Original Research

Evaluating the Impact of Social Deprivation on Mid-Term Outcomes Following Distal Radius Open Reduction Internal Fixation

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A R T I C L E   I N F O

Purpose: Although baseline biopsychosocial factors are associated with short-term patient-reported outcomes following distal radius fracture open reduction internal fixation (ORIF), their effect on mid-term outcomes is unclear. We aimed to evaluate the effect of social deprivation, previously established as a surrogate for depression, pain interference, and anxiety, on quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) scores >1 year following distal radius ORIF.

Methods: Adult patients (≥18 years) with an isolated distal radius fracture treated with ORIF by orthopedic trauma and hand surgeons at a single tertiary academic center over a 3-year period were included. Outcomes at ≥1 year postoperatively were evaluated using QuickDASH. Age, follow-up duration, area deprivation index (ADI; a measure of social deprivation), subspecialty (hand vs trauma), and postoperative alignment were assessed using linear regression with 95% confidence intervals after bootstrapping and a permutation test for P values to test for their association with the final QuickDASH score.

Results: Follow-up data were obtained for 98 of 220 (44.5%) patients at a mean of 3.1 ± 1.0 years after surgery. Mean age and ADI were 53.2 ± 15.4 years and 26.8 ± 18.7, respectively. Most fractures were intra-articular (67.3%), and 72.4% had acceptable postoperative alignment parameters, as defined by the American Academy of Orthopaedic Surgeons clinical practice guidelines. The mean QuickDASH score was 13.0 ± 16.5. There were no significant associations between the final QuickDASH score and any studied factor, including ADI, as determined using univariable analysis. Multivariable analysis showed no association between ADI and the final QuickDASH score, independent of age, sex, treating service, follow-up duration, and fracture alignment or pattern.

Conclusions: At mid-term follow up after distal radius ORIF, ADI did not correlate with QuickDASH scores, and the QuickDASH scores of the patients did not differ from those of the general population. However, our cohort mostly comprised patients with levels of deprivation below the national median. Although studies have shown that the short-term outcomes of distal radius ORIF are influenced by biopsychosocial factors, outcomes at the time of final recovery may not be associated with social deprivation.

Type of study/level of evidence: Prognostic IV.

Distal radius fractures represent 1 of the most commonly treated skeletal injuries.[1] Over time, the decision to treat these fractures with open reduction internal fixation (ORIF), rather than with casting, has been increasing.[2,3] Much of the research regarding the outcomes of distal radius fracture ORIF has focused on postoperative complications and the restoration of anatomic alignment.[1,4–6]

Recent research, however, has focused on biopsychosocial factors that affect the outcomes of upper- and lower-extremity surgery.[7–13] More specifically, evidence has suggested that biopsychosocial factors such as depression, pain interference, catastrophizing, education level, and income level are associated with worse short-term (≤1 year) outcomes following distal radius fractures.[7,14–16] Studies have shown that these factors and higher levels of social deprivation are also associated with lower levels of

physical function.[17–20] However, the effect of biopsychosocial factors and social deprivation on mid- and long-term outcomes remains less clear. Because the management of distal radius fractures contributes a substantial amount of burden to the health care system, it is critical to understand which factors impact the outcomes.[21,22]

The purpose of this study was to evaluate the effect of social deprivation on patient-reported outcomes more than 1 year following distal radius ORIF. Specifically, we hypothesized that increased levels of social deprivation are associated with worse outcomes, determined using quick Disabilities of the Arm, Shoulder and Hand (QuickDASH), following distal radius ORIF.

Materials and Methods

This study was approved by our institutional review board. Adult patients (≥18 years of age) who sustained a distal radius fracture treated with ORIF by orthopedic trauma and hand surgeons between January 2014 and March 2019 were identified using current procedural terminology codes (25607, 25608, and 25609). The patients were excluded if they did not have radiographs at least 5 weeks after ORIF, sustained additional upper-extremity injuries at the same time as the distal radius fracture, were less than 18 years of age, had been treated nonsurgically, or had undergone the surgery less than 1 year prior.

QuickDASH was used as a measure of functional outcome in the patients. QuickDASH is an abbreviated version of the Disabilities of the Arm, Shoulder and Hand questionnaire, a valid measure of physical function in patients with upper-limb musculoskeletal disorders. QuickDASH is a shorter, 11-item questionnaire that has been shown to have the same validity and reliability as the Disabilities of the Arm, Shoulder and Hand questionnaire, with lesser burden on the patient.[23,24]

Age, sex, follow-up duration, subspecialty (hand vs trauma), intra-articular versus extra-articular fractures, and postoperative alignment parameter data were collected via a chart review. The postoperative alignment parameter data collected included radial height, ulnar variance, and volar tilt. Acceptable postoperative parameters were defined by the American Academy of Orthopaedic Surgeons (AAOS) criteria of a radial shortening of <3 mm, a dorsal tilt of <10°, or an intra-articular stepoff of <2 mm.[25] Radial height outside of the AAOS criteria was defined as less than 8.6 mm, based on the average population's radial height.[26] The methods of measurement were based on those described by Mulders et al.[27] Patients who met the inclusion criteria were notified via email that they would be receiving a request to complete a QuickDASH questionnaire via email or phone call, and if they did not want to be contacted, they could notify the study investigators or decline the request. For responders, REDCap was used to collect QuickDASH scores at the time of final follow up.

The degree of social deprivation was measured using each patient's area deprivation index (ADI) (higher ADI represents more social deprivation; the possible range of scores span from 1 to 100). The ADI was developed by the Health Resources and Services Administration as a measure of social deprivation in a specific area based on 17 United States census-based factors, including education level, employment status, housing quality, the cost of living, and poverty level.[28,29] A patient's zip code is used to identify their ADI score. The ADI value used is reported as the national percentile. Based on data from a previous study, we expected the ADI to be associated with QuickDASH scores, where a 1-point increase in the ADI was associated with a 0.53-point (95% confidence interval: 0.26–0.80) increase in the QuickDASH score.[30] For the current study with 98 subjects, we had 80% power at a 0.05 significance

Table 1
Patient Demographic and Baseline Characteristics

Variable	Value (n = 98)
Age (y)	
Mean (SD)	53.2 (15.4)
Sex	
Male	22 (22.4%)
Female	76 (77.6%)
Race	
Caucasian	94 (95.9%)
Hispanic	3 (3.1%)
Asian	1 (1%)
Area deprivation index	
Mean (SD)	26.8 (18.7)
Quartile 1 (range 1–25)	54 (55.1%)
Quartile 2 (range 25–50)	36 (36.7%)
Quartile 3 (range 51–75)	4 (4.1%)
Quartile 4 (range 76–100)	4 (4.1%)
Treating orthopedic subspecialty	
Hand	78 (79.6%)
Trauma	20 (20.4%)
Follow-up duration (y)	
Mean (SD)	3.1 (1.0)
Range	1–98
Alignment parameters outside of AAOS criteria	
Yes	27 (27.6%)
No	71 (72.4%)
Fracture type	
Extra-articular	32 (32.7%)
Intra-articular	66 (67.4%)

level to detect an effect size of 0.089 or greater in a multivariable regression model adjusting for 5 additional variables.

Associations between variables of interest and the final QuickDASH score were analyzed using univariable and multivariable linear regression analyses. Because the QuickDASH score distribution exhibited a notable right skew with a minimum value of 0, we used bias-corrected and accelerated 95% bootstrap confidence intervals and permutation test *P* values estimated from 3,000 samples. To obtain *P* values, on each iteration, we permuted QuickDASH values across the subjects, and the *P* values were estimated as the proportion of coefficients that were as extreme as or more extreme than the coefficients estimated for the original data. Regression coefficients were reported as mean changes in QuickDASH scores. The analyses were conducted using R, version 4.0 (R Core Team [2020]. R: A language and environment for statistical computing. R Foundation for Statistical Computing. https://www.R-project.org/). *P* values <.05 were deemed significant. All the tests were 2-sided.

Results

A total of 371 patients were identified using the current procedural terminology code query, and 220 met the inclusion criteria. Follow-up QuickDASH scores at least 1 year after surgery were obtained for 98 of 220 (44.5%) patients at a mean of 3.1 ± 1.0 years after surgery. The mean age was 53.2 ± 15.4 years, and 77.6% (76/98) of the patients were women (Table 1). Most fractures were intra-articular (67.3%), and 72.4% had acceptable postoperative AAOS alignment parameters. For patients with alignment parameters outside of the AAOS criteria, the majority had unacceptable radial height (23/27, 85.2%), whereas 2 (7.4%) patients had a dorsal angulation of >10°, and 3 (11.1%) patients had an intra-articular stepoff of >2 mm. The mean ADI percentile was 26.8 ± 18.7 (interquartile range: 14.0–37.8), representing the bottom of the second quartile, and the mean QuickDASH score was 13.0 ± 16.5. The average QuickDASH score of patients with alignment parameters within the AAOS criteria was 14.4 ± 17.9, whereas the average QuickDASH score of patients with alignment parameters outside of

Table 2
Distal Radius Alignment Parameters for Patients With Parameters Within or Outside of AAOS Criteria

Value	All Patients	Alignment Parameters Within AAOS Criteria (n = 71)	Alignment Parameters Outside of AAOS Criteria (n = 27)
Radial height (mm)	10.1 ± 2.0	10.9 ± 1.7	8.1 ± 1.1
Volar angulation (°)	5.2 ± 6.5	5.9 ± 5.6	3.6 ± 8.5
Intra-articular stepoff (mm)	0.2 ± 0.6	0.1 ± 0.4	0.4 ± 0.9

the AAOS criteria was 9.3 ± 11.7 ($P > .05$). Most patients (95/98 or 96.9%) were treated with volar plate fixation, whereas the remaining patients were treated with a dorsal spanning plate. Table 2 presents data regarding the radial height, angulation, and stepoff for each group's AAOS alignment parameters.

In the univariable analysis (Table 3), no significant association was found between the final QuickDASH score and any studied factor, including ADI, final fracture alignment, type of fracture (intra- vs extra-articular), treating service, sex, or age. Similarly, in the multivariable analysis (Table 3), no association was found between ADI and the final QuickDASH score, independent of age, sex, treating service, fracture type, final fracture alignment, or follow-up duration.

Discussion

The main finding of this study is that at an average of 3.1 years after distal radius ORIF in a cohort with an average ADI of 26.8 ± 18.7 (interquartile range 14.0–37.8), the outcomes are not affected by social deprivation, as measured using the ADI. The ADI serves as a surrogate for a variety of biopsychosocial factors, with the prior demonstration of a significant correlation with depression, anxiety, and pain interference.[20] Furthermore, we found no association between the final QuickDASH score and any of the variables investigated, including age, fracture type, final alignment parameters, or sex.

There has been increasing focus on biopsychosocial factors that are associated with the patient-reported outcomes of upper- and lower-extremity surgeries.[7–13] In a recent study, Jayakumar et al suggested that factors such as depression, pain interference, and pain catastrophizing, which are associated with higher levels of social deprivation, are associated with worse early outcomes following distal radius fractures.[7,17–20] Notably, this study was specific to adult patients with distal radius fractures, although only 16% of the enrolled patients had undergone ORIF. With the caveat that the study population differed from that of the current study, the use of opioids and greater pain interference or pain catastrophizing within 1 week of injury were predictive of the results at 6–9 months after surgery. This must be interpreted in light of their evaluation of the early postoperative phase because other studies have suggested that continued recovery after distal radius fractures can be expected for 1 or more years after surgery.[31–35]

In addition, in a prospective study, Chung et al[15] found that in 66 patients, worse outcomes 1 year after distal radius ORIF, as measured using the Michigan Hand Outcome Questionnaire, were associated with increased age and lower income. In addition, there was no association with sex, fracture classification, radiographic parameters, or workers' compensation status. Additionally, in another prospective study, MacDermid et al[36] found that in 120 patients sustaining a distal radius fracture (with varying treatment options), injury compensation and lower levels of education were associated with worse outcomes at 6 months after fracture, as

measured using the patient-rated wrist evaluation. It should be noted that the ADI takes into account an area's average income and education level, and our results would argue that these factors might play a role in the short-term outcomes of distal radius fractures but may not actually have an effect on their mid- or long-term outcomes. In fact, in the current study, it was found that at a mean of 3.1 years following ORIF, the QuickDASH scores were actually similar to those of the general population.[37] This suggests that provided a long enough follow-up period, patients undergoing ORIF for a distal radius fracture function similar to the general population, regardless of social deprivation and other biopsychosocial factors that may be impactful in the early recovery phase.[7]

We also found that regardless of whether the patients' final radiographic parameters were within the AAOS criteria or not, there was no clinically relevant or statistically significant difference between each group's QuickDASH score.[38] There has been a large amount of research on the radiographic parameters that are the most important to restore after a distal radius fracture. Studies have suggested that malunions involving dorsal angulation, ulnar variance, and radial height tend to have worse outcomes.[39–43] However, multiple studies have also suggested that clinically important differences in the outcomes are not associated with anatomic radiographic reduction parameters and that other factors may play a more important role.[27,44–52] This study supports that near-anatomic reduction, especially at the time of long-term follow up, may provide no clinically important additional benefit. More studies are needed to evaluate whether a poor anatomic reduction leads to long-term issues due to potential changes in carpal stability and radiocarpal degenerative changes.

We also found that age had no impact on the QuickDASH scores at the time of final follow up. Therefore, despite how young or old a patient was, their outcome was essentially the same after distal radius ORIF. Older patients are thought to place less demand on their wrist and, therefore, usually treated with the traditional method of casting and closed reduction because it is thought to have the same final outcome as operative treatment.[53–55] However, there has been a growing trend toward fixing distal radius fractures in older adults rather than treating them conservatively because of the advent of volar locking plates.[56] Although studies have shown that ORIF may provide an improvement in the outcome scores and grip strength earlier, most patients have the same outcome at 1 year or more.[56–59]

There are several limitations to this study. The retrospective nature of this study introduces inherent biases based on the study's design. Furthermore, QuickDASH questionnaires were sent out to patients for response, and our response rate was 44.5%; thus, there was likely a large component of responder bias that could not be accounted for. Our results may have changed with a greater follow-up rate. Although some studies may call into question the validity of QuickDASH, multiple studies in the literature have supported the use of this patient-reported outcome measure for distal radius fractures, and it has been established as a primary outcome measure.[23,60–65] In addition, the generalizability of these results is somewhat limited. Our sample of patients included only patients treated with ORIF, and therefore, the result does not apply to patients treated with closed reduction and casting. In addition, the median patient age was 56 years, and the mean ADI was 26.8 (relatively low levels of social deprivation); so, these results may not apply to much older or younger patients as well as to more or less socially deprived areas. We acknowledge that although this ADI may have captured a group of less disadvantaged or deprived patients, the results of this study provide at least 1 data point indicating that perhaps biopsychosocial factors play less of a role in long-term outcomes. Further studies should continue to

Table 3
Univariable and Multivariable Regression Analyses With Bootstrapped Confidence Intervals for Correlation With QuickDASH Score[*]

Variable[†]	Univariable Coefficient (95% CI)	P Value	Multivariable Coefficient (95% CI)	P Value
Age	0.09 (−0.11 to 0.25)	.45	0.20 (−0.05 to 0.55)	.10
Female versus male sex	−3.0 (−17.2 to 3.7)	.46	−3.5 (−17.2 to 6.7)	.44
ADI	0.11 (−0.05 to 0.43)	.23	0.14 (−0.04 to 0.42)	.14
Trauma versus hand service	3.2 (−3.5 to 12.6)	.46	4.2 (−2.7 to 12.6)	.33
Follow-up duration	2.4 (−0.45 to 6.2)	.14	2.5 (−0.32 to 6.1)	.13
Parameters outside AAOScriteria	−5.1 (−10.9 to 0.95)	.18	−5.1 (−12.3 to 0.73)	.20
Extra-articular versus intra-articular fractures	−3.6 (−10.0 to 1.7)	.30	−3.6 (−10.4 to 1.9)	.33

CI, confidence interval.
[*] Reported as mean differences.
[†] Independent variables. The dependent variable is the QuickDASH score.

investigate this in more socially deprived patients. Last, we used the ADI as the biopsychosocial factor of interest in this study. Although studies have shown that factors such as depression and pain interference are associated with higher levels of social deprivation and lower levels of physical function, the true measures of each patient's level of depression, anxiety, or pain interference were not data points in this study.[17–20]

The results of this study in a relatively narrow cohort contribute to the growing literature that focuses on the psychological and socioeconomic factors that contribute to the outcomes of hand surgery and, more specifically, distal radius fracture ORIF. Prior studies have suggested that depression, anxiety, income, employment, and education levels impact outcomes up to 1 year after a distal radius fracture.[66–68] However, at mid-term follow up, we found that ADI deprivation, which has previously been established as a surrogate for depression, pain interference, and anxiety, was not associated with the functional outcomes.[20]

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