The Association Between Psychological Factors and Outcomes After Distal Radius Fracture

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Purpose The aim of this study was to identify psychological factors associated with pain intensity and disability following distal radius fracture.

Methods We prospectively followed 216 adult patients with distal radius fracture for 9 months. Demographics, injury and treatment details, and psychological measures (Hospital Anxiety and Depression Score [HADS], Pain Catastrophizing Scale, Posttraumatic Stress Disorder Checklist−Civilian, Tampa Scale for Kinesiophobia, Illness Perception Questionnaire Brief [IPQB], General Self-Efficacy Scale, and Recovery Locus of Control [RLOC]) were collected at enrollment. Multivariable linear regression was used to identify factors associated with Disabilities of the Arm, Shoulder, and Hand Questionnaire (DASH) and Likert pain scores.

Results Higher 10-week DASH scores were associated with increased age, the presence of a nerve pathology, increased HADS Depression subscale scores, increased IPQB scores, and lower RLOC scores. Higher 9-month DASH scores were associated with increased age, increased deprivation scores, increased numbers of medical comorbidities, a greater degree of radial shortening, increased HADS Depression subscale scores, and lower RLOC scores. A higher 10-week pain score was associated with increased deprivation and IPQB scores. A higher pain score at 9 months was associated with an increased number of medical comorbidities.

Conclusions Psychosocial factors measured early after fracture are associated with pain and disability up to 9 months after distal radius fracture. Illness perception is a potentially modifiable psychological construct not previously studied in hand conditions. It may provide a suitable target for psychological interventions that could enhance recovery. *(J Hand Surg Am. 2022;47(2):190.e1-e10. Copyright © 2022 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Prognostic II.

Key words Distal radius, fracture, patient-reported outcome, psychology.

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Distal radius fracture is a common injury. The majority of people recover well, but a proportion have ongoing pain, stiffness, deformity, and functional limitations. Associations between these outcomes, injury characteristics, and treatment methods are unpredictable. For example, a deformed wrist is not always painful, stiff, and functionally limiting.

It is recommended that radiocarpal alignment and radial length be restored and an articular gap of less than 2 mm be achieved to optimize outcomes after distal radius fracture.[1–6] However, the associations between these radiographic parameters and patient-reported outcomes (symptom intensity and disability) are inconsistent.[1,7–10]

The World Health Organization (WHO) recognizes the impact of psychological, social, and environmental factors in the translation of a pathophysiological (biomedical) process to disability, symptom intensity, and ultimately health.[11] It has been demonstrated that psychosocial factors are associated with patient-reported outcomes and pain responses in a number of conditions affecting the hand.[9,12,13] The psychological response to fracture and the specific role that individual psychological factors play in recovery remain poorly understood. The identification of potentially modifiable psychological factors that can be measured quantitatively at an early stage following injury and are associated with longer-term outcomes may help target additional psychological interventions aimed at enhancing recovery.

The aim of this prospective cohort study was to identify psychological factors, measured within 4 weeks of injury, that are associated with disability and pain intensity at 10 weeks and 9 months after distal radius fracture.

MATERIALS AND METHODS

All patients with distal radius fractures presenting within 4 weeks of injury to a single orthopedic trauma department at the Royal Infirmary Edinburgh, Edinburgh, UK, between August 2015 and February 2016, were assessed for eligibility for recruitment into the study. This department is the sole provider of orthopedic trauma care to patients over age 13 for a population of approximately 560,000.[14] All skeletally mature patients age 16 and over were included, regardless of treatment type. Patients were offered 1 of either: open reduction and internal fixation with a volar plate, closed reduction and cast, or cast immobilization alone. Treatment decisions were made by the consultant orthopedic surgeon in charge of care following a discussion of treatment options with the patient. Patients were excluded if they declined involvement, did not speak English, lacked the cognitive capacity to understand and complete questionnaires, were undertaking injury compensation proceedings, were using illicit drugs, or had a psychiatric diagnosis resulting in psychosis. The study was approved by the South East Scotland Research Ethics Service.

Details of demographics, the level of social deprivation (The Scottish Index of Multiple Deprivation[15]), medical history, radiographic parameters; Orthopaedic Trauma Association (AO-OTA) fracture classification,[16] radiocarpal alignment, radial shortening, and dorsal tilt, injury and treatment characteristics, and psychological assessment questionnaires were collected prospectively at enrollment. Outcome questionnaires were completed at a mean of 10 weeks and 9 months. Psychological measures were the Hospital Anxiety and Depression Score (HADS) Depression subscale, HADS Anxiety subscale, Pain Catastrophizing Scale (PCS), Tampa Scale for Kinesiophobia (TSK), Posttraumatic Stress Disorder Civilian Checklist (PCL-C), Illness Perception Questionnaire Brief (IPQB), General Self-Efficacy Scale (GSES) and Recovery Locus of Control (RLOC) scores. Outcome measures were the Disabilities of the Arm, Shoulder, and Hand Questionnaire (DASH) score and Numerical Rating Scale (NRS) pain score.

Psychological measures

The HADS is a 14-item scoring system used to screen patients for symptoms of anxiety and depression.[17] It has both Anxiety and Depression subscales, each with 7 items scored between 0–3, giving a score of between 0 and 21 for each. The PCS is a 13-question scoring system of catastrophic thinking, scored between 0 and 52.[18] Higher scores reflect higher levels of catastrophic thinking. The TSK measures fear of movement related to pain or fear of reinjury.[19] It is scored between 17 and 68, with higher scores representing greater fear avoidance behavior. The PCL-C assesses symptoms of posttraumatic stress disorder. It is scored between 17 (low) and 85 (high).[20,21] The IPQB is a 9-item measure in which each question represents 1 dimension of illness perception (consequence, timeline acute/chronic, timeline cyclical, personal control, treatment control, identity, coherence, emotional representation, and cause). An overall score is calculated, which represents the degree to which an illness or injury is perceived to be threatening (high) or benign (low).[22] The GSES assesses beliefs about the personal ability to cope with difficult situations: perceived self-efficacy.[23,24] It is

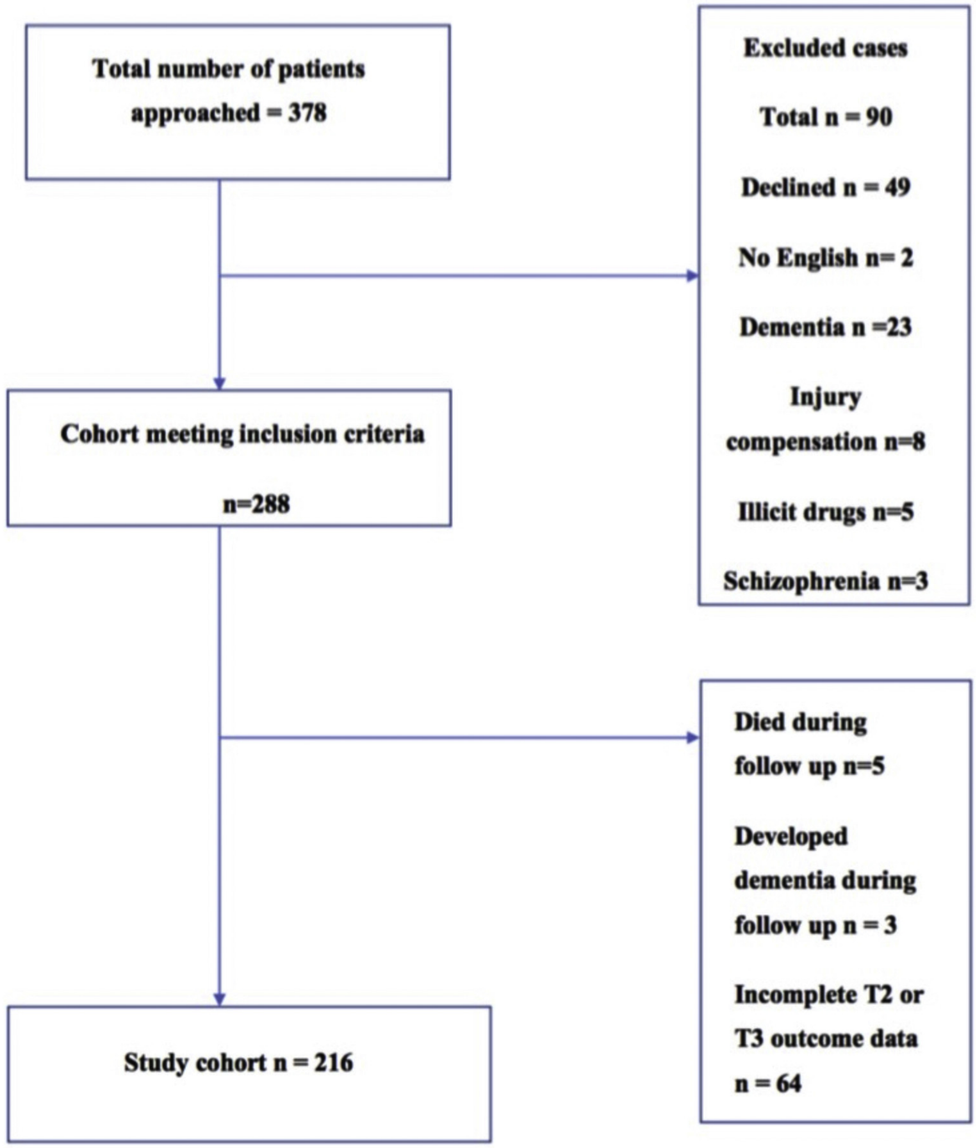

FIGURE 1: Final study cohort.

scored from 10 (low) to 40 (high). The RLOC is used to evaluate an individual's beliefs about the control they have over their recovery from a traumatic event.[25] It is scored from 9 (high external locus) to 45 (high internal locus). "High external locus" refers to a patient's belief that their recovery is dependent on external factors that they have no control over, in contrast to a "high internal locus," which refers to a mindset where patients believe they have control over the recovery from and outcome of their injury.

Outcome measures

The DASH score is a patient-reported scoring system used in the assessment of upper extremity conditions. It is scored between 0 and 100, with a higher score representing greater disability.[26,27] It contains items that assess all 3 aspects of the WHO's International Classification of Functioning, Disability and Health (ICF) framework: impairment, activity limitation, and participation restriction.[28] The NRS pain score assesses average pain over the preceding week, measured on an 11-point Likert scale from 0 (no pain) to 10 (worst pain imaginable).

Posteroanterior and lateral radiographs of the wrist were taken in a standard manner. All radiographic assessments were carried out by a single Trauma and Orthopaedic Specialty Trainee Registrar using a picture-archiving and communication system (Carestream, Version 11.40.1253).

Cohort

Of the 288 patients with complete outcome data at both 10 weeks and 9 months, 216 formed the final study cohort (Fig. 1). Details of the study cohort and a comparison with those lost to follow-up are seen in Appendix E1 (available online on the *Journal*'s website at www.jhandsurg.org).

Statistical methods

Descriptive statistics were used to present demographic, comorbidity, injury, treatment, radiographic, and psychological characteristics. Patients who did not complete follow-up are compared to the study cohort in Appendix E1. The Wilcoxon signed rank test and Freidman's test were used to assess changes in outcome variables over time.

The response variables were DASH scores and pain intensity at 10 weeks and 9 months. The explanatory variables were age; sex; social deprivation quintile; number of medical comorbidities; AO-OTA fracture classification (grouped as A, B, or C); nerve pathology; multiple fractures; radiographic alignment at T2: radiocarpal alignment, radial shortening, and dorsal tilt; surgical or nonoperative management; time to presentation and follow-up; and psychological measures (HADS Anxiety, HADS Depression, PCS, TSK, PCL-C, IPQB, GSES, and RLOC scores). Spearman correlations, Mann-Whitney U tests, and Kruskal-Wallis tests were used for nonparametric data and Pearson correlations, Student *t* tests, and analyses of variance were used for parametric data. Factors with P values $<$ .1 in a bivariate analysis were entered into multivariable linear regression models. Where there was a correlation of $>$0.7 between factors in any regression analysis, 1 factor was dropped from the model. For the study cohort of 216 patients, outcome data were 100% complete and data for each explanatory variable were over 90% complete. Missing explanatory variable data were completed with mean imputation.

RESULTS

Enrollment psychological scores are shown and compared to normative and chronic pain cohorts in Table 1. The enrollment psychological scores of the study cohort were better than those of both chronic pain and normative populations. Radiographic outcomes following treatment are seen in Table 2.

Disability and pain

The median DASH and NRS pain scores improved with time. DASH returned to near the quoted normal population value of 10 (Table 3).[37]

Multivariable regression analysis

Those factors associated with outcomes at each time point on bivariate analysis ($P < .1$) were entered into the multivariable regression analysis.

Table 4 shows the factors included in the multivariable regression models that predicted worse DASH scores at 10 weeks ($P < .05$; adjusted [adj] $R^2 = 0.4$) and 9 months ($P < .05$; adj $R^2 = 0.3$). Increasing age, level of social deprivation, HADS Depression subscale score, IPQB score, an external locus of control (RLOC), and nerve pathology were associated with an increased DASH score at 10 weeks. Increasing age, level of social deprivation, HADS Depression subscale score, an external locus of control (RLOC), an increased number of medical comorbidities, and increased radial shortening were associated with an increased DASH score at 9 months.

Table 5 shows the factors included in the multivariable regression models that predicted increased pain scores at 10 weeks ($P < .05$; adj $R^2 = 0.3$) and 9 months ($P < .05$; adj $R^2 = 0.2$). Increasing levels of social deprivation and IPQB scores were associated with increased pain scores at 10 weeks. An increasing number of medical comorbidities was associated with an increased pain score at 9 months.

DISCUSSION

This study identifies a number of demographic, psychosocial, and injury characteristics associated with outcomes after distal radius fracture. It confirms the association with psychosocial factors, as previously demonstrated in other conditions of the upper limb. It identifies illness perception, RLOC, and depressive symptoms as specific psychological factors that can be measured within 4 weeks of injury and are associated with longer-term DASH scores. These may provide potential targets for psychological interventions to enhance recovery from this common injury.

Increased age was associated with an increased DASH score at 9 months and was the factor most strongly associated with an increased DASH score 10 weeks after injury. This is unsurprising given the reduced functional level that comes with increasing age, and likely reflects the higher baseline levels of disability seen as patients get older.[38]

An increased level of social deprivation was associated with worse DASH scores at 10 weeks and 9 months and a higher pain score at 10 weeks. Similar trends are seen in pediatric upper extremity fracture[39] and carpal tunnel syndrome.[40] The association is less profound when measures that more specifically assess impairments are used. A prospective study of 3,893 patients with distal radius fracture found that

TABLE 1. Comparison of Mean Cohort Enrollment Psychological Scores with Reference Populations

Psychological Factor	Distal Radius Fracture Study Cohort, Mean (Range, SD, 95% CI)	Reference Normative Population Scores	Reference Chronic Pain Population Scores
PCS	6.9 (0–47, 9.1, 6–8)	12 (0–52, 9.1)[29]	20.9 (0–50, 12.5)[30]
HADS Depression	3.1 (0–15, 3.2, 2.7–3.6)	Female 4.1 (3.8)[31] Male 3.8 (3.7)[31]	8.1[32]
HADS Anxiety	4.6 (0–16, 3.5, 4.1–5.1)	Female 6.8 (4.2)[31] Male 5.5 (4)[31]	9.3[32]
TSK	37.9 (22–55, 6, 37–39)	n/a	41.2 (9.4)[33]
PCL-C (PTSD)	23.6 (17–71, 9.5, 22–25)	Gunshot wound 30 (22–48)[34] Assault 30 (23–53)[34] Fall 21 (18–28)[34]	35 (13)[35]
IPQB	33 (0–61, 12, 31–34)	n/a	n/a
GSES	31.9 (12–40, 5.3, 31–33)	n/a	29 (6)[36]
RLOC	35.6 (20–45, 4.9, 35–36)	n/a	n/a

CI, confidence interval; n/a, not available; PTSD, posttraumatic stress disorder.

TABLE 2. Radiographic Outcomes Following Treatment*

	n (%)	
	Study Cohort	Incomplete Follow-Up
Radiographic Parameters at 10 Weeks	n = 216	n = 72
Radiocarpal alignment maintained		
Yes	151 (70)	55 (76)
No	65 (30)	17 (24)
Dorsal tilt degrees Mean (range, SD, 95% CI)	0 (−39 to 43, 14, −2 to 2)	−2 (−12 to 31, 11, −5 to 1)
Ulnar variance, mm Mean (range, SD, 95% CI)	1 (−4 to 11, 3, 1–2)	1 (−7 to 10, 2, 0–1)

CI, confidence interval.
*Data provide a comparison of participants in the study cohort to those lost to follow-up.

TABLE 3. Change in Outcome Variables Over Time

	Enrollment (<3 Weeks)	10 Weeks	9 Months	*P* Value
Median DASH (IQR)	n/a	28 (14–45)	13 (4–29)	<.05*
Median NRS pain score (IQR)	5 (2–6)	4 (2–6)	2 (1–4)	<.05†

IQR, interquartile range; n/a, not available.
*Wilcoxon signed rank test.
†Friedman's test.

increased social deprivation was not associated with a decreased range of motion, grip strength, or the Moberg Pick-Up Test. These measures are more specific to wrist impairment than the DASH score, which measures the broader concept of patient-reported disability in the upper extremity.[28]

The number of medical comorbidities a patient had at the time of injury was associated with longer-term outcomes, pain, and disability at 9 months. This may be due to a slower functional recovery from fracture in more frail populations, as well as the incidental influence of comorbid conditions.[41,42]

TABLE 4. Factors From Multivariable Linear Regression Models That Predict DASH Scores at 10 Weeks and 9 Months Following Distal Radius Fracture

Variable	Regression Coefficient (Unstandardized)	Standardized Coefficient	95% Confidence Limits	*P* Value
DASH score at 10 weeks				
Age (increased age with higher DASH)	0.4	0.3	0.2 to 0.5	<.05
SIMD quintile 1 (most deprived)	9.7	0.2	2.0 to 17.4	<.05
HADS Depression	1.5	0.2	0.4 to 2.6	<.05
IPQB	0.4	0.2	0.2 to 0.7	<.05
Nerve pathology	16.0	0.1	3.3 to 28.6	<.05
RLOC	−0.6	−0.1	−1.1 to −0.1	<.05
Sex (female with higher DASH score)	1.7	0.0	−3.9 to 7.4	.548
Number of medical comorbidities	0.6	0.0	−0.8 to 2.1	.396
Fracture at multiple site in body	2.0	0.0	−6.1 to 10.1	.627
Dorsal tilt	0.1	0.1	−0.1 to 0.2	.581
Radial shortening	0.8	0.5	−0.2 to 1.2	.107
Radiocarpal alignment	0.4	2.7	−4.8 to 5.6	.886
PCS	0.0	0.2	−0.3 to 0.4	.787
HADS Anxiety	−0.6	0.4	−1.4 to 0.3	.186
PTSD	0.1	0.2	−0.3 to 0.5	.739
TSK	−0.1	0.2	−0.6 to 0.4	.785
GSES	0.1	0.3	−0.4 to 0.7	.581
Time to follow-up	−1.0	0.6	−2.1 to 0.2	.091
DASH score at 9 months				
SIMD quintile 1 (most deprived)	10.1	0.2	2.1 to 18.1	<.05
HADS Depression	1.4	0.2	0.3 to 2.5	<.05
Age (increased age with higher DASH score)	0.2	0.1	0 to 0.3	<.05
Number of medical comorbidities	1.6	0.1	0.1 to 3.2	<.05
Radial shortening	1.1	0.1	0.1 to 2.1	<.05
RLOC	−0.6	−0.1	−1.2 to −0.1	<.05
Sex (female with higher DASH score)	4.9	3.0	−1.1 to 10.8	.109
Dorsal tilt	0.0	0.1	−0.2 to 0.3	.683
Radiocarpal alignment	0.4	2.7	−5.0 to 5.8	.887
AO-OTA Group B	−3.4	3.3	−9.9 to 3.0	.295
Nerve pathology	12.2	6.7	−1.0 to 25.4	.070
PCS	−0.1	0.2	−0.4 to 0.2	.454
HADS Anxiety	−0.2	0.4	−1.1 to 0.7	.646
PTSD	0.3	0.2	−0.1 to 0.7	.134
TSK	−0.1	0.3	−0.6 to 0.4	.676
IPQB	0.1	0.1	−0.1 to 0.4	.365
GSES	0.0	0.3	−0.5 to 0.5	.972
Time to follow-up	−0.3	0.4	−1.1 to 0.5	.429

PTSD, posttraumatic stress disorder; SIMD, The Scottish Index of Multiple Deprivation.

The association between these demographic factors and patient reported outcome measures (PROMs) is strong but these factors are not modifiable in the context of treatment of distal radius fracture. The potentially modifiable factors most strongly associated with outcomes are psychological, and therefore these are of interest.

TABLE 5. Factors From Multivariable Linear Regression Models That Predict Pain Scores 10 Weeks and 9 Months Following Distal Radius Fracture

Variable	Regression Coefficient	Standardized Coefficient	95% Confidence Limits	*P* Value
NRS pain score at 10 weeks				
IPQB	0.1	0.3	0 to 0.1	<.05
SIMD quintile 1 (most deprived)	1.0	0.1	0 to 2.0	<.05
Sex (female with higher score)	0.1	0.4	−0.6 to 0.8	.756
Number of medical comorbidities	−0.0	0.1	−0.2 to 0.2	.875
Nerve pathology	0.7	0.8	−1.0 to 2.3	.415
Radiocarpal alignment	−0.1	0.3	−0.7 to 0.6	.881
Radial shortening	0.1	0.1	0.0 to 0.2	.157
Dorsal angulation	0.0	0.0	0.0 to 0.0	.102
PCS	0.0	0.0	0.0 to 0.1	.245
HADS Depression	0.0	0.1	−0.1 to 0.1	.974
HADS Anxiety	0.1	0.1	−0.1 to 0.2	.340
PTSD	0.0	0.0	0.0 to 0.1	.847
TSK	0.0	0.0	−0.1 to 0.1	.774
GSES	0.0	0.0	−0.1 to 0.1	.688
RLOC	0.0	0.0	−0.1 to 0.0	.219
Time to follow-up	−0.1	0.1	−0.3 to 0.0	.050
NRS pain score at 9 months				
Number of medical comorbidities	0.2	0.1	0 to 0.4	<.05
Sex (female with higher score)	0.1	0.4	−0.7 to 0.9	.814
Radial shortening	0.1	0.1	−0.1 to 0.2	.329
Dorsal angulation	0.0	0.0	0.0 to 0.0	.354
PCS	0.0	0.0	0.0 to 0.0	.894
HADS Depression	0.0	0.1	−0.1 to 0.2	.627
HADS Anxiety	0.0	0.1	−0.1 to 0.1	.650
PTSD	0.0	0.0	0.0 to 0.1	.330
IPQB	0.0	0.0	0.0 to 0.1	.166
GSES	0.0	0.0	−0.1 to 0.1	.923
RLOC	0.0	0.0	−0. to 0.0	.450
AO-OTA Group C	0.4	0.4	−0.4 to 1.1	.361

PTSD, posttraumatic stress disorder; SIMD, The Scottish Index of Multiple Deprivation.

Increased levels of depressive symptoms and a belief in an external locus of control (belief that the outcome is dependent on others rather than oneself) were associated with increased disability at 10 weeks and 9 months. An increased perception that injury posed a threat to health (IPQB score) was associated with increased disability and pain at the 10-week follow-up.

The measured psychological score after injury is likely to reflect both an individual's preinjury condition and their response to injury. It was not possible to make a distinction between the 2 with our data because patients were recruited after injury. A better understanding of this association would help target interventions, because acute psychological responses to injury may be more amenable to modification with interventions than long-standing psychological traits.

These findings are in keeping with work in the wider orthopedic literature. In cross-sectional studies of patients with mixed upper limb conditions, depressive symptoms have been associated with poorer grip strength, patient-reported functional outcomes, and pain.[43–45] In a cross-sectional study of 594 patients with acute hand and wrist fractures, Ross et al[46] found that depression affected the relationship between pain and disability. Nota et al[47] found that increased depressive symptoms at enrollment were associated with poorer functional scores 8 months following injury in a longitudinal study of a mixed cohort of orthopedic trauma patients. A longitudinal study of patients admitted to hospital with injuries (Injury Severity Score $\geq$ 9) found an association between illness perceptions at 3 months and functional outcomes at 6 months following injury.[48]

Baseline psychological scores in the study cohort were better than established normative scores. Catastrophic thinking is thought to have a dose-dependent association with outcomes.[49] This may explain the failure of this study to corroborate the previously demonstrated association between catastrophic thinking and outcomes.

Injury, radiographic, and treatment factors were associated with outcomes to a lesser degree than demographic and psychological factors. The presence of symptoms or signs of nerve pathology was associated with increased disability at 10 weeks and the degree of radial shortening was associated with the severity of disability at 9 months. No other associations were found between biomedical factors and outcomes in this study.

Radial shortening has been associated with outcomes following distal radius fracture in a number of other studies but, in general, the associations between radiographic measures and patient-reported outcomes are inconsistent.[1,7–10] It should be noted that in the cohort of patients studied, the majority of the injuries were low energy, and good radiographic outcomes were achieved. This may have reduced the influence of these factors on the outcomes.

Although the cohort is from a well-defined population, those lost to follow-up were younger and had radiographically less severe injuries. Patients with a cognitive impairment or psychosis were excluded. Baseline psychological scores in the study cohort were better than recognized normative values. Variation in baseline scores would be expected in different populations, but the reasons for better scores in this cohort are unclear. These points must be considered when generalizing the results. The results do not establish causality.

The average time to a final follow-up was 9 months. The majority of recovery should have occurred within this period, and in the study cohort the mean DASH score had returned to near population normative levels.[50,51] However, outcomes can still be expected to improve beyond this point. The R^2 value in the multivariable regression models indicates that a proportion of the variance in outcome scores remains unexplained.

Of the psychological factors identified, more were associated with variance in disability than variance in pain. The DASH score contains items that measure pain, activity limitations, and restrictions in social participation.[28] Thus, the larger number of predictive factors for this measure might simply reflect the fact that disability is a broader concept than pain and, as such, has more variability.

There may be unrecognized collinearity between factors used as entry variables. This was addressed by dropping 1 entry variable in the event of a correlation coefficient > 0.7 between entry variables on bivariate analysis. There were no such correlations between any of the psychological variables.

The psychological questionnaires used were large in number and often in length; this can create questionnaire fatigue. Multiplicity and resultant type I errors must be considered in the type of bivariate analysis used, particularly with the number of entry variables and outcome measures considered. Attempts to limit this were made by rationalizing the entry factors used and focusing on the primary outcome measure. In order to develop a psychological intervention that can supplement current best-practice management of distal radius fracture, an association between the psychological construct upon which the intervention acts and the outcome after fracture must be demonstrated. In an attempt to find such a construct, multiple psychological scoring systems were included in the analysis. Each system used was distinct and represents a different, potentially modifiable psychological construct that can be quantitatively measured. Of all the psychological constructs used, illness perception (IPQB) may be the best focus for future work. It is associated with both pain and disability and is potentially modifiable following fracture.[52] The scoring system is also quick and easy to administer.

The associations between depressive symptoms, illness perceptions, perceived locus of control, and outcomes in this cohort of patients with distal radius fracture are significant but small. Psychological factors are potentially modifiable after injury.[52] Measuring these factors at baseline may identify those subgroups of patients at risk of poor outcomes and allow referrals to specialized services designed to improve psychological responses to injury, and ultimately PROMs. Future work should focus on how best to identify these patients and how best to intervene, with the aim of treatment being to optimize both the physical and psychological conditions for recovery from fracture.

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