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Contribution of Functional Parameters to Patient-rated Outcomes after Surgical Treatment of Distal Radius Fractures

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Abstract

Purpose—Outcomes of distal radius fractures can be measured radiographically, functionally, or via patient-rated questionnaires; but previous studies report conflicting results regarding the relationship between these outcomes. Our specific aim was to explore the role that functional outcomes play in the score of the Michigan Hand Outcomes Questionnaire (MHQ), a patient-rated hand instrument.

Methods—Data were obtained for 207 patients. Demographic information was collected as part of the MHQ. Function (wrist motion and grip and pinch strength) was assessed 3 and 6 months following fracture fixation. Linear regression analysis was applied to determine each item's contribution to total MHQ score.

Results—After linear regression analysis was applied, it was determined that 3 months following fixation all included factors contributed 37% of MHQ score. Only grip strength difference between the injured and uninjured hands was significantly associated, contributing 22% of MHQ score. Six weeks and 6 months after fixation all included factors contributed 43% and 34% of MHQ score, respectively. No individual factors were significant contributors.

Conclusions—Measured functional outcomes variables account for less than 40% of total MHQ score. Identifying the unmeasured factors that make-up the additional 60% of total MHQ score would be beneficial in the continued examination of patient-rated outcomes. Furthermore the use of multiple outcomes assessment modalities should be considered in any study measuring patient-rated outcomes.

Level of Evidence—II, Prognostic

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Keywords

distal radius fractures; patient-rated outcomes

Introduction

Distal radius fractures (DRFs) are the most common fracture encountered by physicians and are the cause of over 600,000 emergency department visits annually.(1) This endemic injury has been widely studied, and historically outcomes are measured radiographically and functionally via grip strength, pinch strength, and wrist motion. However, radiographic outcomes are of little relevance to patients. Functional outcomes may seem more germane, but few patients are interested in measured wrist angles. They are more concerned with the ability to turn a key or swing a golf club – everyday activities that would be difficult with limited wrist motion. Patients are constantly judging their own recovery progress and outcomes, often based on pain relief and functional recovery.(2) The idea that patients are the best judges of their own outcomes gained national prominence with the 2004 development of the Patient-Rated Outcomes Measurement System by the National Institutes of Health and the creation of the Patient-Centered Outcome Research Institute as part of the 2010 Patient Protection and Affordable Care Act.(3,4) The result of this interest has been the creation of hundreds of instruments capable of querying patients about a myriad of topics from broad to specific. Undoubtedly, including patients in the assessment of their own outcomes is positive, but without standardization it is difficult to compare and compile results.

The Michigan Hand Questionnaire (MHQ) was created in 1998 to assess the patient perspective on a variety of hand and wrist conditions and injuries.(5) The MHQ measures outcomes in 6 domains: function, activities of daily living, pain, work performance, aesthetics, and satisfaction. The domains may be examined separately or averaged to give a total MHQ score. A DRF affects many aspects of a patient's life, but previous studies have reported conflicting results regarding how the injury, a patient's psychosocial make-up, and the social and physical environment contribute to overall outcomes after treatment.(6–9) Furthermore, although functional and radiographic outcomes and patient-rated outcomes are assessing the same patient and same injury, there is weak correlation between these outcome ratings.(10–12) Despite this there is likely some connection between more traditional outcome measures and patient-rated outcomes. Our specific aim was to expand upon previous projects by exploring the role functional measures play in total MHQ score. We wished to determine which aspects contributed the most to patients' ratings of their health status. Knowing the areas that are most important to patients guides providers to focus recovery efforts on those items.

Materials and Methods

We analyzed data from a prospective cohort of 207 patients with DRFs who were inadequately reduced following closed manipulation and who required treatment with a volar locking plate. This cohort was created to obtain long-term outcomes of that device.(13)

Inadequate reduction was based on the following radiographic criteria: apex volar angulation of > 10°, radial inclination angle of <15°, radial height of <10mm, and/or intra-articular stepoff ≥2mm. Additional inclusion criteria were age of 18 years or older and the ability to complete the questionnaire in English. Patients with bilateral or open fractures were excluded, as were patients with neurological deficits affecting the upper extremities. Patients were splinted and wrist motion was begun 1 week following fixation. The MHQ was completed 6 weeks, 3 months, 6 months, and 12 months after surgery.(13) At the same time points, grip and pinch strengths (adjusted for hand dominance (14)) were measured. Grip strength was measured with a standard, adjustable-handle Jamar dynamometer (Sammons Preston Rolyan, Bolingbrook, IL), set to the second rung position, which is considered the optimal setting for measuring grip strength with this instrument.(15) Key pinch strength was measured with a standard pinch gauge (B & L Engineering, Santa Ana, CA). Both pieces of equipment were calibrated yearly per manufacturers' recommendations. Wrist flexion, extension, and ulnar and radial deviation and forearm rotation were measured by a certified hand therapist. A 3-month ceiling effect was observed, so prospective data collection for the 6-week timepoint was begun approximately 2 years into the study. Therefore just over 50% of the cohort had data for this timepoint. Demographic data were collected as part of the MHQ. Written informed consent was obtained.

The difference between measurements for the uninjured and injured hands was calculated for grip and pinch strength. Descriptive statistics were calculated for patient demographics, functional measurements (grip strength difference between injured and uninjured hand, pinch strength difference between injured and uninjured hand, flexion, extension, active arc of motion, ulnar deviation, radial deviation, pronation, and supination) and overall MHQ score at all follow-up time points. A stepwise forward linear regression analysis was applied to determine the relationships of patients' demographic information and functional measurements with overall MHQ score. We started with no variables in the model and added 1 variable at a time to calculate the most suitable model. R-squared was calculated in order to investigate the proportion of variance in the dependent variable (total MHQ score) that can be predicted from all independent variables (patient demographic factors and functional measurements). When applied to a linear model R-squared is interpreted as the proportion of dependent variable change explained by the independent variables in the model, which can be shown as explained variation / total variation. Explained variation measures the proportion that included independent variables account for variation of the dependent variable (total MHQ). and total variation stands for the total variance in MHQ score. R-squared ranges from 0 to 1, with an R-squared of 1 indicating that the proposed model fit the data perfectly. Statistical significance was set at P-value ≤0.05.

Results

A total of 207 patients were included in this analysis. Patient demographic information is presented in Table 1. Our sample was primarily female (67%) and white (92%). Mean age at time of surgery was 50 years (range 18–85 years). As is typical of this injury, the mean age for female patients was older (53 year) than for male patients (43 years), although this was not statistically significant. Our patients were generally well-educated (72% had college, graduate, or professional degrees), and 66% had household incomes of $30,000 per year or more.

The stability of fixation experienced with the use of a volar locking plate results in an outcomes ceiling effect earlier than that seen using other surgical treatment methods.(16) MHQ scores increased the most between 6 weeks and 3 months after surgery ($p<0.001$) and between 3 months and 6 months ($p<0.001$). By 6 months after surgery most patients have returned nearly to pre-injury function. Therefore there was no statistically significant increase in MHQ score between 6 months and 12 months ($p=0.08$). (Table 2) The minimal clinically important difference in total MHQ score has not been calculated. We were unable to calculate minimal clinically important differences for domains due to the ceiling effect observed after 3 months. (17) We opted to focus our linear regressions on the pre-plateau 6-week to 3-month and 3-month to 6-month post-surgical follow-up time points.

Stepwise forward linear regression showed that the model with the best fit included difference in patients' education, income, age at time of surgery, difference in grip strength between injured and uninjured hand, difference in pinch strength between injured and uninjured hand, flexion, extension, active arc of motion, ulnar deviation, radial deviation, pronation, and supination. Three months following surgery, patients' education, income, age at time of surgery and all measured outcome variables accounted for 37% of the variability in overall MHQ score (R-square=0.37). In other words, these variables explained 37% of the variability in overall MHQ score; meaning that 63% of the MHQ variability could not be attributed to the variables included in the model. Among these variables, only difference in grip strength had a significant effect on MHQ score ($P < 0.001$). In our cohort, for each kilogram increase in the difference in grip strength between the injured hand the uninjured hand, overall MHQ score was 0.7 points lower (Table 3). That is, if one subgroup of our patients (group A) had a mean difference in grip strength of 15kg and another subgroup (group B) had a mean of 10kg, we would expect group A's mean MHQ score to be approximately 3 points lower (worse) than group B's mean MHQ score (5kg×0.7 points/kg).

Six months after surgical fixation, all the included variables accounted for 34% of the variability in overall MHQ score (R-square=0.34). No individual outcome was significantly associated with MHQ score (Table 4).

Six weeks after surgical fixation, all the included variables accounted for 43% of the variability in overall MHQ score (R-square=0.43). No individual outcome was significantly associated with MHQ score (Table 5). However, this may be an artifact of the smaller sample size at this timepoint.

Discussion

Our analysis found that total MHQ score was affected significantly by grip strength . However, the range of variables we measured only accounted for 37% of the variability in overall MHQ score 3 months after fixation and 34% of the variability 6 months after fixation. This means that there are numerous factors that were not captured by the common outcomes collected by this analysis. These factors are likely not typical clinical outcomes variables and may not be measurable at all. This is similar to the results of Harris et al., who were only able to account for a maximum of 33% of the variation in Short Form-36 score with variables collected within the Patient-Rated Wrist Evaluation and the Wrist Outcome measure.(9)

Squitieri et al. performed a similar analysis using the MHQ satisfaction domain as the dependent variable with the aim of mapping independent variables to the Brief International Classification of Functioning, Disability, and Health Core Set for Hand Conditions conceptual model.(7) Through this analysis the investigators were able to determine that variables assigned to Activities and Participation and Body Function and Structure were most predictive of patient satisfaction. This aligns with our results that models including functional measures, rather than personal factors, were the best fit. Yet Squitieri et al. calculated R-squared values that far exceeded what we found. This may have been the result of including 5 additional variables: sex, marital status, race, religious affiliation, and Jebsen-Taylor test score. None of these variables were significant items in their model, however.(7) It is more likely, then, that the disparity is the result of the difference in dependent variables. In our model we used the total MHQ score, whereas Squitieri et al. used MHQ satisfaction score. They also used the other domains of the MHQ as independent variables. The satisfaction domain is composed of 6 questions, including 2 questions asking specifically about satisfaction with pain and satisfaction with function. Because the MHQ also measures pain and function in their own domains, it is possible that scores in these domains may directly correlate to satisfaction score, leading to an overestimation of the R-squared value of the model.

Sourer et al. used 3 instruments (Disabilities of the Arm, Shoulder, and Hand, Mayo Wrist score, and the Gartland and Werley score) as dependent variables to determined score contributions 6 months after operative treatment for DRF. They found that pain accounted for 53% and 65% of the variability of the Gartland and Werley score and Disabilities of the Arm, Shoulder, and Hand score, respectively, whereas 47% of the variability of the Mayo Wrist score was attributed to grip strength.(18) Swart et al., could account for 56% of Disabilities of the Arm, Shoulder, and Hand score after internal fixation with pain, grip strength, and supination.(19) MacDermid et al. determined that prereduction radial shortening, patient educational attainment, and worker compensation status accounted for 25% of the variability in Patient-Rated Wrist Evaluation score 6 months following DRF.(20) Although the models used to determine these results included a large array of variables, none of the contributions approaches 100%. Clearly, there is something more influencing patients' ratings of post-DRF disability.

Three limitations may have affected our results. First, complications in our cohort were minimal, and few of our patients had truly poor outcomes. Younger and more affluent patients report better outcomes,(21) and our cohort had a mean age of 50 years and the majority reported a household income of $30,000 or higher. We did not include radiographic parameters in our model.(21) Thus, our model was created using relatively homogenous and mostly positive experiences and may not have had enough variability to provided illustrative results. This can be seen in the ceiling effect demonstrated by our data. Finally, as mentioned above, we were not able to include pain as an independent variable because it is incorporated in total MHQ score, the dependent variable of this analysis.

Our results highlight the potential benefit of using multiple outcomes assessment modalities when measuring patient-rated outcomes. The goal of including patient-rated outcomes in research was to include the experiences of patients in medical decision-making.(22) As the psychosocial effects of illness and injury have come into prominence, the importance of reporting patient-rated outcomes has increased.(23) Only a maximum of 37% of MHQ score variability can be accounted for by hand strength, wrist motion, or other functional parameters. Therefore, more than 60% is accounted for by something we did not measure or something that may not be considered for measurement. Although this analysis has calculated the limitations of a commonly used, hand-specific patient-rated outcomes instrument, the limitations of several others are cited in this manuscript.(24) The patient-rated outcomes movement has resulted in a slew of instruments, and it is important to acknowledge the weakness of these instruments along with their strengths. Modeling the relationships between instruments and other outcomes measures can provide further information that customary clinical measurements. Further exploration, with the inclusion of additional dependent variables and more complex modeling, may shed some light on what factors influence patient-rated outcomes beyond traditional clinical determinations.

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Table 1

Table saw injuries in the literature

First Author	Year	Sample	Database used and/or location sampled
Al-Qattan, MM	2012	Phalangeal neck fractures caused by saws	King Khalid University Hospital; Riyadh, Saudi Arabia
Beavis, RC	2006	Injuries to hand and/or wrist sustained in shop class, ages 12–18	Royal University Hospital; Saskatoon, SK
Becker, TM	1996	Convenience sample of amateur and professional woodworkers	Albuquerque, NM
Conn, JM	2005	Non-occupational finger amputations	National Electronic Injury Surveillance System
Hoxie, SC	2009	Injuries caused by table saws	Mayo Clinic; Rochester, MN
Justis, EJ	1987	Readers of *Fine Woodworking*	US nationwide
Knight, S	2000	Injuries sustained in shop class, grades 7–12	Utah statewide Student Injury Report database
Shields, BJ	2011	Non-occupational table saw injuries	National Electronic Injury Surveillance System
Waller, JA	1990	Injuries associated with woodworking, logging, wood construction activities	Medical Center Hospital; Burlington, VT

Table 2

Table saw-attributable injuries sustained by adult and minor patients

	Total		Minors		Adults	
	n	*%*	*n*	*%*	*n*	*%*
Finger/Thumb Injuries	10,338	100%	322	3.1%	10,016	96.9%
Laceration	6,593	63.8%	198	65.1%	6,395	63.9%
Fracture/Dislocation	1,304	12.6%	47	14.6%	1,257	12.6%
Amputation	1,442	13.9%	40	12.4%	1,402	14.2%
Other*	999	9.7%	37	11.5%	962	9.6%

*Other injuries include abrasion, contusion, foreign body, burn, and electrical shock

Table 3

Mean medical costs, time off work, and wage loss by injury severity

	Minor laceration	Amputation	Replantation or laceration with tendon, nerve, and/or artery repair
Medical costs	$2,906	$15,816	$40,121
Time off work (days)	24	60	125
Wage loss*	$2,731	$6,790	$14,220

*based on Minnesota mean income 2006

Data from Hoxie SC, Capo JA, Dennison DG, Shin AY. The economic impact of electric saw injuries to the hand. J Hand Surg Am 2009;34:886–9.

Table 4

Recommendations for the prevention of table saw-related injuries

- All new table saws purchased by schools and other organizations that allow minors access to woodworking tools should be equipped with SawStop technology
- Incentives to SawStop purchase, such as health or homeowners' insurance rebates, should be considered
- Alternative methods of presenting safety information should be considered including DVDs or podcast that integrate technique and safety instruction

Table 5

Regression Model at 6 week post-surgical follow-up

Variables	Parameter Estimate	95% CI	P value
Education (ref. High School)			
College Degree	2.94	−43.74 to 49.62	0.90
Graduate or professional degree	6.76	−39.36 to 52.89	0.78
Income (ref. $0–30,000)			
$30000–59999	3.76	−23.25 to 30.77	0.79
$60,000+	3.13	−23.49 to 29.75	0.82
Age at injury	−0.28	−0.63 to 0.06	0.12
Grip difference	−0.72	−1.51 to 0.07	0.08
Pinch difference	−3.00	−6.3 to 0.3	0.08
Active flexion + active extension	−0.04	−0.31 to 0.22	0.74
Ulnar deviation	−0.13	−0.95 to 0.69	0.76
Radial deviation	0.44	−0.41 to 1.3	0.32
Pronation	−0.07	−0.76 to 0.61	0.83
Supination	−0.05	−0.74 to 0.64	0.88

[#] Difference between injured and uninjured hands