

# Early Psychological and Social Factors explain the recovery trajectory after Distal Radius Fracture

## Abstract

## Background

This prospective study identifies **the association between** demographic, injury, psychological, and social variables, measured early during recovery, with limitations in function (measured by **PROMIS UE**) **at 6-9 months after distal radius fracture. Additionally, we assessed variables associated with** PROMIS UE, QuickDASH, PRWE, EQ-5D-3L **over time.**

## Methods

**A total of 364 adult patients (73% female, median age 65 years , IQR 45.5 – 77 years)** sustaining an isolated distal radius fracture completed questionnaires within 1 week post fracture, between 2-4 weeks, and between 6-9 months after injury. We **created a multivariable regression model and Generalized Least Square random effects models,** accounting for multicollinearity using correlation matrices, variable inflation factor and partial  $R^2$ .

## Results

Multiple variables within a week of injury correlated with 6-9 month **limitations** in bivariate analysis. Being retired (Partial  $R^2 = 0.9$ ,  $p < 0.001$ ), using **opioids (Partial  $R^2 = 0.04$ ,  $p < 0.001$ ), using** anti-depressants (Partial  $R^2 = 0.11$ ,  $p < 0.001$ ), **greater pain interference (Partial  $R^2 = 0.03$ ,  $p = 0.001$ ) and greater pain catastrophization (Partial  $R^2 = 0.04$ ,  $p < 0.002$ )** within a week of injury were strong predictors of **greater limitations (PROMIS UE)** at 6-9 months in multivariable analysis. **Longitudinal analysis of variables over time demonstrated greater pain interference, greater fear of movement, lower self-efficacy, older age and being female as strong predictors of limitations.**

## Conclusions

Recovery from a distal radius fracture **is** influenced by a series of demographic, psychological and social variables. Of these factors, being retired, **using opioids,** using antidepressants, **greater pain interference and greater pain catastrophization within a week of injury** explain the largest amounts of unique variance in upper extremity physical function. **Evaluating the impact of change in variables over time underlined the influence of pain interference as well as the influence of fear of movement and self-efficacy (or resiliency) on limitations in physical function and general health.** These findings have important implications for identifying individuals who can benefit from **behavioural interventions for these psychological factors** to optimize recovery.

Level of Evidence: Level II -Prospective Cohort Study

## Introduction

Distal radius fractures are the most common upper extremity fractures across most age groups (1)(2)(3). In spite of extensive scientific investigation, there is ongoing debate regarding which factors and treatments have the greatest influence on symptom intensity and magnitude of limitations over the long-term (3)(4)(5)(6)(7)(8). The World Health Organisation (WHO) International Classification of Disability, Functioning and Health (ICF) framework encourages a comprehensive, biopsychosocial approach to human illness (9). There is mounting evidence that psychological factors (e.g. depression, anxiety, somatization, catastrophic-thinking, lower self-efficacy), within the contextual factors domain of the WHO framework, are associated with greater symptom intensity and magnitude of limitations after distal radius fractures yet these factors are not routinely assessed (10).

This is a prospective, longitudinal cohort study that comprehensively investigates the role of demographic, injury, psychological, and social factors measured early during recovery (e.g. 1 and 2-4 weeks after a fracture of the distal radius) on limitations in function 6-9 months later (Figure 1). We measured upper extremity limitations using some of the most widely used PROMs in upper extremity conditions, namely the Patient Reported Outcome Measurement Information System Upper Extremity Physical Function Computer Adaptive Test (PROMIS UE v1.0), Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH), Patient Rated Wrist Evaluation (PRWE) and the European Quality of Life Index-3L (EQ-5D-3L) (11)(12).

The primary null hypothesis was that psychological factors, social factors, **demographic and injury-related factors** assessed within a week of injury, were not associated with the magnitude of limitations (measured by PROMIS UE) at 6-9 months after a distal radius fracture. Secondly, we assessed the influence of psychological factors, **social factors, demographic and injury-related factors over time on PROMIS UE, QuickDASH, PRWE and EQ-5D-3L.**

## Materials and Methods

We invited 399 consecutive, adult patients presenting to a Level I trauma center within a week of sustaining an isolated distal radius fracture to participate in this prospective, research and ethics committee approved study between 1<sup>st</sup> January 2016 and 31<sup>st</sup> August 2016 (IRAS No.16/YH/0017). **Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were used throughout reporting.** Inclusion criteria were fluency in spoken English, age eighteen years or older, and ability to provide informed consent. We excluded people with other injuries sustained at the time of the distal radius fracture, refracture of the wrist during recovery from a prior injury, fracture in a malunited wrist and peri-prosthetic fracture around a previous fixation.

Of the 399 patients, 15 (3.7%) declined participation due to time constraints leaving a total of 384 enrolled for analysis, including 284 women and 100 men with a mean age of 61 years  $\pm$  20 (range, 18-99) (Table 1). Six patients died of unrelated illness during the study and 14 were lost to follow-up leaving 364 completing final assessments at 6-9

months after injury. Demographic details included education level, marital, social and work status. Clinical variables included prior arm injuries, side of injury, neurovascular compromise, open/closed fracture, operative treatment, and complications. Age-adjusted Charlson Comorbidity Index (CACI), a validated scoring tool predictive of one-year mortality accounting for a range of comorbidities (13) was gathered along with the Index of Multiple Deprivation 2015 (IMD), a relative rank of social deprivation based on location defined by the UK Office for National Statistics (14).

PROMs were completed on a secure, encrypted, web-based data collection platform (Assessment Center<sup>SM</sup>, Northwestern University) (15). Data was captured at baseline (initial orthopaedic visit, within a week following emergency department review), early follow-up (2-4 weeks) and final assessment (6-9 months). Patients completed assessments in person (71%), by telephone (24%) or via email using an electronic link (5%).

Complications were limited to adverse events directly related to fracture treatment e.g. wound infection, revision surgery, as well as those with strong subjective components e.g. prolonged wrist stiffness treated with manipulation. Injuries were classified by energy [e.g. high speed road traffic accident (high); fall from standing height (low)] and the AO classification (16) prior to further classification into two fracture categories (i.e. extra-articular or inter-articular) providing a characterization of injury types. Use of opioid analgesia was defined as continued use of any opioids more than 2 weeks after injury or an increase in opioid intake secondary to fracture in patients already taking these medications. Use of anti-depressants included use for a pre-existing diagnosis of depression or newly diagnosed major depression within the first month after injury.

Measures were delivered in the following order: i) PROMIS UE (17), ii) PROMIS Pain Interference (PROMIS PI) (18), iii) PROMIS Depression (19,20), iv) PROMIS Anxiety (20), v) PROMIS Emotional support (PROMIS ES) (21), vi) PROMIS Instrumental support (PROMIS IS) (21), vii) QuickDASH (22-24), viii) PRWE (25), ix) EQ-5D-3L (26,27), x) Pain Catastrophizing Scale (PCS) (28), xi) Pain Self-efficacy Questionnaire-2 (PSEQ-2) (29,30), xii) Tampa Scale for Kinesiophobia-11 (TSK-11) (31) (Appendix 1). All **PROMs measuring physical limitations** were administered at baseline, 2-4 weeks and 6-9 months. **Psychosocial PROMs were administered at baseline and 2-4 weeks** except for PROMIS ES and IS (at 2-4 weeks only) (Table 2).

These time points were selected in order to feasibly capture patient outcomes as close as possible to the injury event (i.e. less than a week after injury), followed by an early stage (i.e. 2-4 weeks) when most patients have gained control over pain, stability of their fracture, and familiarity in living with a fracture, and a further longer term follow-up where a plateau may be reached with some reasonable return to activities of daily life, and potentially work and recreation. These time points were also aligned with our clinical care pathway and intention to limit the burden on responders with more timepoints for assessment.

### *Statistical analysis*

Descriptive statistics included frequencies and percentages for discrete variables, and median and interquartile range for continuous variables. Bivariate analysis involved Wilcoxon rank-sum test or Kruskal-Wallis test for comparing continuous and discrete variables and Spearman rank correlation for continuous variables. Data was assessed for multicollinearity, a phenomenon where two or more predictor variables in a multiple regression model are highly correlated, meaning one can be linearly predicted from the other with relatively high accuracy. This may be indicated by wide 95% confidence intervals, high standard error and high beta, and assessed by partial R<sup>2</sup>, correlation matrices, and variance inflation factor (VIF). A correlation greater than 0.80 was considered indicative of multicollinearity and led to the omission of one of two variables with high correlation i.e. the variable causing the lowest change in the model's adjusted R<sup>2</sup>. VIF measures the extent to which variance of estimated regression coefficients and independent variables increase due to collinearity. To address multicollinearity we build the linear regression model for our primary hypothesis by considering variables with  $p < 0.10$  on bivariate analysis. Subsequently, variables were included or retained if they increased the adjusted R<sup>2</sup> of the model.

Our secondary hypotheses addressed the effect of independent variables over time on our outcome variables (PROMIS UE, QuickDASH, PRWE and EQ5D). We created a Generalized Least Square random effects model; variables were selected if they increased the adjusted R<sup>2</sup> of the model.

To address the effect of any non-normal distribution on the assumption of our models we report robust (White Huber) standard errors. To assess the relative influence through the beta coefficient of continuous variables we included all continuous variables on standardized scales.

An a-priori power analysis indicated a minimum sample size of 312 subjects would provide 90% statistical power with alpha set at 0.05. This was based on regression with ten predictors and an assumption that an independent variable would account for 2% or more of the variability in limitations and the complete model would account for at least 40% variability. All statistical analysis was performed using Stata 14.0. No sources of funding were related to this work.

### Results

Multiple variables within a week of injury correlated with PROMIS UE 6-9 months after injury in bivariate analysis (Appendix 2). Among factors measured 1 week after injury, being retired (Partial R<sup>2</sup> = 0.19,  $p < 0.001$ ), using opioids (Partial R<sup>2</sup> = 0.04,  $p < 0.001$ ), using anti-depressants (Partial R<sup>2</sup> = 0.11,  $p < 0.001$ ), greater pain interference (Partial

$R^2 = 0.03$ ,  $p=0.001$ ) and greater pain catastrophizing (Partial  $R^2 = 0.04$ ,  $p=0.002$ ) explained the variance in increased limitations at 6-9 months in multivariable analysis (Table 3). The model including **these factors** accounted for **58%** of the variance in PROMIS UE.

Longitudinal analysis of variables over time demonstrated greater pain interference as a strong predictor across all measures of limitations at 6-9 months, while greater fear of movement or reinjury contributed to the variance in PROMIS UE, QuickDASH and PRWE, and lower pain self-efficacy contributed to EQ-5D-3L (Table 4). Older age and being female were strong predictors of limitations measured by PROMIS UE and QuickDASH respectively. Regression models explained a substantial amount of variance in PROMs (e.g. 78% of the overall variance for PROMIS UE at 6-9 months explained by the change in variables over time).

## Discussion

This study aimed to understand the relative importance of demographic, clinical, psychological and social factors (measured early in the recovery process) on the magnitude of limitations measured by widely used PROMs at 6-9 months after distal radius fractures. Our goal was to identify modifiable factors and opportunities for targeted skills interventions that can be delivered early on to optimize recovery after such a common injury.

Being retired, using **opioids**, using anti-depressants, **having greater pain interference and greater pain catastrophizing within a week of injury** accounted for most of the variation in longer term limitations in function at 6-9 months after injury. **Considering the impact of change in each variable over time further highlights the strong influence of greater kinesiphobia (i.e. fear of movement), lower pain self-efficacy (i.e. less belief in being able to perform activities in spite of pain), older age and being female on a range of PROMs.**

**Notably**, we were able to prospectively account for **78%** of the variation in PROMIS UE and over **54%** of the variation in **other PROMs measuring physical limitations and general health** using psychological and social factors assessed early after injury. These factors appeared more important than any injury severity factors assessed. The pattern of results was relatively similar regardless of PROM used to measure functional limitations (e.g. generic quality of life versus region or joint-specific measures; computer adaptive versus fixed scale questionnaires). The findings suggest, that functional limitation questionnaires measure a similar underlying psychological, social and general health construct in response to injury rather than an objective marker of physical recovery or surgical success.

Our work supports a growing body of evidence that objective markers of illness such as clinical or radiographic injury severity, and type of treatment (operative or not) account for a limited amount of variation in the magnitude of limitations measured by PROMs (32)(32)(33)(34)(35). In our model, injury severity (represented by fracture

classification, energy level, neurovascular compromise and open or closed injury) and whether or not surgery was performed, did not account for any of the variability in limitations. A growing number of studies show the strong influence of psychosocial factors on PROMs and comparatively limited influence of impairment (or objective pathophysiology) across a range of traumatic and atraumatic upper extremity conditions (36)(37)(38)(39). It is becoming clear that there is more to generating optimal outcomes than resolving pathophysiology, restoring anatomy and focusing on technical components alone in fracture management (2)(40)(41)(42)(43). Similar to other orthopaedic conditions, psychological and social factors continue to be largely unassessed among patients with distal radius fractures. This represents an untapped opportunity, particularly in light of evidence showing feasibility, acceptability and improved recovery outcomes after brief skills based interventions, among injured patients (44)(45).

Skills programs using elements of cognitive behavioural therapy and mindfulness-based interventions help patients understand their reactions to injury, and learn helpful strategies to delineate accurate and useful thoughts from misconceptions that may increase symptoms and delay recovery. Mindset training to foster the healthiest thoughts and emotions in response to nociception, delivered early in the recovery process might prove to be the most effective way to improve PROMs (45)(46). In our study, **some of** the psychological variables targeted by these programs **e.g. stress and distress, coping with pain**, explained the largest amount of variance. Our finding that those taking antidepressants (commonly prescribed for depression or anxiety) had higher limitations further reinforces the need for skills programs. Antidepressant efficacy is controversial (47)(48)(49), and while some patients do benefit from prescription, they do not learn coping and resiliency skills which appear paramount when dealing with injuries. Based on our findings and prior recommendations, this is not an effective approach to optimizing recovery.

Only 3 prior studies have explored the role of skills training in optimizing recovery in orthopaedic patients, and all found encouraging results (45)(44)(50). Patients with acute orthopaedic injury with ineffective coping skills randomized to a brief mind-body skills program in addition to usual care experienced significant decrease in depression, symptoms of post-traumatic stress, pain and limitations, as well as increase in coping abilities, when compared to those randomized to usual care alone (46). Results of this program were maintained when the intervention was shortened to 4 sessions and delivered via video-link to increase feasibility and reach (51). A brief 60 second mindfulness-based intervention was associated with immediate decrease in pain and improvement in mood among outpatient orthopaedic patients (45). There is a growing need for fully powered, randomized controlled trials of these interventions among patients with orthopaedic injuries.

The results of our study should be viewed in light of several limitations. First, although we had diverse patient demographics, the findings may apply best to our institution. Further studies should explore influential factors in a range

of populations from different cultural and socioeconomic backgrounds and settings. Second, despite a substantial portion of the variance being explained by the set of explanatory variables in our study, other variables e.g. **extent of displacement**, further displacement, **radiographic alignment**, change in management, surgeon seniority, quality of clinician-patient interaction, duration of immobilization and timing of surgery may have also influenced outcomes, but were not included. Third, although most patients completed PROMs in person, some were conducted via telephone or online which may have introduced some procedural, measurement and responder bias. Most of the instruments we used were validated for phone administration (46). Fourth, responder burden is possible given the use of multiple instruments, however this was felt acceptable based on mean test times checked during development of the measurement platform. Fifth, the 2-part fracture classification used for analysis may not have provided adequate detail for injury severity. There were relatively few fractures within some AO/OTA categories, which may have compromised analysis. A larger study might better assess the variation in PROMs by fracture sub-type but evidence to date suggests this is unlikely to yield additional insights (53). **Sixth, we did not differentiate between patients taking opiates prior to injury from those being prescribed a limited batch of opiates in the emergency department or those receiving extended prescriptions beyond this course. Future studies should delineate these patients to determine the impact of these different patterns of opiate administration on patient outcomes.** Finally, PROMIS ES and PROMIS IS were not assessed at less than 1 week due to a programming error, however, this is unlikely to have led to any significant impact on the overall interpretation.

## Conclusion

Early modifiable psychological and social factors are associated with poor long-term recovery and substantial functional limitations after distal radius fracture. Patients who are retired, **taking opioids or antidepressants**, **having high levels of pain interference, pain catastrophizing, kinesiophobia** and low pain self-efficacy should be encouraged to undergo skills interventions early in the recovery process. These findings support routine assessment of psychological and social factors along with usual clinical care. Findings also support referrals for brief mind-body and cognitive behavioural intervention. By working together, surgeons and psychologists have the opportunity to dramatically improve outcomes for patients with **common** orthopaedic injuries.

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#### Figure legends

*Figure 1. Components of the WHO ICF Framework represented by PROMs and other variables used to assess limitations after Distal Radius Fracture*