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Assessing Results After Distal Radius Fracture Treatment: A Comparison of Objective and Subjective Tools

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Abstract

Objectives: Functional outcomes following distal radius fractures are directly influenced by the choice of outcome assessment instruments used. Our objective was to compare scoring systems in measuring patient functional outcomes and to determine which scoring system compared most favorably with the widely used Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire. Methods: In all, 108 patients between May 2004 and November 2006 were treated operatively following distal radius fractures. Follow-up was at 3 months, 6 months, 1 year, and 2 years postsurgery, during which anatomical and functional assessments were performed. Patient outcomes were recorded using DASH, Green and O'Brien system, Gartland and Werley system, and Sarmiento radiological scoring system. Results: There was a stronger correlation between the Green and O'Brien scoring system and DASH ($r = -.54$) than Gartland and Werley and DASH ($r = .44$). The Green and O'Brien scoring system was more demanding so patients rated "excellent" or "good" had better functional outcome than those bearing the same grade in the Gartland and Werley system. Nonetheless, the Green and O'Brien score and Gartland and Werley score showed good correlation with each other ($r = .66$). The Sarmiento radiological score had no significant correlation with any of the other scoring systems. Significant predictors of the DASH score were function ($r = .42$), power grip ($r = .41$), pain ($r = .37$), and range of motion ($r = .28$). Conclusion: The Green and O'Brien scoring system correlated most strongly with the DASH score. Radiological scoring (reflecting anatomical deformity) was not significantly correlated with functional outcome. While subjective parameters "pain" and "function" are influenced by psychosocial factors and thus highly variable, it is paramount to include subjective tools in outcome assessment in future studies on wrist fractures.

Keywords

distal radius fractures, outcome assessment, patient self-assessment, elderly

Introduction

Distal radius fractures are the commonest fractures in the elderly individuals. The measurement of results of treatment is dependent on the type of outcome assessment used. It is important to know which assessment tool is the most useful to the surgeon and the patient, and which outcome measures are the most reliable in reflecting disability and function after trauma.

The correlation between objective and subjective measures has shown to be variable, although many of these reports have been based on relatively small sample sizes.[1-5] Traditional measures of objective variables like grip strength and range of motion do not always accurately correlate with patient-reported pain and function.[6] Although scoring systems like the Gartland and Werley score and the Green and O'Brien score have come into favor, substantial differences still exist between these scoring systems.[4] In recent years, the most widely used instrument in evaluating upper extremity outcome is the Disabilities of the Arm, Shoulder, and Hand (DASH) patient-rated health questionnaire.[5,7] According to kinesiological theory, the upper extremity operates as a single-functional unit. The DASH questionnaire, although neither side specific nor joint specific, is highly responsive to change in assessment of function following distal radius fractures.[8]

This was a retrospective study conducted in a tertiary teaching hospital, between May 2004 and November 2006, looking at how closely objective and subjective measurements reflected patient functional outcome following open reduction

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and internal fixation of distal radius fractures. Our objective was to compare different assessment tools in measuring patient outcomes and to see which scoring system compared most favorably to the DASH score.

Materials and Methods

Between May 2004 and November 2006, 108 patients with distal radial fractures were treated using the 2.4- and 3.5-mm locking plate fixation (Synthes, Switzerland). The indication for surgery was a displaced fracture of the distal radius following unsuccessful closed reduction or fracture with intra-articular disruption. Patients with an operative procedure performed 1 month after the initial injury and patients with polytrauma with an injury severity score >16 were excluded.[9]

Patient Demographics and Characteristics

Of the 135 patients, 27 lost to follow-up or had incomplete assessments performed and were excluded from the study. Of the 108 patients, 42 (39%) were men and 66 (61%) women, with a mean age of 55.5 (range 13-90 years). A 2.4-mm plate was used in 62 patients (57%) and 3.5-mm plate on 46 (43%) patients.

Follow-Up Protocol

All patients were seen in an outpatient follow-up clinic 2 weeks after the operation for wound check and suture removal. Subsequent follow-up was at 3 months, 6 months, 1 year, and 2 years postsurgery. Anatomical and functional assessments were performed at an average of 20.6 months (range 3-26 months).

Anatomical Assessment

Posteroanterior and lateral radiographs were taken at each follow-up visit and measurements were recorded using the method developed by Kreder et al[10] On the posteroanterior films, radial length, radial angle, and articular step-off and gap were measured. On the lateral film, palmar tilt and articular step-off and gap were measured. A radiological score was derived from the above measurements—in this study, Sarmiento et al's modification of the Lidström and Frykman radiological classification was used.[11]

Functional Assessment

Three evaluation tools were used in this study. The Cooney modification of the Green and O'Brien score[12] is an examiner-rated assessment of pain, functional status, range of motion, and grip strength. Each of the 4 parameters is given a weighting of 25 points, giving a total score of 100. With excellent being 90 to 100, good 80 to 89, fair 65 to 79, and poor <65.

The demerit system of Gartland and Werley[13] is a mixed subjective and objective assessment that includes residual deformity (3 points), subjective evaluation (6 points), objective evaluation based on range of movement (5 points), and complications including pain (5 points). With excellent being 0 to 2, good 3 to 8, fair 9 to 20, and poor ≥21.

The DASH questionnaire is a patient-rated tool and is the most validated measure of upper extremity functional status.[14] Questions are based on daily activities, symptoms including pain, and an optional work and sports/performing arts module. A final score is calculated, ranging from 0 (*no disability*) to 100 (*the most severe disability*). Thus, a higher score indicates greater disability. A validated Chinese version of the DASH questionnaire was used in this study.[15]

Table 1. Mean DASH Scores (Standard Deviation) for Each Final Grade When Using Different Scoring Systems

	Green and O'Brien	Gartland and Werley	Sarmiento
A) In under 55 years			
Excellent	8.9 (11.8)	9.9 (12.8)	13.4 (15.8)
Good	19.0 (19.0)	31.5 (22.0)	10.5 (14.6)
Fair	29.5 (23.7)	25.0 (-)	
Poor	34.1 (-)		
B) In over 55 years			
Excellent	7.5 (10.7)	9.1 (11.7)	12.8 (16.4)
Good	15.6 (14.3)	16.7 (17.9)	9.2 (9.3)
Fair	16.7 (15.3)	30.3 (28.8)	17.1 (24.1)
Poor	47.7 (19.8)		

Abbreviations: DASH, disabilities of the arm, shoulder and hand; -, no standard deviation available as n = 1.

Statistical Analyses

Continuous variables were described using means, standard deviations (SDs), and ranges. The Pearson product–moment correlation coefficient was used to evaluate the association in scores between the outcome instruments. The Spearman rho correlation was used to evaluate association in the final grading (excellent, good, fair, and poor) between different outcome instruments. Multiple linear regression analysis was performed to identify which predictor variables were significantly associated with outcome score (DASH). P values of <.01 were regarded significant. All analyses were carried out using the SPSS software package (version 16; SPSS Inc, Chicago, Illinois)

Results

Of the 108 patients, there were 46 (43%) under 55 years and 62 (57%) over 55 years. Their mean DASH scores were 12.5 (SD = 15.3) and 12.1 (SD = 15.1), respectively. As the under 55 years and over 55 years age groups showed no significant difference between their mean DASH scores (Table 1), no further breakdown of their respective correlations to the grading instruments was carried out; patients of all ages were analyzed together (Table 2).

Table 2. Mean DASH Scores (Standard Deviation) for Each Final Grade When Using Different Scoring Systems—Includes Patients of all Ages

	Green and O'Brien	Gartland and Werley	Sarmiento
Excellent	8.2 (11.1)	9.5 (12.2)	15.6 (17.8)
Good	16.9 (11.7)	20.2 (17.4)	6.5 (7.2)
Fair	20.7 (18.3)	29.0 (23.7)	17.1 (24.1)
Poor	44.3 (17.6)		

Abbreviation: DASH, disabilities of the arm, shoulder, and hand.

Correlation in Scores Between Outcome Instruments

A moderate correlation was seen between scores in Green and O'Brien and DASH ($r = -.54$, $P = .01$) as well as between Gartland and Werley and DASH ($r = .44$, $P = .01$).

Between the 2 clinician-based scoring systems (Green and O'Brien and Gartland and Werley), there was good correlation ($r = -.75$, $P = .01$).

Correlation in Final Grading Between Outcome Instruments

As seen in Table 3, there was a moderate rank correlation between final Green and O'Brien grade and DASH ($r = -.42$, $P = .01$), but a weaker correlation between Gartland and Werley and DASH ($r = .31$, $P = .01$). No correlation was shown between the Sarmiento score and DASH ($r = -.045$, $P = .652$). Correlation between Green and O'Brien and Garland and Werley scoring systems was strong, however ($r = .66$, $P = .01$).

Predictors of Clinical Outcome

Multiple linear regression analysis identified function ($r = .42$, $P < .01$), power grip ($r = .41$, $P < .01$), pain ($r = .37$, $P < .01$), and range of motion ($r = .28$, $P = .02$) as significant predictors to the DASH score (Table 4).

Discussion and Conclusions

Distal radius fractures are among the most common fractures encountered by orthopedic surgeons as they are the commonest fractures in the elderly individuals. Although the initial description by Colles stated that there is little functional compromise in its aftermath, for years this has been a subject of debate and there is no clear consensus regarding its appropriate treatment. Scoring systems help clinicians evaluate the necessity for operative treatment by looking at patients' function outcome but correlation of scoring systems to the DASH score—the most widely used health questionnaire for upper extremity outcome—is variable.

We have shown in this study that the Green and O'Brien scoring system has a stronger correlation to DASH in both its raw score and final grading than that of Gartland and Werley and DASH. Table 2 also shows that patients had a higher average DASH score (ie, less disability) when graded with the Green and O'Brien system compared with using the Gartland and Werley system. Therefore, patients rated "excellent" or "good" have better functional outcome than those bearing the same grade in the latter scoring system. Green and O'Brien system is a more demanding scoring system, requiring 100% normal grip and function for the maximum mark to be awarded in those parameters.

Reliance on certain variables can impact on their correlation with the DASH score. We have shown that significant predictors of the DASH score were found to include power grip, pain, function, and range of motion—the exact 4 parameters used in the Green and O'Brien score. The Gartland and Werley score, however, takes into account other parameters such as residual deformity and complications (nerve complications) but not grip strength. It is unsure as to how significant the contribution of these factors is toward the DASH score.

The Sarmiento radiological score has proven to have no correlation with the DASH score. This suggests that radiographic outcome and thus anatomical deformity has little effect toward functional outcome. These findings are consistent with results from previous studies.[3,16] This may explain the comparatively weak correlation of Gartland and Werley score with DASH. It should be noted that all the participants in this study were treated operatively, thus few patients were left with substantial residual deformity.

In the Gartland and Werley score as well as in the DASH score, the "pain" and "function" parameters are subjective rather than physician rated. Perception of pain and function by patients is known to be strongly influenced by psychosocial factors.[17] Although such parameters are important, it can produce highly variable results. There is less of such variability in the Green and O'Brien score. Patient self-assessment questionnaires rely highly on compliance; often lower completion rates can be expected of longer questionnaires and in older and frailer populations, particularly patients with poor hand and wrist function. This can pose a potential selection bias in this wrist fracture population.

Recently, there been increasing popularity in the use of the patient-rated wrist evaluation (PRWE) score.[6,18] It comprises 2 subscales—pain and function—and was developed specifically for patients with wrist fractures. Following validity, reliability, and responsiveness testing, it has proven to be a robust scoring system correlating well with patient functional outcome. However, the PRWE score was not included in our study as it was only recently introduced and had not been widely adopted during the period of data collection.

Given the weight of patient-rated factors in influencing final outcome, a suggestion drawn from the results of this study is that a subjective tool should always be included as part of outcome assessment in all future studies in distal radius fractures, even if it produces variability in results. This is applicable for both young and osteoporotic adults.

The weakness of this study is that the follow-up times were variable, hence patients might have been in different stages of rehabilitation. Also, we have only carried out linear regression analysis on the DASH score. It would be interesting to carry out a similar analysis for the Green and O'Brien and Gartland and

Table 3. Spearman's Rank Correlation Between Final Grading in Green and O'Brien, Gartland and Werley, Sarmiento, and DASH

		Sarmiento	DASH	Green and O'Brien Grade	Gartland and Werley Grade
Sarmiento	Correlation coefficient		−.045	−.073	−.026
	Significance (2-tailed)		.642	.455	.791
DASH	Correlation coefficient	−.045		**.423**[a]	**.307**[a]
	Significance (2-tailed)	.642		.000	.001
Green and O'Brien grade	Correlation coefficient	−.073	**.423**[a]		**.662**[a]
	Significance (2-tailed)	.455	.000		.000
Gartland and Werley grade	Correlation coefficient	−.026	**.307**[a]	**.662**[a]	
	Significance (2-tailed)	.791	.001	.000	

Abbreviations: DASH, disabilities of the arm, shoulder, and hand. Figures in bold represents significant correlation.
[a] Correlation is significant at the .01 level (2-tailed).

Table 4. Regression Analysis of Predictor Variables in Green and O'Brien, Gartland and Werley, Sarmiento, and DASH Scores

	DASH Score	
	Correlation coefficient (*r*)	*P* value
Age	.095	.168
Gender	.056	.286
Fracture type	−.071	.235
Plate	.059	.274
Power grip %	**−.406**	**.000**
Pain	**−.365**	**.000**
Function	**−.415**	**.000**
ROM	**−.278**	**.002**
Length of follow-up	.16	.434

Abbreviations: DASH, disabilities of the arm, shoulder, and hand; ROM, range of motion. Figures in bold represents significant correlation.

Werley scores to find out the impact of each individual factor on each scoring system. In terms of statistical analyses, in this study, only linear regression was performed—we made the assumption that the parameters (age, function, pain, range of motion, etc) formed a linear relationship with the DASH score. However, we have found that significant collinearity exists between variables, for example, between age and range of motion (−.37), pain and function (.41), and plate type and range of motion (−.64). High correlations between variables may pose the problem of multicollinearity in regression analysis. Fractures of the distal radius are common in older people, particularly in postmenopausal women. Often they are the result of low-energy trauma. Since rehabilitation potential is highly variable with age, it would be useful to see whether significant differences exist using the same outcome assessment instruments in younger and older populations.

Appendix A

Green and O'Brien Score (Cooney modification)[12]

I. Pain (25 points)
- 25 None
- 20 Mild, occasional
- 15 Moderate, tolerable
- 0 Severe or intolerable

II. Range of motion (25 points): flexion + extension, percentage of normal
- 25 100
- 15 75-99
- 10 50-74
- 5 25-49
- 0 0-24

III. Grip strength (25 points), percentage of normal
- 25 100
- 15 75-99
- 10 50-74
- 5 25-49
- 0 0-24

IV. Activities (25 points)
- 25 Returned to regular employment
- 20 Restricted employment
- 15 Able to work but unemployed
- 0 Unable to work because of pain

V. Final result
- 90-100 Excellent
- 80-89 Good
- 65-79 Fair
- <65 Poor

Appendix B

Gartland and Werley Score (demerit system)[13]

I. Subjective evaluation—6
- Excellent: no pain, disability, or limitation of motion (0)
- Good: occasional pain, slight limitation of motion, and no disability (2)
- Fair: occasional pain, some limitation of motion, feeling of weakness in wrist, no particular disability if careful and activities slightly restricted (4)

- Poor: pain, limitation of motions, disability, and activities more or less markedly restricted (6)

II. Objective evaluation—5
- Loss of dorsiflexion (5)
  ulnar deviation (3)
  supination (2)
  palmar flexion (1)
  radial deviation (1)
  circumduction (1)
  distal radioulnar joint (1)

III. Residual deformity—3
- Prominent ulnar styloid (1)
- Residual dorsal tilt (2)
- Radial deviation of hand (2-3)

IV. Complications—5
- Arthritic changes minimal (1)
  minimal with pain (3)
  moderate (2)
  moderate with pain (4)
  severe (3)
  severe with pain (5)
- Nerve complications (median) (1-3)
- Poor finger function due to cast (1-2)

Final result
0-2 Excellent
3-8 Good
9-20 Fair
≥21 Poor

Appendix C

Sarmiento Radiological Score (modified from Lidström and Frykman)[11]

Excellent	No or insignificant deformity
	Dorsal angulation ≥0°
	Shortening of <3 mm
	Loss of radial deviation <4°
Good	Slight deformity
	Dorsal angulation of 1-10°
	Shortening of 3-6 mm
	Loss of radial deviation 5-9°
Fair	Moderate deformity
	Dorsal angulation of 11-14°
	Shortening of 7-11 mm
	Loss of radial deviation 10-14°
Poor	Severe deformity
	Dorsal angulation of >15°
	Shortening of >12 mm
	Loss of radial deviation >15°
	(Average radial deviation of 23°)

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References

1. McQueen M, Caspers J. Colles fracture: does the anatomical result affect the final function? *J Bone Joint Surg Br*. 1988; 70(4):649-651.
2. Karnezis IA, Fragkiadakis EG. Association between objective clinical variables and patient-rated disability of the wrist. *J Bone Joint Surg Br*. 2002;84(7):967-970.
3. Young BT, Rayan GM. Outcome following non-operative treatment of displaced distal radius fractures in low-demand patients older than 60 years. *J Hand Surg Am*. 2000;25(1):19-28.
4. Bradway J, Amadio P, Cooney W. Open reduction and internal fixation of displaced, comminuted intra-articular fractures of the distal end of the radius. *J Bone Joint Surg Am*. 1989;71(6): 839-847.
5. Goldhahn J, Angst F, Simmen BR. What counts: outcome assessment after distal radius fractures in aged patients. *J Orthop Trauma*. 2008;22(8 suppl):S126-S130; doi:10.1097/BOT.0b013 e31817614a1.
6. MacDermid JC, Richards RS, Donner A, Bellamy N, Roth JH. Responsiveness of the short form-36, disability of the arm, shoulder, and hand questionnaire, patient-rated wrist evaluation, and physical impairment measurements in evaluating recovery after a distal radius fracture. *J Hand Surg*. Am. 2000;25(2): 330-340.
7. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder, and head). *Am J Ind Med*. 1996;29(6): 602-608.
8. MacDermid JC, Tottenham V. Responsiveness of the disability of the arm, shoulder, and hand (DASH) and patient-rated wrist/hand evaluation (PRWHE) in evaluating change after hand therapy. *J Hand Ther*. 2004;17(1):18-23.
9. Baker SP, O'Neill B, Haddon WJ, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma*. 1974;14(3): 187-196.
10. Kreder HJ, Hanel DP, McKee M, Jupiter J, McGillivary G, Swiontkowski MF. X-ray film measurements for healed distal radius fractures. *J Hand Surg Am*. 1996;21(1):31-39.
11. Sarmiento A, Pratt G, Berry N, Sinclair W. Colles' fractures. Functional bracing in supination. *J Bone Joint Surg Am*. 1975; 57(3):311-317.
12. Cooney WP, Bussey R, Dobyns JH, Linscheid RL. Difficult wrist fractures perilunate fracture-dislocations of the wrist. *Clin Orthop Relat Res*. 1987;214:136-147.
13. Gartland JJ Jr, Werley CW. Evaluation of healed Colles' fractures. *J Bone Joint Surg Am*. 1951;33(4):895-907.

14. Dowrick AS, Gabbe BJ, Williamson OD, Cameron PA. Outcome instruments for the assessment of the upper extremity following trauma: a review. *Injury*. 2005;36(4):468-476.
15. Lee EWC, Lau JSY, Chung MMH, Li APS, Lo SK. Evaluation of the Chinese version of the disabilities of the arm, shoulder and hand (DASH): cross-cultural adaptation process and reliability study. *J Hand Ther.* 17:417-423.
16. Anzarut A, Johnson JA, Rowe BH, Lambert RG, Blitz S, Majumdar SR. Radiologic and patient-reported functional outcomes in an elderly cohort with conservatively treated distal radius fractures. *J Hand Surg Am*. 2004;29(6):1121-1127.
17. Souer JS, Lozano-Calderon SA, Ring D. Predictors of wrist function and health status after operative treatment of fractures of the distal radius. *J Hand Surg*. 2008;33(2):157-163.
18. MacDermid JC. Development of a scale for patient rating of wrist pain and disability. *J Hand Ther*. 1996;9(2):178-183.
19. Colles A, On the Fracture of the Carpal Extremity of the Radius. *J Med Surg Coll Br Sci.* 1814;3:368-372.