Baseline Predictors of Pain and Disability One Year Following Extra-Articular Distal Radius Fractures

Ruby Grewal · Joy C. MacDermid ·
Janet Pope · Bert M. Chesworth

Received: 20 December 2006 / Accepted: 7 February 2007 / Published online: 23 March 2007
© American Association for Hand Surgery 2007

Abstract Distal radius fractures are common injuries; however, identifying which factors are responsible for predicting outcomes remains an area of controversy. The purpose of this study was to define factors predictive of patient-reported pain and disability at 1 year in a prospective cohort of extra-articular distal radius fractures ($n=222$). Data were collected at the initial visit and after 3, 6, and 12 months. The primary outcome was the 1-year patient-rated wrist evaluation (PRWE) score. The effect of baseline patient and injury characteristics on the 1-year PRWE score was assessed. Univariate and forward stepwise regression analyses both agreed that the most influential predictor of pain and disability at 1 year was injury compensation. The 1-year PRWE score was significantly higher for subjects involved with third-party claims (35.48) compared to those

that were not involved in any claims (14.97), $p=0.006$. The regression model found that three baseline factors – injury compensation, education, and other medical comorbidities – explained 16.4% of the variance in PRWE scores at 1 year. No injury characteristic, including the degree of initial fracture displacement, was found to significantly influence the 1-year PRWE score. This study has shown that baseline patient and injury characteristics play a small role in predicting 1-year patient-reported pain and disability in extra-articular distal radius fractures. Conceptual factors outside of this biomedical model should be investigated.

Keywords Wrist · Fracture · Outcome · Pain · Disability

Introduction

Distal radius fractures are among the most common orthopedic injuries, accounting for one sixth of all fractures treated in the emergency room [10]. Despite our long history of experience with these fractures, the final outcome is not always predictable. Some patients with severe radial malunion do surprisingly well, whereas others with no apparent causative factor do poorly. In the current literature, little is reported about the specific patient and injury characteristics that are responsible for predicting long-term outcomes in extra-articular distal radius fractures. Studies have been published regarding the role of different factors in predicting outcome; however, most published studies report on a mixed cohort of intra- and extra-articular distal radius fractures (usually with a predominance of intra-articular fractures) [1, 9, 11–14], they report only short-term (≤ 6 months) outcomes [9, 12, 14], and they do not utilize validated patient-reported outcome scales specific to the wrist [1, 11–14].

R. Grewal (✉) · J. C. MacDermid
Division of Orthopedic Surgery, Hand and Upper Limb Center,
St Joseph's Health Care, University of Western Ontario,
268 Grosvenor St,
London, Ontario N6A 4L6, Canada
e-mail: rgrewa@uwo.ca

J. C. MacDermid
e-mail: joy.macdermid@sjhc.london.on.ca

J. Pope
Division of Rheumatology and Department of Epidemiology
& Biostatistics, St Joseph's Health Care,
268 Grosvenor St,
London, Ontario N6A 4L6, Canada
e-mail: Janet.Pope@sjhc.london.on.ca

B. M. Chesworth
Ontario Joint Replacement Registry,
100 Collip Circle, Suite 225,
London, Ontario N6C 2G5, Canada
e-mail: Bert.Chesworth@lhsc.on.ca

Historically, the outcome scale used in published reports of distal radius fractures [1, 11, 12] has been the Gartland and Werley demerit system [4]. This scale is a demerit system, scored by the physician who deducts points for deficits in movement, strength, radiographic changes, pain, and deformity. The reliability or validity of this scoring system has not been reported. It has also been stated that, with this system, poor outcomes are only assigned to patients with severe problems [2]. Traditional measures of impairment (i.e., grip strength, range of motion, and x-ray abnormalities) also do not necessarily reflect patient-reported pain and disability.

The purpose of this study was to evaluate which baseline factors (patient and initial injury characteristics) are most predictive of patient-reported pain and disability [based on the patient-rated wrist evaluation (PRWE) score] at 1 year in a cohort of extra-articular distal radius fractures. By gaining a better understanding of the factors that predict outcome, we can help guide treatment decisions, giving patients and their care givers a better understanding of their expected outcome.

Materials and Methods

This study was conducted as part of an ongoing prospective cohort study evaluating outcomes of distal radius fractures. A subset of patients with extra-articular fractures was identified. All patients were recruited from the practices of nine fellowship-trained hand surgeons at a single tertiary-care referral center. Subjects provided informed consent for the use of their results in this study. Testing was incorporated into scheduled clinic visits.

All skeletally mature patients with extra-articular distal radius fractures were enrolled from June 1997 to June 2004 ($n=297$). All fractures with intra-articular extension (displaced and undisplaced) were excluded. After the initial visit, patients were seen at 3-, 6-, and 12-month intervals.

At the initial visit, potential predictors such as age, gender, smoking history, menopausal status, and medical comorbidities were recorded. Patients also reported on their level of occupational demand (low, moderate, or high, as determined by the patients themselves), whether they were involved in a worker's compensation claim, and the highest level of education they had obtained (some high school, finished high school, or completed postsecondary training). Injury characteristics and their effect on final function were also assessed. The injury characteristics evaluated were the overall energy of injury (low, intermediate, high), the degree of initial displacement, whether the dominant or the nondominant hand was injured, and the presence of an ulnar-sided injury [ulnar styloid/head fracture or distal radio-ulnar joint (DRUJ) involvement].

The primary outcome used was the 1-year PRWE score. This outcome instrument provides a score, reflecting the patient's own perception of their level of pain and disability. The PRWE has been shown to be valid, reliable, and highly responsive in the distal radius fracture population [6–8].

Data Analysis

Descriptive statistics were calculated for all independent variables and the PRWE. Then, bivariate relationships between baseline characteristics and 1-year PRWE score were calculated. For dichotomous categorical variables, a *t* test was used to compare the difference in mean PRWE scores between groups. For variables with three or more categories, ANOVA testing was used to detect differences in outcomes across categories. When ANOVA tests were found to be statistically significant, post hoc Tukey tests were used to determine which comparisons were significantly different.

A forward-stepwise multiple linear regression model was created to determine factors predictive of outcome. Intrinsic patient factors and injury factors were expected to contribute at least partially to the overall model and were therefore analyzed separately. The variables that were retained in these two models were then combined to create a single overall model to predict which overall baseline factors influenced patient reported pain and disability 1 year after a distal radius fracture. Variables that were missing from the database in more than 15% of cases and that did not have significant univariate correlations were not considered for entry into the model.

Results

Descriptives

A total of 297 patients met the eligibility criteria and were included in our study. Of the 297 patients with extra-articular distal radius fractures, 222 had completed at least 1 year of follow-up and were included in the final analysis.

The mean age was 55.2 ± 17.5 years. The range was 18–89 years (71 years) and the median age was 57.50 years. The cohort consisted primarily of women; there were 49 male (22.1%) and 173 female (77.9%) subjects. Of the 173 women in this cohort, 100 subjects (57.8%) were postmenopausal. There were 20 subjects (9.0%) that had a third-party claim surrounding their injury. The cohort was quite healthy, with minimal medical comorbidities and very few (14.4%) smokers. A wide range of education levels, occupations, and occupational demands was represented (Table 1).

Table 1 Patient characteristics and influence on PRWE.

Characteristic	Number of Patients (%)	Mean 1-year PRWE	<i>p</i> value
Gender			
Male	49 (22.1)	14.91	0.45
Female	173 (77.9)	17.76	
Dominant hand involved			
Dominant hand involved	110 (49.5%)	15.81	0.36
Non-dominant hand	112 (50.5%)	18.62	
Third-party compensation			
Claim or pending claim	20 (9.0%)	35.48	0.006
No associated claim	202 (91.0%)	14.97	
Menopause			
Premenopausal	54 (24.3)	16.33	0.48
Postmenopausal	100 (45)	19.18	
Missing	19 (8.6)		
Medical comorbidities <i>n</i> =195			
Heart			
Yes	17 (8.7)	24.83	0.20
No	178 (91.3)	17.23	
Arthritis			
Yes	41 (21.0)	24.27	0.051
No	154 (79.0)	16.21	
Diabetes			
Yes	10 (5.1)	16.49	0.83
No	185 (94.9)	18.02	
Other			
Yes	72 (36.9)	19.86	0.38
No	123 (63.1)	16.79	
>3 medical comorbidities			
Yes	14 (7.2)	25.79	0.19
No	181 (92.8)	17.31	
Smoking history <i>n</i> =207			
Smokers	32 (14.4)	25.16	0.052
Ex-smokers	48 (21.6)	12.29	
Never smoked	127 (57.2)	17.38	
Education <i>n</i> =205			
Not finished high school	44 (21.5)	22.71	0.016
Finished high school	76 (37.0)	20.11	
Completed postsecondary training	85 (41.5)	12.12	
Occupational demand <i>n</i> =193			
Low	96 (43.2)	17.01	0.94
Moderate	23 (10.4)	15.04	
High	19 (8.6)	18.47	

The majority of patients sustained their distal radius fracture as a result of a low-energy fall (see Table 2). With the initial injury, there were also 95 (42.8%) patients with associated ulnar styloid fractures, six (2.7%) with ulnar head fractures, and four (1.8%) with DRUJ involvement. There were 142 patients with available prereduction radiographs (80/222, 36% missing). Prior to reduction, the average degree of dorsal angulation was $10.8^{\circ} \pm 17.5^{\circ}$ (range 23° volar to 53° dorsal), the average degree of radial inclination was $18.9^{\circ} \pm 7.1^{\circ}$ (range -19° to 35°) and the average ulnar variance was 1.1 ± 2.3 mm (range -4 to $+8$ mm). Overall, the patient-reported outcomes were

favorable. Initially, the mean PRWE score was 66.59 and improved to 17.16 at 1 year.

Bivariate Analysis

Patient and Injury Characteristics

When considered as individual variables, most patient and injury characteristics did not influence 1-year PRWE scores. Neither gender, menopausal status, occupation, occupational demand, mechanism of fall, energy of fall, nor hand dominance were found to significantly influence

Table 2 Injury characteristics and influence on PRWE.

Characteristic	Number of Patients (%)	Mean 1-year PRWE	<i>p</i> value
Mechanism of injury <i>n</i> =222			
Fall on ice/snow	56 (25.2)	13.67	0.41
Other fall	147 (66.2)	18.28	
Other mechanism (i.e., MVA)	19 (8.6)	18.78	
Hand injured <i>n</i> =222			
Dominant	110 (49.5)	15.81	0.36
Nondominant	112 (50.5)	18.62	
Energy of fall <i>n</i> =222			
Low (i.e., fall from standing height)	176 (79.3)	16.47	0.57
Moderate (i.e., fall >8 ft or higher-energy sporting injury)	33 (14.9)	18.57	
High (i.e., high-speed MVA)	13 (5.9)	22.90	
Ulnar-sided injury <i>n</i> =214			
Ulnar styloid fracture			
Yes	95 (44.4)	19.17	0.13
No	119 (55.6)	14.57	
Ulnar head fracture			
Yes	6 (2.8)	11.90	0.59
No	208 (97.2)	16.79	
DRUJ involvement			
Yes	4 (1.9)	14.50	0.85
No	210 (98.1)	16.69	

MVA = motor vehicle accident

PRWE scores in this cohort of extra-articular distal radius fractures. The presence of a third-party compensation claim, however, did significantly influence the PRWE ($p=0.006$) score. We also found that the highest education level also affected outcome. Patients who completed postsecondary training had significantly lower PRWE and disability of the arm, shoulder, and hand scores than those who did not ($p=0.016$) (Table 1).

Age

When comparing outcome scores in patients younger (PRWE=18.04) and older than 65 (PRWE=15.52), no significant difference was found in 1-year PRWE scores ($p=0.430$). When age was considered as a continuous variable, the correlation with the PRWE scores was also not significant (Pearson $r_{\text{age}}=-0.018$, $p=0.811$).

Medical Comorbidities

Subjects with multiple (≥ 3) medical comorbidities ($p=0.194$), heart disease ($p=0.198$), or diabetes ($p=0.830$) were not found to have significantly lower PRWE scores than those subjects without such problems (Table 1). However, there was a trend towards a higher 1-year mean PRWE score in subjects with arthritis compared to those without arthritis ($p=0.051$, 95% CI of the difference in PRWE scores=-16.16 to 0.048).

Smoking

There was a trend towards a significant change in PRWE depending on smoking status ($p=0.052$), with the highest mean PRWE seen in smokers (Table 1). Post hoc Tukey testing indicated that the significant difference was between those who quit smoking and those who currently smoke ($p=0.040$, 95% CI: -25.29 to -0.45).

Radiographs

The 1-year PRWE score did not correlate with any of the prerelation radiographic measurements (dorsal angulation, $p=0.84$; radial shortening, $p=0.86$; radial inclination, $p=0.81$). The presence of an ulnar styloid fracture, ulnar head fracture, or DRUJ involvement also did not result in a significant difference in 1-year PRWE scores (Table 2).

Regression Model

When considering characteristics intrinsic to the patients themselves, the following variables were included in our model: age, gender, menopause, smoking history, medical comorbidities (heart problems, diabetes, arthritis, other problems, and the presence of multiple medical comorbidities), level of education, occupation, and the presence of current or pending third-party compensation claims. The variables that were found to be predictive of the 1-year

Table 3 Baseline patient characteristics and 1-year PRWE scores (model summary).

Model	<i>R</i>	<i>R</i> Square	Adjusted <i>R</i> Square	Std. Error of the Estimate	Change Statistics				
					<i>R</i> Square Change	<i>F</i> Change	df1	df2	Sig. <i>F</i> Change
1	0.335 ^a	0.112	0.106	21.12031	0.112	17.519	1	139	0.000
2	0.413 ^b	0.170	0.158	20.48754	0.058	9.719	1	138	0.002

Dependent variable: 1-year PRWE total score

^a Predictors: (constant), third-party claim

^b Predictors: (constant), third-party claim, education

PRWE score were the presence of a third-party compensation claim and the level of education. Together, these two factors predicted 15.8% of the variability seen in the PRWE score (Tables 3 and 4).

The next model included characteristics of the injury itself: the mechanism of injury, the energy of the fall, the involvement of the dominant hand, the presence of an ulnar-sided injury (ulnar styloid fracture or DRUJ involvement), the prereduction dorsal angulation, radial inclination, and radial shortening. This model did not contain any variables that were predictive of the 1-year PRWE score.

Finally, a model that included all baseline factors (intrinsic patient and initial injury factors) was created. In this model, the variables that were found to be predictive of the 1-year PRWE score were the presence of a third-party compensation claim, the level of education, and the presence of other medical problems. Together, these three factors predicted 16.7% of the variability seen in the PRWE score (Tables 5 and 6).

Discussion

To develop a model to determine which baseline characteristics predict patient-reported pain and disability, both intrinsic patient characteristics and characteristics associated with the injury itself were examined. It was expected that both patient and injury factors would contribute, at

least partially, to the overall model, and therefore, these attributes were modeled separately and together to create a comprehensive model of baseline characteristics.

This study has shown that baseline patient and injury characteristics play a small role in predicting 1-year patient-reported pain and disability in extra-articular distal radius fractures. We found that the presence of a third-party compensation claim, the level of education, and the presence of other medical problems together predicted 16.7% of the variability seen in the 1-year PRWE score. Injury compensation contributed 0.106, education 0.051, and the presence of other medical problems 0.028.

The results of our regression model provide support for the previous work published by MacDermid et al. in that a third-party payer or lower education had a negative impact on outcomes [9]. MacDermid et al. prospectively analyzed the effect of patient vs injury factors as predictors of pain and disability 6 months after a distal radius fracture in a smaller cohort of mixed fracture types. The studies were similar in that both used the PRWE as their primary outcome. However, they differed in fracture types included, follow-up times, and that MacDermid et al. did not include medical comorbidities as a potential predictor. We had purposely limited our analysis to extra-articular fractures and used only two evaluators to take radiographic measurement as a means to create tighter control over the fracture construct. We expected that this might enhance the

Table 4 Baseline patient characteristics and 1-year PRWE scores (coefficients).

Model	Unstandardized Coefficients		Standardized Coefficients Beta	<i>t</i>	Sig.
	<i>B</i>	Std. Error			
1					
Constant	15.903	1.889		8.419	0.000
Any pending claim during recovery WCB or legal	23.472	5.608	0.335	4.186	0.000
2					
Constant	31.644	5.371		5.891	0.000
Any pending claim during recovery WCB or legal	22.717	5.445	0.324	4.172	0.000
Education in 3 levels	−7.052	2.262	−0.242	−3.117	0.002

Dependent variable: 1-year PRWE total score

WCB = Workers' Compensation Board

Table 5 Baseline factors (patient + injury characteristics) and 1-year PRWE scores (model summary).

Model	<i>R</i>	<i>R</i> Square	Adjusted <i>R</i> Square	Std. Error of the Estimate	Change Statistics				
					<i>R</i> Square Change	<i>F</i> Change	df1	df2	Sig. <i>F</i> Change
1	0.326 ^a	0.106	0.099	20.27537	0.106	16.019	1	135	0.000
2	0.397 ^b	0.157	0.145	19.75861	0.051	8.154	1	134	0.005
3	0.431 ^c	0.185	0.167	19.49863	0.028	4.597	1	133	0.034

Dependent variable: 1-year PRWE total score

^a Predictors: (constant), third-party claim^b Predictors: (constant), third-party claim, education^c Predictors: (constant), third-party claim, education, other medical problems

predictive power of our modeling, but the opposite effect was observed. This suggests that the reduced variability of the fracture construct may have contributed to lower prediction. This also implies that neither limitations to the fracture construct nor reliability of radiographic measurements was responsible for limited prediction in the previous cohort study. This implies that conceptual factors outside of this biomedical model should be investigated.

In the mixed-fracture cohort study, the most influential predictor of pain and disability at 6 months was injury compensation, followed by patient education level and preradial shortening [9]. The *R*-squared for the full model (injury compensation, patient education level, and preradial shortening) was 0.25, which means that these three factors together account for 25% of the variability in the final PRWE score [9]. In our model, the baseline characteristics were only able to predict 16.4% of the variability seen in the final PRWE score. In their model, injury compensation contributed 0.16, which is slightly higher than that of our study (0.106), and education contributed an additional 0.04, which was similar to our

finding of 0.051. Unlike this study, the preradial shortening did not achieve significance in our model.

When considering each variable independently, the presence of a third-party compensation claim (workers compensation or insurance claim) was found to significantly influence the 1-year PRWE scores. The 1-year PRWE was significantly higher for subjects involved with third-party claims (35.48) compared to those that were not involved in any claims (14.97), $p=0.006$. These findings are consistent with those of other reports in the literature [3, 9]. We also found that patients with some postsecondary education had significantly lower PRWE scores than those who did not ($p=0.016$).

Although statistical significance was not achieved, there was a trend toward higher PRWE scores in smokers ($p=0.052$) and in subjects with arthritis ($p=0.051$). This differs from the results reported by MacDermid et al., who state that smoking status did not affect patient-reported pain and disability scores [9].

The other independent variables that were studied did not significantly influence 1-year pain and disability scores as reported by patients in this study. While these other

Table 6 Baseline factors (patient + injury characteristics) and 1-year PRWE scores (coefficients¹).

Model	Unstandardized Coefficients		Standardized Coefficients	<i>t</i>	Sig.
	<i>B</i>	Std. Error	Beta		
1					
Constant	15.397	1.836		8.388	0.000
Any pending claim during recovery WCB or legal	22.203	5.548	0.326	4.002	0.000
2					
Constant	29.598	5.285		5.600	0.000
Any pending claim during recovery WCB or legal	21.118	5.420	0.310	3.897	0.000
Education in 3 levels	−6.346	2.222	−0.227	−2.856	0.005
3					
Constant	25.927	5.489		4.723	0.000
Any pending claim during recovery WCB or legal	22.221	5.373	0.326	4.136	0.000
Education in 3 levels	−6.053	2.197	−0.217	−2.755	0.007
Other medical problems	7.354	3.430	0.169	2.144	0.034

Dependent variable: 1-year PRWE total score

WCB = Workers' Compensation Board

factors may influence impairment, other measures of disability, or short-term results, they were not significant for the 1-year PRWE scores.

Previous studies, evaluating both intra- and extra-articular distal radius fractures together, state that hand dominance did not appear to predict outcome. In our cohort of extra-articular fractures, we reached a similar conclusion [9, 11, 13]. In this cohort, age and gender did not influence patient-reported pain and disability at 1 year. This is in keeping with other reports in the literature that analyzed both intra- and extra-articular distal radius fractures together [1, 9, 11, 13] and used either the Gartland and Werley scale [1, 11] or another subjective scale for evaluating outcome [13].

There are reports in the literature supporting the claim that age and gender play some role in influencing final outcome after distal radius fractures. In a study of intra- and extra-articular distal radius fractures, Stewart et al. showed that age and gender were found to have some effect, as males under the age of 65 had both better reductions and better final results [12].

This conflicting information about the influence of age and gender on final outcomes can possibly be explained by the role that age and gender play in determining bone mineral density. That is, although age and gender cannot independently predict outcome, they can sometimes be influential in predicting bone mineral density (i.e., it can often be assumed that older women have lower bone mineral density). Therefore, age and sex may be acting as a surrogate for bone mineral density in some cases.

Hollevoet et al. found that clinical results correlated better with bone mineral density than with the radiological parameters, suggesting that osteoporosis may be one of the factors affecting the outcome of distal radius fractures [5]. Based on a pilot study of intra- and extra-articular distal radius fractures, conducted by Wakefield and McQueen, it was shown that age was strongly linked with poor outcome, and older women (>55 years), of limited physical ability and poor bone stock appeared to be particularly at risk [14]. The correlation of bone mineral density with outcome is an important area that requires future investigation.

None of the other injury characteristics (mechanism, energy, degree of initial displacement, or presence of ulnar/DRUJ involvement) influenced 1-year PRWE scores in our cohort of extra-articular distal radius fractures. These results are similar to those reported by Porter and Stockley, who state that the severity of initial fracture displacement had no significant relationship to wrist function (based on Gartland and Werley) at 2 years [11].

Although we did not find evidence of the importance of fracture displacement, most other reports in the literature support the existence of a significant relationship between initial fracture displacement and final outcome. In a cohort of intra- and extra-articular fractures, MacDermid et al. found that the prereduction radial shortening was influential

in predicting outcomes at 6 months [9]. Stewart et al. also report that the functional result at 3 months is related to the severity of the initial displacement of the fracture [12]. Wakefield and McQueen also demonstrated that poor outcomes at 6 months were predicted by the severity of the initial displacement of the fracture [14]. The reasons for these differences are not clear, but it may be that outcomes of extra-articular fractures are less influenced by fracture displacement than cohorts where intra-articular fractures are included.

The only study with long-term results (1.5 to 6 years follow-up) that supports this association is by Altissimi et al., who found that displaced fractures had a higher percentage of unsatisfactory results (14.5%) when compared to fractures without displacement (6%); their cohort of distal radius fractures consisted primarily of intra-articular fractures (75%) [1].

The overall energy of the injury was also examined by MacDermid et al. They also report that this had no effect of final outcome when energy was classified as mild, moderate, or severe based on fracture mechanism [9]. Trumble et al., however, found that the greater the number of cortices that are comminuted, the greater the decrease in functional outcome [13]. This suggests that the energy of the injury (assuming increased energy causes increased comminution) is related to functional outcome; however, this cohort consisted primarily of intra-articular (77%) distal radius fractures. Similar to our results, Stewart et al. also report that the presence of an ulnar styloid fracture has no bearing on the expected final outcome [12].

There are several limitations of this study. Although this study was based on prospectively collected data, the research question was designed after data collection began. Thus, not all potentially interesting predictors were included (socioeconomic status, recreational interests, living conditions, and presence of support networks). Although the sample size was large ($n=222$), due to missing values on certain variables, most regression equations had an actual n of only 140. This sample of 140 was achieved by dropping variables that had >15% of their values missing from analyses. Although these variables were of interest (occupational demand, alcohol, history of falls, other injuries) this strategy was necessary to retain optimal statistical power.

Another weakness was that the number of available prereduction x-rays was limited. This is due to the fact that the study was conducted at a tertiary care center, and many cases were referred from community hospitals where the initial reduction was performed. As such, we were unable to obtain prereduction x-rays in 80 of the 222 cases.

This study evaluated the role of predictive baseline factors on 1-year pain and disability in a population of extra-articular distal radius fractures. It was determined that three baseline factors adversely affected outcome – injury compensation, education, and other medical comorbidities –

which explain 16.7% of the variance in patient-reported pain and disability 1 year after an extra-articular distal radius fracture. Additional studies based on comprehensive models of health may provide greater explanatory power.

References

1. Altissimi M, Antenucci R, Fiacca C, Mancini GB. Long term results of conservative treatment of fractures of the distal radius. *Clin Orthop* 1986;206:202–10.
2. 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;71:839–47.
3. Filan SL. The effect of workers' or third-party compensation on return to work after hand surgery. *Med J Aust* 1996;165(2):80–2.
4. Gartland J, Werley C. Evaluation of healed Colles' fractures. *J Bone Joint Surg Am* 1951;33A:895–907.
5. Hollevoet N, Verdonk R. Outcome of distal radius fractures in relation to bone mineral density. *Acta Orthop Belg* 2003;69(6):510–4.
6. MacDermid J. Development of a scale for patient rating of wrist pain and disability. *J Hand Ther* 1996;9:178–83.
7. MacDermid J, Turgeon T, Richards R, Beadle M, Roth J. Patient rating of wrist pain and disability: a reliable and valid measurement tool. *J Orthop Trauma* 1998;12:577–86.
8. MacDermid J, Richards R, Donner A, Bellamy N, Roth J. 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;25:330–40.
9. MacDermid JC, Donner A, Richards RS, Roth JH. Patient versus injury factors as predictors of pain and disability six months after a distal radius fracture. *J Clin Epidemiol* 2002;55(9):849–54.
10. Owen RA, Melton LJ, Johnson KA, Ilstrup DM, Riggs BL. Incidence of Colles' fracture in a North American community. *J Bone Joint Surg* 1982;72:605–7.
11. Porter M, Stockley I. Fractures of the distal radius intermediate and end results in relation to radiologic parameters. *Clin Orthop* 1987;220:241–52.
12. Stewart HD, Innes AR, Burke FD. Factors affecting the outcome of Colles' fracture: an anatomical and functional study. *Injury* 1985;16(5):289–95.
13. Trumble TE, Wagner W, Hanel DP, Vedder NB, Gilbert M. Intrafocal (Kapandji) pinning of distal radius fractures with and without external fixation. *J Hand Surg [Am]* 1998;23:381–94.
14. Wakefield AE, McQueen MM. The role of physiotherapy and clinical predictors of outcome after fracture of the distal radius. *J Bone Joint Surg Br* 2000;82:972–6.