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Caitlin J. Symonette
The University of Western Ontario

Joy C. MacDermid
The University of Western Ontario

Ruby Grewal
The University of Western Ontario

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Original Research

Radiographic Thresholds With Increased Odds of a Poor Outcome Following Distal Radius Fractures in Patients Over 65 Years Old

Caitlin J. Symonette, MD, MSc, [*] Joy C. MacDermid, PhD, [*, †, ‡] Ruby Grewal, MD, MSc [*, †]

[*] Department of Surgery, Western University, London, Ontario, Canada
[†] Department of Surgery, Roth–McFarlane Hand and Upper Limb Center, St. Joseph's Health Center, London, Ontario, Canada
[‡] Department of Physical Therapy, Western University, London, Ontario, Canada

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Purpose: Older patients (aged older than 65 years) appear to tolerate a great degree of anatomic deformity after DRFs; however, the threshold beyond which the deformity becomes unacceptable is unknown. The purposes of this study were to identify the acceptable threshold for radiographic parameters after DRFs in patients aged over 65 years according to a patient-rated pain and disability outcome measure and to determine whether baseline activity levels influenced these parameters.

Methods: A cohort of 190 older adults (aged 65 years and older) with DRF were selected from an existing prospectively collected database. The influence of specific radiographic parameters (ulnar variance, radial inclination [RI], and volar-dorsal tilt) and baseline activity levels on 1-year Patient-Rated Wrist Evaluation (PRWE) scores was investigated. The odds ratio (OR) of a poor outcome according to a 1-year PRWE (cutoff score of $\geq$25) at various alignment thresholds was calculated with 95% confidence intervals (CIs). Activity level (underactive vs active) was determined using the Rapid Assessment of Physical Activity survey.

Results: Radiographic parameters for the cohort varied widely (mean ulnar variance, 1.9 ± 0.9 mm, range −2.4 to 8.0 mm; mean RI, 18.7°± 5.9°, range, 0.1° to 38°; and mean dorsal tilt, 4.5° ±11.9°, range −24.0° to 33.6°). Most of the cohort (n = 158, 83%) had a good outcome (mean PRWE, 14.4 ± 19.5). The OR of a poor outcome was significant for RI less than 20° (OR = 3.6; 95% CI 1.5–8.7) and dorsal tilt greater than 15° (OR = 5.3; 95% CI, 1.0–27.8). Malalignment on radiographs and a poor outcome according to PRWE were not significantly different in the underactive versus active subpopulations.

Conclusions: This study provides alignment cutoffs that best discriminate adverse pain and disability patient outcomes after DRF in a cohort aged more than 65 years. This information can be used to counsel older patients about their increased likelihood of a poor outcome with RI less than 20 or a dorsal tilt greater than 15°. Further research is required to examine outcomes after applying these thresholds in a prospective manner to management decision algorithms for DRF in patients aged over 65 years.

Type of study/level of evidence: Prognostic II.

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Malunion is a known complication of distal radius fracture (DRF) that can lead to functional impairment. However, unlike younger patients, individuals aged over 65 years can tolerate anatomic deformity without significant functional impairment.[1–5] Although the literature does not show a definitive advantage to obtaining anatomic alignment, there is evidence that malunions negatively influence outcomes in older patients.[6] The reason for these conflicting findings is that cohorts aged over 65 years are a heterogeneous group. Factors such as occupational roles, functional demands, activity level, social context, and the presence of medical conditions such as osteoporosis[7–9] affect outcomes after DRF. How these influence outcomes alongside alignment parameters is unknown.

Standard radiographic parameters used in a younger cohort to inform surgical decision-making do not uniformly apply to patients aged over 65 years. The literature has shown that in cohorts aged over 65 years, 1-year patient rated outcomes (Disabilities of the

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Corresponding author: Caitlin J. Symonette, MD, MSc, Department of Surgery, Western University, 268 Grosvenor Street, Room D0-215, London, Ontario N6A 4V2, Canada.

E-mail address: caitlin.symonette@gmail.com (C.J. Symonette).

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Arm, Shoulder, and Hand [DASH] and Patient-Rated Wrist Evaluation [PRWE]) are no different between surgical and nonsurgical cases despite malalignment in the nonsurgical groups. Nonsurgical 1-year postfracture radiographic values cited for 2 landmark articles include radial inclination (RI) (15.9 ±9.0°,[1] 18.0 ± 4.0°[3]), volar tilt (−10.4° ± 19.1°,[1] −5.8° ± 10.4°[3]), and ulnar variance (UV) (3.2 ± 2.9 mm,[1] 2.8 ± 1.8 mm[3]). The challenge is how to balance the interpretation of radiographic results in the context of additional factors in treatment decision-making after DRF in older individuals. It would be advantageous to be able to select cases in which conservative management is unlikely to provide good patient outcomes rather than to assume that all patients aged over 65 years do not benefit from surgery.

The purpose of our investigation was to identify radiographic alignment thresholds that could predict a poor patient outcome as defined by 1-year PRWE scores in patients aged over 65 years with a DRF. The secondary outcome measure was to determine whether malalignment and poor PRWE were different between active and underactive older individuals according to the Rapid Assessment of Physical Activity (RAPA) survey.

Materials and Methods

This study was a prospective cohort study designed to evaluate the influence of different thresholds of standard radiographic parameters on a patient-reported outcome (PRO) of pain and disability in patients aged over 65 years.

Cohort recruitment

Participants were recruited from the practices of 9 fellowship-trained hand surgeons at a single tertiary referral center between January, 1996 and December, 2014. Inclusion criteria included any individual aged 65 years and older with a DRF. Exclusion criteria included skeletally immature patients and those who were unable to complete the questionnaire or follow up, including patients with incomplete data. All participants provided informed written consent; the study was approved by the local health sciences research ethics board.

Patient demographics and injury characteristics

At the baseline visit, patient demographic and injury characteristics were recorded. Demographic data included age, gender, and activity status according to the RAPA survey.[10] The RAPA is a 9-item questionnaire containing 2 sections to assess both aerobic activities and strength and flexibility in individuals aged over 50 years. A score below 6 indicates that the individual is underactive.[10] Injury characteristics included whether the dominant or nondominant hand was injured, the overall energy of the injury (low [eg, fall from a standing height], intermediate [eg, sporting injury], or high [eg, trauma from high velocity such as a motor vehicle collision]), whether the fracture was open versus closed, and the treatment of the fracture (nonsurgical vs surgical). Bone mineral density data were also recorded when available.

Radiographic assessment

The first author recorded radiographic parameters including dorsal tilt, UV, and RI. Dorsal tilt and RI were recorded in degrees and UV was recorded in millimeters. The overall severity of the fracture was assessed according to the AO Classification system.

Outcome variable

The primary outcome variable was the PRWE score 1 year after DRF. The PRWE is a 15-item questionnaire composed of 3 subscales: pain, specific activities, and usual activities. The total score of the PRWE, including all 3 subscales, can range from 0 (no pain or disability) to 100 (maximal pain or disability). A threshold PRWE score of 25 was used to identify a poor outcome.[11]

Data analysis

We analyzed demographics and injury characteristics using descriptive statistics. The odds ratio (OR) of a poor PRWE outcome at 5° increments for RI and dorsal tilt and 1-mm increments for UV was calculated with 95% confidence intervals (CIs). Patients were not subdivided according to treatment (nonsurgical vs surgical) for the analysis. The aim was to examine how alignment thresholds influenced outcomes regardless of how that alignment was obtained (surgical or nonsurgically). $P < .05$ was considered statistically significant. We used Fisher exact test to determine whether the activity level was related to a poor PRWE score at the significant alignment thresholds determined by the OR.

Results

A total of 190 patients met eligibility criteria to be included in the study. Participants were aged 65 to 88 years (mean age, 71.8 ± 5.0 years). Most were female (171 of 190; 90%) and active (54 of 81; 66.7%) according to the RAPA survey. Approximately half of the injuries (44.5%) occurred to the dominant wrist. The mechanism of injury was commonly low-energy, such as a fall on ice or snow (26.5%) or a fall from a standing height (65.4%). The cohort included both intra-articular (AO classes B [17.6%] and C [38.8%]) and extra-articular (AO class A; 43.6%) DRFs. Most individuals were treated with closed reduction and cast immobilization (77%), whereas 23% underwent operative intervention including K-wire fixation with or without external fixation and volar plating. In the cohort, 31% (n = 35 of 112) had normal bone mineral density, 36% (n = 40 of 112) were osteopenic, and 27% (n = 30 of 112) had osteoporosis.

According to traditional malalignment parameters (UV greater than 3 mm) [n = 43 of 190; 22.6%], RI less than 20° [n = 94 of 190; 49.5%], and dorsal tilt less than 10° [25 of 190; 13.2%]), 85.3% of the cohort was malaligned on at least one parameter. Only 5.3% displayed malalignment on all 3 parameters. Average radiographic parameters for the cohort were a mean UV of 1.9 ± 1.9 mm (range, −2.4 to 8.0 mm), mean RI of 18.7 ±5.9° (range, 0.1° to 38°), and mean dorsal tilt of 4.5° ±11.9° (range, −24.0° to 33.6°).

At baseline (within 1 week after fracture), most patients (95.5%) had a poor PRWE score (mean ± SD, 64.8 ± 21.9). Fortunately, most patients (83%) had a good outcome according to the 1-year PRWE score. Average one-year postinjury PRWE score in the cohort was 14.4 ± 19.5. Table 1 lists these results according to the activity level; Table 2 shows them according to surgical versus nonsurgical treatment.

The OR of a poor outcome was 2 when UV was 4 mm or more. This indicates that the likelihood of a poor outcome was twice as likely if UV was 4 mm or more; however, this was not statistically significant (Fig. 1). The odds of a poor outcome were significantly increased for an RI less than 20° (OR = 3.6; 95% CI, 1.5–8.7; $P = .005$) (Fig. 2). In addition, the odds of a poor outcome were significantly increased for a dorsal tilt greater than 15° (OR = 5.3; 95% CI, 0.0–27.8; $P = .05$) (Fig. 3).

No significant relationship was found between activity level as determined by the RAPA survey (active, underactive, and sedentary) and traditional malalignment cutoffs for radiographic

Table 1
Demographic Information and Radiographic Parameters According to Activity Level

	Active	Underactive	*P* Value
Cohort characteristics			
Age, y	71 ± 5	73 ± 5	.49
Sex (M/F) (%)	11/89	11/89	1.00
Bone mineral density, n (normal/osteopenia/osteoporotic)	13/13/8	7/10/4	0.10
Injury characteristics			
Dominant hand (yes/no) (%)	38/62	59/40	.76
Energy of injury (low/high/other) (%)	90/0/9	82/4/15	.22
AO classification (A/B/C) (%)	26/26/47	30/22/48	.91
Surgery (yes/no) (%)	24/76	19/82	.57
Final radiographic parameters			
UV, mm	1.8 ± 1.9	1.9 ± 1.9	.81
RI (degrees)	17.8 ± 6.2	19.1 ± 5.5	.49
Dorsal tilt (degrees)	2.7 ± 12.2	5.1 ± 12.1	.56
PRWE 1 year after injury (good/poor) (%)	83.3/16.7	81.5/18.5	.83

alignment (RI of 15° or less, dorsal tilt of 10° or less, and UV of 3 mm or more)[6] resulting in a poor PRWE at 1 year after injury. A trend toward significance ($P = .07$) was determined for active individuals using the alignment cutoff values, which resulted in a poor PRWE determined in the current study (RI of 20° or less, dorsal tilt of 15° or less, and UV of 4 mm or more).

Discussion

Ideal management of unstable DRF in individuals aged over 65 years remains controversial.[1,6,12,13] Given the heterogeneous nature of this population with varying expectations, functional demands, medical comorbidities, and social situations, it is unsurprising that one approach does not fit all. This study provides discrete radiographic thresholds that may be helpful when counseling patients aged over 65 years about the likelihood of a poor outcome after DRF.

We found that the odds of a poor outcome based on the PRWE increased when the RI was less than 20° or dorsal tilt was greater than 15°. Biomechanically, loss of RI can increase the load across the lunate.[14,15] In addition, loss of the normal volar tilt of the radius leads to progressively increased contact between the radius and proximal carpals.[14,15] Alterations in the radiocarpal relation has the potential to damage articular cartilage and affect wrist stability. Wilcke et al[16] also reported a worse PRO (DASH) when the dorsal angulation was greater than 15°. Others[14] support volar tilt and UV as important factors for maintaining a good functional outcome after DRF.

The radiographic parameters we identified as a cutoff for the increased likelihood of a poor outcome were similar to those identified by other authors.[13,17] Kodama et al[13] evaluated a group of adults aged over 60 years who required a corrective osteotomy after failed conservative treatment of DRF. They reported that average parameters in this group were a volar tilt of −19.2° ± 9.7°, UV of 6.4 ± 3.4 mm, and RI of 14.1° ± 6.6°. The odds of a poor outcome were not significantly increased in relation to UV in the current study. However, the trend of a poor outcome was higher when the UV was 4 mm or greater. This may represent a clinically significant threshold, although statistical significance was not obtained. Overall, it appears that elderly patients tolerate a greater degree of ulnar positive variance than their younger counterparts.[1,13,17] We were unable to establish a significant effect of baseline activity level or bone mineral density on outcome.

Nelson et al[18] concluded that in an older cohort (aged greater than 65 years), active individuals with distal radius malunions did not have worse outcomes compared with those with well-aligned fractures. However, their study was unable to identify a malalignment threshold beyond which a poor outcome would be expected. Although it is intuitive that activity level and presumed higher demands on the wrist would influence outcomes, the literature does not support this theory. Active patients aged over 65 years must be able to accommodate functionally for the deformity after malunion of a distal radius, but these patients may not be as tolerant of secondary degenerative changes that may occur with time. However, longer-term follow-up after DRF of active patients aged greater than 65 years is required to investigate this possibility further.

Proponents of operative fixation of an unstable DRF cite a faster return to activities of daily living with improved functional and

Table 2
Demographic Information and Radiographic Parameters According to Management

	Nonsurgical	Surgical	*P* Value
Cohort characteristics			
Age, y	72 ± 0	70 ± 1	.01
Sex (M/F) (%)	12/88	5/95	.19
Injury characteristics			
Dominant hand (yes/no) (%)	45/55	43/57	.60
Energy of injury (low/high/other) (%)	90/2/8	92/0/8	.64
AO classification (A/B/C) (%)	46/19/35	37/12/51	.12
Final radiographic parameters			
UV, mm	2.1 ± 0.2	1.1 ± 0.3	.01
RI (degrees)	18.4 ± 0.5	19.5 ± 0.7	.27
Dorsal tilt (degrees)	6.7 ± 1.0	-2.8 ± 1.1	.00
PRWE 1 year after injury (good/poor) (%)	84.4/15.6	79.1/20.9	.67

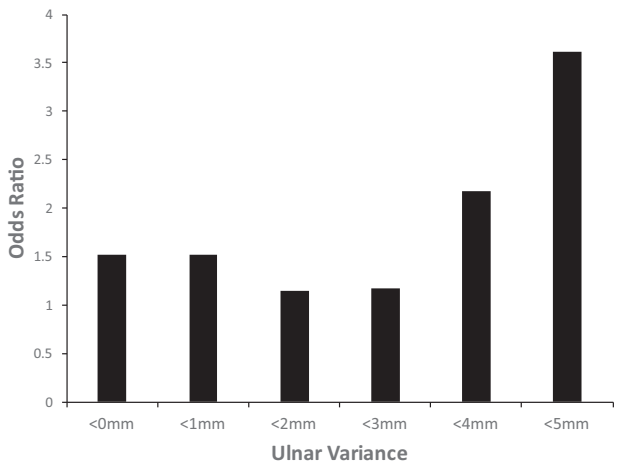

Figure 1. Odds ratio of a poor outcome with UV.

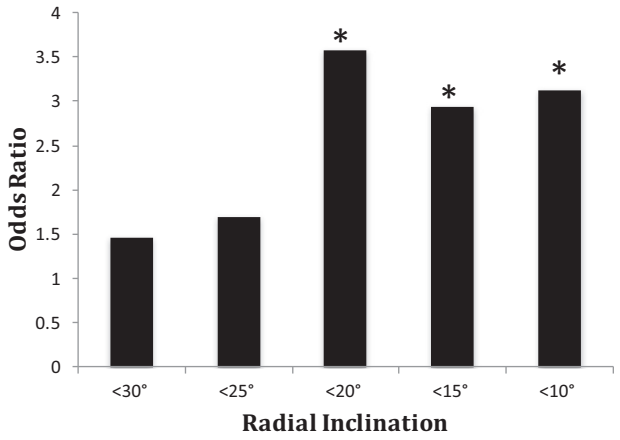

Figure 2. Odds ratio of a poor outcome with RI. *$P < .05$.

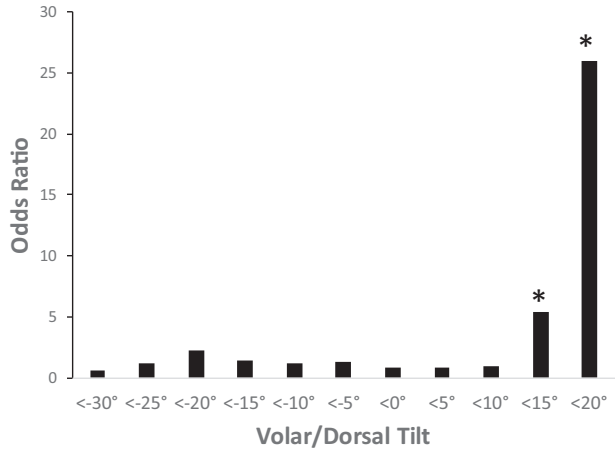

Figure 3. Odds ratio of a poor outcome with volar-dorsal tilt. Negative values indicate volar tilt and positive values indicate dorsal tilt. *$P < .05$.

radiographic parameters.[19–21] Unfortunately, operative groups have been associated with a higher complication profile. One case series of 64 older patients with intra-articular DRF treated with volar locking plate fixation showed promising results in terms of wrist range of motion and grip strength.[19] However, approximately 7% of patients required a second operation for plate removal. In a smaller group of patients treated with open reduction internal fixation (n = 20), Jupiter et al[20] described excellent results according to PRWE but complications in almost half of the cohort. In a matched cohort study of over 250 patients with DRF over age 65 years, Lutz et al[22] demonstrated a higher complication profile in the surgical compared with the nonsurgical group. The most common complications were median neuropathy, surgical site infections, and complex regional pain syndrome. Egol et al[3] looked at a retrospective cohort of patients aged over 65 years with displaced DRF. Their group concluded that final radiograph results and grip strength were superior in the operative group in which anatomic alignment was restored. However, there was no difference in pain and PROs between the surgical and nonsurgical groups at 1 year. In a systematic review of patients aged over 60 years, these results were largely echoed.[4] Reviewing 5 common techniques to manage unstable DRFs, no difference was established in range of motion, grip strength, or PRO (Disability Arm Shoulder Hand or DASH). A prospective randomized trial by Arora et al[1] comparing volar locking plate fixation with nonsurgical treatment of DRF in elderly patients also found no difference in PROs at 1 year after injury. To date, the literature does not provide strong evidence to recommend for or against operative intervention in patients aged older than 55 years.[23] Although operative intervention is a suitable alternative in select patients with DRF aged over 65 years, the increased risk of a postoperative complication with an uncertain gain in patient-perceived outcome must be weighed carefully.

Strengths of this study include a large cohort (n = 190) of prospectively collected data on DRF in patients aged over 65 years. In addition, the PRWE was specifically validated for wrist problems. A limitation of the study was that the treatment received was not randomized a priori for operative intervention. Thus, it is likely that more severely displaced fractures were managed operatively at the discretion of the surgeon. In addition, as reflected by the literature, fortunately, most subjects had a good outcome after DRF. This created a challenge when studying the rarer outcome of a poor PRWE result, in that the sample size of this subgroup was small. An additional limitation of the study was that RAPA scores employed to look at activity levels were not available for all subjects.

The odds of a poor outcome in patients aged 65 years and older according to the PRWE are increased if the postreduction RI is less than 20° or the dorsal tilt is greater than 15°. They showed a trend toward statistical significance when UV was 4 mm or greater. Activity levels and bone mineral density did not affect these parameters. This information can be used to guide clinical decision-making. Future research should be directed at identifying additional factors that may contribute to a poor outcome in the older adult population after an unstable DRF, and how best to differentiate low-demand/expectation and high-demand/expectation subgroups within this population.

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