means of two groups (ie, to compare radiographic data of operative and nonoperative groups). Chi square tests were used to compare the proportions of two or more groups (ie, the rate of operative interventions in patients with different numbers of parts for fracture comminution). Finally, multivariate regression analysis was used to determine the independent influence of treatment modality on the functional outcomes data. Our third question examined the influence of demographic factors (age, gender, length of followup) as continuous variables on the radiographic displacement and functional outcome. Multivariate regression analysis was used to evaluate the independent effect of these demographic variables on the functional outcome. For each of these analyses, the majority of the data sets fulfilled the Lilliefors criteria [31] for normality justifying the use of parametric tests; exceptions included the data for articular gap/stepoff and the MASS07 and Gartland and Werley subjective assessments. For data sets that did not meet these criteria for normality, nonparametric testing was used. We conducted all analyses using the SPSS® software package (Version 15.0; SPSS Inc, Chicago, IL).

Results

We observed no influence of anatomic deformity, as measured by radiographic displacement and comminution, on the functional outcomes data. Specifically, we found no

differences (all $p > 0.11$) in the following outcomes between those without and with residual radiographic deformity: flexion-extension, radioulnar deviation, supination-pronation, pinch strength, DASH, PRWE, MASS07, Gartland and Werley score, and Jebsen-Taylor observed and timed hand performance test (Table 3). Percent recovery of grip strength (of the affected side as a percentage of the unaffected side) was greater ($p = 0.05$) in patients without evidence of radiographic displacement compared with recovery of patients with displacement. When considering severity of displacement as measured by the total number of displaced parameters, only the MASS07 showed an association ($p = 0.04$) between worsened function and residual radiographic deformity (Table 4). We also found no relationship between the degree of fracture comminution by parts and the functional outcomes data (Table 5). Multivariate linear regression analysis indicated no major multivariate predictors of radiographic displacement on the markers of functional outcome used in this study.

We observed a relationship between surgical treatment and various radiographic outcomes but no influence of operative intervention on functional outcomes. Our analysis showed the fractures of patients receiving operative fixation were less deformed ($p < 0.001$ and $p = 0.04$, respectively) with respect to dorsal angulation and radial shortening compared with patients receiving nonoperative treatment (Table 6). Despite this, we observed no differences ($p = 0.10$) in the proportion of fractures that healed with

Table 3. Comparison of functional outcomes between patients with and without evidence of radiographic displacement

Outcome	Nondisplaced (n = 27)	Displaced (n = 26)	p Value
Range of motion (% recovery)			
Flexion-extension	83.9 ± 13.8	81.0 ± 11.1	0.40
Radioulnar	78.8 ± 18.7	85.7 ± 15.8	0.15
Supination-pronation	96.2 ± 10.3	96.6 ± 4.1	0.85
Strength (% recovery)			
Grip strength	85.1 ± 21.7	74.3 ± 17.7	0.05
Pinch strength	93.5 ± 18.4	85.6 ± 16.9	0.11
Subjective function (scaled score)			
DASH	14.3 ± 13.1	14.0 ± 11.9	0.92
PRWE	12.8 ± 12.9	16.0 ± 15.1	0.41
MASS07	5.8 ± 9.0	7.6 ± 10.2	0.50
Gartland and Werley	3.1 ± 3.5	4.0 ± 2.8	0.36
Objective hand performance (% recovery)			
Jebsen-Taylor test	90.9 ± 15.7	93.6 ± 13.1	0.50

Values are expressed as average ± standard deviation; DASH = Disabilities of the Arm, Shoulder, and Hand; PRWE = Patient-rated Wrist Evaluation; MASS07 = Modernized Activity Subjective Survey of 2007.

Table 4. Comparison of functional outcomes according to number of displaced radiographic parameters

Outcome	Zero (n = 27)	One (n = 13)	Two or more (n = 13)	p Value
Range of motion (% recovery)				
Flexion-extension	83.9 ± 13.8	80.8 ± 12.4	81.2 ± 10.0	0.70
Radioulnar	78.8 ± 18.7	81.9 ± 15.5	89.5 ± 15.8	0.20
Supination-pronation	96.2 ± 10.3	97.6 ± 3.8	95.7 ± 4.2	0.81
Strength (% recovery)				
Grip strength	85.1 ± 21.7	76.7 ± 20.6	71.8 ± 14.5	0.13
Pinch strength	93.5 ± 18.4	82.3 ± 20.0	88.8 ± 13.3	0.18
Subjective function (scaled score)				
DASH	14.3 ± 13.1	12.9 ± 11.2	15.1 ± 12.8	0.91
PRWE	12.8 ± 12.9	15.5 ± 13.5	16.5 ± 17.2	0.70
MASS07	5.8 ± 9.0	4.9 ± 6.4	10.3 ± 12.6	0.04
Gartland and Werley	3.1 ± 3.5	3.7 ± 3.0	4.2 ± 2.8	0.43
Objective hand performance (% recovery)				
Jebsen-Taylor test	90.9 ± 15.7	92.6 ± 13.7	94.7 ± 12.9	0.75

Values are expressed as average ± standard deviation; DASH = Disabilities of the Arm, Shoulder, and Hand; PRWE = Patient-rated Wrist Evaluation; MASS07 = Modernized Activity Subjective Survey of 2007.

Table 5. Comparison of operative intervention and functional outcomes according to comminution based on number of parts

Outcome	Two parts (n = 20)	Three parts (n = 23)	Four + parts (n = 10)	p Value
Rate of operative intervention (%)	25	65	70	0.01
Range of motion (% recovery)				
Flexion-extension	85.5 ± 12.7	79.6 ± 13.3	82.8 ± 9.4	0.31
Radioulnar	81.0 ± 17.7	79.8 ± 17.6	90.2 ± 16.3	0.28
Supination-pronation	96.8 ± 8.4	95.9 ± 8.5	97.0 ± 5.2	0.91
Strength (% recovery)				
Grip strength	82.0 ± 21.7	77.7 ± 21.0	80.3 ± 17.8	0.79
Pinch strength	90.9 ± 20.4	85.9 ± 14.5	95.5 ± 20.0	0.35
Subjective function (scaled score)				
DASH	15.2 ± 14.2	15.7 ± 11.0	8.5 ± 10.9	0.28
PRWE	14.5 ± 14.8	16.9 ± 14.8	8.5 ± 8.7	0.29
MASS07	8.9 ± 11.1	6.9 ± 9.5	1.9 ± 3.5	0.17
Gartland and Werley	3.1 ± 2.9	4.4 ± 3.9	2.5 ± 1.1	0.22
Objective hand performance (% recovery)				
Jebsen-Taylor test	92.0 ± 15.1	91.1 ± 15.1	95.3 ± 12.2	0.75

Values are expressed as average ± standard deviation; DASH = Disabilities of the Arm, Shoulder, and Hand; PRWE = Patient-rated Wrist Evaluation; MASS07 = Modernized Activity Subjective Survey of 2007.

residual displacement (ie, a fracture with any radiographic parameter exceeding the criterion for displacement) between the two groups. Moreover, we observed no differences between the two groups when considering our functional outcome assessments (Table 6). We also found the proportion of patients receiving operative intervention was greater ($p = 0.01$) in groups of patients with increasing degrees of fracture comminution as measured by parts (Table 5). Multivariate regression analysis showed operative intervention had no independent predictive value on the functional outcome data.

Gender and duration of followup did not influence the functional outcomes data although we found an equivocal association between patient age and functional data. Using multivariate regression analysis, we observed no associations between gender and ROM, grip strength, subjective outcomes assessments, or objective hand performance testing. We observed no relationship between the length of followup and any of the subjective or objective outcomes. Although increasing patient age had no effect on ROM, grip strength, or Jebsen-Taylor test outcomes, it was associated ($p = 0.06, 0.02, \text{ and } 0.02$ for the DASH, PRWE,

Table 6. Comparison of outcomes with respect to treatment modality

Outcome	Nonoperative treatment (n = 26)	Operative treatment (n = 27)	p Value
Radiographic			
Dorsal tilt (degrees)	21.0 ± 10.9 (n = 16)	6.5 ± 3.9 (n = 12)	< 0.001
Volar tilt (degrees)	10.8 ± 5.4 (n = 10)	7.3 ± 5.0 (n = 15)	0.11
Radial shortening (mm)	3.4 ± 3.6	1.7 ± 1.9	0.04
Articular gap (mm)	1.3 ± 2.3	0.8 ± 1.3	0.31
Articular stepoff (mm)	1.2 ± 1.2	1.5 ± 1.1	0.45
Displaced (number)	16	10	0.10
Range of motion (% recovery)			
Flexion-extension	84.3 ± 12.7	80.7 ± 12.4	0.30
Radioulnar	84.8 ± 17.7	79.7 ± 17.3	0.30
Supination-pronation	98.4 ± 3.4	94.6 ± 10.2	0.08
Strength (% recovery)			
Grip strength	79.2 ± 22.9	80.4 ± 18.2	0.83
Pinch strength	88.7 ± 19.0	90.5 ± 17.3	0.15
Subjective function (scaled score)			
DASH	15.7 ± 13.5	12.7 ± 11.2	0.38
PRWE	16.0 ± 14.9	12.8 ± 13.2	0.41
MASS07	8.3 ± 10.2	5.2 ± 8.7	0.23
Gartland and Werley	3.7 ± 3.0	3.4 ± 3.4	0.69
Objective hand performance (% recovery)			
Jebsen-Taylor test	93.2 ± 12.8	91.2 ± 16.0	0.62

Values are expressed as average ± standard deviation; DASH = Disabilities of the Arm, Shoulder, and Hand; PRWE = Patient-rated Wrist Evaluation; MASS07 = Modernized Activity Subjective Survey of 2007.

and MASS07, respectively) with worsened survey outcomes.

Discussion

Despite numerous techniques used to restore anatomic congruity after distal radius fractures, it is unclear if such restoration translates to improved functionality when considering an older patient population. The primary purpose of our study was to evaluate the relationship between anatomic alignment, measured by radiographic displacement and comminution, and our functional outcomes assessments. Our second question investigated the role of operative intervention on radiographic and functional outcomes; our third question assessed the influence of patient demographics (age, gender, length of followup) on the functional outcomes data.

We note some study limitations. All patients came from one tertiary care academic institution, and the results of the patient population and treatment preferences of this institution may not be generalizable to other patients in this age group. However, the demographics of our patient population (ie, age and gender) are similar to those of comparable studies [3, 19, 49]. There were various followups for patients in our study cohort (6–45 months); we recognize 6 months' minimum followup is perhaps not enough time to unmask major effects of certain potential complications of distal radius fracture, including posttraumatic arthritis, intercarpal instability, and pseudosubluxation, which may occur as a result of long-standing major malalignment. However, similar studies use a comparable followup in terms of minimum or average followup [3, 12, 19, 22, 29, 32]. Moreover, we found no correlations between length of followup and functional outcome. Nevertheless, our results may not be generalizable beyond the ranges of the radiographic data, patient age, and duration of followup included in our study. Because of the retrospective nature of our study, treatments were not randomized; all patients in our study were treated according to surgeon preference before enrollment in the study. However, data revealed no correlation between treatment modality and functional outcome. Increasing fracture comminution as defined by number of parts positively influenced rate of surgery, but we found no link between comminution and any of the assessments of functional outcome in this cohort. The functional outcomes data were collected by one investigator, as noted in the Materials and Methods section. Although this eliminates interobserver variability, the potential for systemic bias, particularly regarding the ROM data, still exists. However, we do not believe this jeopardizes the general results of our study because our conclusions are based largely on the relative, and not absolute, differences between groups. Furthermore, several studies suggest using a standard goniometer to measure ROM in joints, including the wrist, shows excellent intraobserver reliability [4, 17, 43]. In another study specifically examining the intertester and intratester reliability of ROM measurements using a standard goniometer; the intraobserver results showed the minimum detectable change in forearm rotation using a goniometer was 8° [4]. Thus, our study may not be able to resolve small differences in ROM between patient subgroups. Bone mineral density would have been useful [7, 26, 47], but was not available at the time of followup.

Comparing the results of our primary question to published results for this topic, we found several studies that attempted to correlate radiographic and functional outcomes in patients with distal radius fracture. Trumble et al. [48] also attempted to determine this correlation in a series of 52 displaced, intraarticular fractures. These fractures

were treated either nonoperatively (cast immobilization) or surgically (external fixation, open reduction and internal fixation, open reduction and internal/external fixation). Functional outcomes measured included ROM, grip strength, and pain evaluation. They reported postoperative gap, stepoff, and radial shortening were all “closely correlated” with the final functional outcomes. Age did not correlate with the functional outcomes. We examined 53 fractures treated with similar methods as those in the study by Trumble et al. [48] (ie, nonoperatively or through closed reduction/percutaneous pinning, open reduction and internal fixation, open reduction and internal/external fixation). However, we focused exclusively on patients older than 55 years with distal radius fractures. We also measured several additional outcomes such as subjective survey responses (DASH, PRWE, MASS07, Gartland and Werley score) and an objective hand performance test (Jebsen-Taylor). We found no associations between residual gap, stepoff, or radial shortening and any of the outcomes measured in the study of Trumble et al. [48] or with the additional outcomes unique to our study. Instead, we found functional outcomes were largely independent of the final radiographic outcomes. A study by McQueen and Caspers [34] evaluated the relationship between functional outcome and radiographic displacement in a series of 30 nonoperatively treated patients with distal radius fractures. The average age of the study cohort was 69 years, and 97% were female. Radiographs were analyzed with respect to dorsal angulation and radial shift, and patients were categorized as having good position or malunion based on these radiographs. The malunited group included all patients with a dorsal angulation greater than 10° or radial shift 2 mm or greater. This study assessed functional outcome using grip strength, ROM measurements, the Jebsen-Taylor test, and subjective surveys. In this study population, the patients with good reduction had improved subjective and objective outcomes compared with their counterparts with malunions. Our study population and functional assessment were similar to those used by McQueen and Caspers [34]; however, we used a more thorough radiographic evaluation. We compared groups of patients with acceptable and unacceptable deformities and compared continuous radiographic data with functional outcomes data in a multivariate analysis. Again, the results of these analyses showed no correlations between radiographic data and functional data. Others have reported results that differ from those of Trumble et al. [48]. Jaremko et al. [19] studied nonoperatively managed distal radius fractures in 74 patients 50 years or older (average age, 69 years; 83% female). Radiographic outcomes included dorsal tilt, radial angle, radial height, ulnar height, and articular gap/stepoff; subjective outcomes included DASH, SF-12, and satisfaction surveys. They reported no

differences in DASH, SF-12, or satisfaction scores between patients with and without evidence of radiographic displacement. Our study had a similar cohort of patients with an average age of 69 years and 87% female patients, and we assessed similar radiographic outcomes (except radial tilt). We likewise reported no major outcome differences between patients with and without evidence of radiographic displacement. However, our study assessed considerably more functional outcomes, including ROM, grip/pinch strength, additional surveys (such as PRWE, MASS07, Gartland and Werley score), and measures of observed function (Jebsen-Taylor performance test). Additionally, our study included a more extensive statistical analysis, comparing the outcomes of patients based on varying numbers of displaced parameters (Table 4) and continuous radiographic data. A study by Young and Rayan [49] assessed the functional outcomes in 25 sedentary, low-demand patients older than 60 years (mean, 72 years; 76% female) with displaced distal radius fractures. Radiographic outcomes included radiographic assessment of dorsal angulation, radial shortening, and radial inclination. Functional outcomes were subjective (overall satisfaction, ability to return to previous activity level, concern over appearance, functional survey) and objective (ROM, grip strength). Radiographs were scored according to the Lidstrom system as modified by Sarmiento et al. [42]. They reported no statistical correlation between the radiographic outcomes and functional outcomes (measured by the Gartland and Werley system as modified by Stewart et al. [45, 46]). Our study had similar patient demographics (with a larger patient cohort) and similar outcomes measured. However, the radiographic scoring system used in the study by Young and Rayan [49] was considerably more generous than that in our study. For example, a fracture with as much as 11 mm radial shortening and as much as 10° dorsal angulation would still have been considered a good radiographic outcome in that study. Such a fracture in our study would have been classified as displaced. Furthermore, results in that study were reported as excellent, good, fair, or poor. Our study also provided quantitative outcomes with respect to all ROM and strength, survey, and objective outcomes measured.

A secondary question addressed in our study is the effect of operative management on radiographic and functional outcomes in this patient population. The study of Trumble et al. [48] reported anatomic improvement in the patients treated by surgical means, particularly with respect to articular congruity and radial length. Similarly, our study showed resolution of dorsal angulation and radial shortening with operative treatment. Whereas Trumble et al. reported improvement in functional outcome with anatomic reduction, these benefits were not realized in our study with respect to subjective and objective functional

testing. However, we used an objective test of function and more detailed statistical analyses to investigate this relationship. For patients in whom surgery was indicated based on radiographic assessment, functional outcomes were similar to those of counterparts who did not require operative fixation.

Our third purpose in this study was to examine the role of demographic information such as gender, age, and length of followup on our results. The study by Young and Rayan [49] reported a major improvement in the outcomes of the female patients compared with their male counterparts. Although our study had a similar distribution of genders as that of Young and Rayan [49], our analysis revealed no effect of gender on the functional outcomes. With respect to age, Trumble et al. [48] observed no effect of increasing age on their results, concluding patients of all ages benefit from anatomic alignment. We found increasing patient age correlated with poorer subjective functional survey scores, although no differences were found with respect to the objective outcomes. We also observed no major relationships between patient outcomes and their length of followup and were unable to identify other studies that attempted to correlate followup to functional and radiographic outcomes.

As the preceding discussion shows, the current literature on our primary question remains equivocal, with studies that support and oppose the existence of an association between radiographic and functional outcomes in this patient population. Although our findings conflict with those of other well-designed studies, including those of Trumble et al. [48] and McQueen and Caspers [34], we believe our results provide an important piece of evidence against a relationship between anatomic deformity and functional outcome for several reasons; our patient cohort consisted of a larger group of only patients older than 55 years, and we collected a wide variety of functional outcomes data, including subjective, objective, and observed function outcomes. Furthermore, we used a more extensive statistical analysis of our data. These expansions in the methodology of our study strengthen our findings that radiographic displacement and comminution do not contribute considerably to the functional outcomes in older patients with distal radius fractures. However, although we are confident our study has clarified and added to the body of literature arguing against a relationship between functional and radiographic outcomes, this important question remains unsettled. A large, prospective trial is likely necessary to answer the question definitively. The results of our second and third investigative questions also suggest operative intervention and demographic factors (age, gender, and duration of followup) had no statistically significant influence on the radiographic and functional outcomes assessed in this study.

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