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Long-term subjective results and radiologic prognosis of a distal radius fracture in working-aged patients – a prognostic cohort study of 201 patients

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Abstract

Objective: To investigate long-term outcomes associated with distal radius fracture (DRF) in working-aged patients. The authors hypothesized that the majority of patients experience no permanent loss of function when measured with patient-rated wrist evaluation (PRWE).

Methods: This was a retrospective cohort study of patients with a DRF aged between 18 and 65 years. The primary outcome measure was PRWE score at a minimum of 4 years after DRF. Secondary outcome measures were pain catastrophizing scale (PCS) and radiographic measurements.

Results: Of 201 patients included, 179 were primarily treated non-operatively with a 5-week cast treatment and 22 were primarily operated. The mean follow-up duration was 5 years. The mean PRWE score was 10.9 (95% confidence interval 8.4, 13.4) and median PRWE was 3.5 (interquartile range, 0.0–13.0). There was minor correlation between PCS and PRWE score (correlation coefficient [CC] 0.3), and between PRWE score and dorsal angulation of the fracture measured after closed reduction (CC 0.2) and in one-week follow-up radiographs (CC 0.2).

Conclusions: Working-aged patients seem to gain nearly normal wrist function after DRF in longer follow-up. Pain catastrophizing appears to correlate with long-term treatment outcome.

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Introduction

Distal radius fracture (DRF) is the most common upper extremity fracture and the most common fracture overall.[1,2] The incidence of DRF is highest in adolescent males and postmenopausal females; however, DRF is also a common injury in other patient groups.[1] In working-aged patients, the need for normal function of the wrist is high, and therefore, the main aim of treatment should be return to previous level of function and the ability to return to work.

Long-term follow-up studies have been conducted in adult patients of all ages and, due to the high incidence of DRF in elderly patients, the mean ages of the study populations have been near to retirement age.[3–7] To the best of the present authors' knowledge, no long-term treatment results focusing solely on working-aged patients have been reported in the literature to date.

In elderly patients with DRF, there is no general linear correlation between radiographic measurements and functional outcome.[6,8–13] In younger patients, associations between fracture alignment and functional results have been published,[12,14–17] but the clinical significance of these findings remains unclear.

Many factors other than radiographic measures may be associated with function following DRF. For example, fear of using the fractured wrist, depression and decreased motivation to do wrist exercises have been reported to have an effect on regaining grip strength.[18–20] The Pain Catastrophizing Scale (PCS) was developed to observe the association between pain and catastrophic thinking.[21] Findings in the published literature on other musculoskeletal disorders have revealed that individuals with negative pain-related thoughts are more likely to develop chronic pain.[21–23]

The purpose of the current study was to investigate the long-term outcomes of working-aged patients with a DRF. The authors hypothesized that: (1) in the majority of patients there is no long-term loss of function measured with patient-reported outcome measures; (2) primary radiographic measurements of the fracture do not correlate with long-term functional results measured with the Patient-Rated Wrist Evaluation (PRWE); and (3) a higher PCS score correlates with a loss of functional capacity, measured with the PRWE.

Patients and methods

Study population

This retrospective cohort study was conducted on patients with a DRF treated at Tampere University Hospital (TAUH) between January 2013 and December 2014. TAUH is one of five Finnish university hospitals and the second largest trauma centre in Finland. All procedures were followed in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Written informed consent to be included

in the study was obtained from all enrolled patients, and all study participants were able to ask additional questions about the study. Ethical approval for the study was obtained from the Regional Ethics Committee of the Expert Responsibility area of TAUH (June 12, 2018, ETL-code R18103), and institutional approval was obtained from TAUH research centre (June 2018).

The original data included all patients aged between 18 and 65 years with International Classification of Diseases (ICD)-10 diagnosis codes S52.5 (distal radius fracture) or S52.6 (distal radius and ulna fracture), treated in the emergency room (ER) at TAUH between 1 January 2013 and 31 December 2014. The hospital ER is centralized and all patients with primary trauma are referred to the unit. During the study period, the catchment area of the ER was approximately 400 000 inhabitants. Data for the study were obtained from the TAUH Research Centre electronic patient archive, and included background information on date of birth, sex, age, date of hospital visit, treatment modality, operation date, Nordic Medico-Statistical Committee (Nomesco) Procedural Classification code and fractured side. On the basis of electronic medical record texts, patients with multiple traumas, distal antebrachium fracture or previous fracture in the same upper extremity, were excluded. Only those patients who were alive and living in the TAUH catchment area were contacted by mailed questionnaires. In cases where patients did not return the study questionnaires within two months, the questionnaires were re-sent. All patient details were de-identified for data analysis and manuscript writing. The manuscript was written according to Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[24]

Treatment

Patients in the study were primarily treated pragmatically according to TAUH treatment guidelines, which follow general national guidelines.[25] Anterior-posterior and lateral radiographs of the fractured wrist were obtained in the ER. In cases of radiographic evidence of fracture displacement, closed reduction under local infiltration anaesthesia, comprising lidocaine or lidocaine-adrenaline, was performed by the treating physician. Closed reduction was not limited to any specific technique. Patients with acceptable fracture reduction were treated non-operatively with a 5-week dorsal cast. TAUH treatment guidelines recommend functional cast position, but the eventual cast position was decided by the treating physician. Radiographs were obtained at 1, 2 and 5 weeks following the fracture. Operative treatment was considered in patients with either initial loss of reduction or late loss of reduction during the follow-up. In Finland, guidelines for acceptable alignment are as follows: $\leq 15^\circ$ dorsal angulation, $\leq 20^\circ$ volar angulation, ≤ 3 mm positive ulnar variance, $\geq 15^\circ$ radioulnar inclination angle, and ≤ 1 mm step-off or gap on the joint line.[25] Volar locking plate using the modified Henry's approach was the most commonly used fixation method. A dorsal splint was used for two weeks following surgery.

Outcome measures

The primary outcome measure was PRWE score at a minimum of 4 years after DRF. The PRWE comprises 15 questions regarding the patient's subjective assessment of function and pain in the wrist and hand, rated on a scale from 0 to 10, giving an overall outcome of 0 to 100, in which 0 is the best possible result. The normative value for PRWE in the healthy population is 7.7 points.[26] If there were unanswered

questions in the PRWE, responses were analysed using the standards in the user manual. Secondary outcome measures were the pain catastrophizing scale (PCS) and radiographic measurements. The PCS is a 13-item self-reported measure with three subscales: rumination (worry), magnification (expectancies for negative outcomes) and helplessness (inability to deal with painful situations).[21] The electronic medical records of patients from the ER and visits to the orthopaedic outpatient clinic were reviewed and recorded to detect any complications during follow-up.

Radiographs

Anterior-posterior and lateral radiographs were obtained according to Finnish treatment guidelines. Radiographs obtained before fracture reduction, immediately after reduction, at a 1-week follow-up, before operative treatment in cases where the patient was operatively treated, and most recently, were analysed. Radioulnar inclination, dorsal or volar angulation, ulnar variance, articular step-off and integrity of the articular surface were all evaluated. Three independent observers (TH, LR, SV-T) first analysed the radiographs and in case of disagreement, consensus was reached.

Statistical analysis

The primary analysis included all patients who returned the study questionnaires. For the PRWE and PCS scores, the mean ± SD and median (interquartile range [IQR]) were calculated. For radiographic measurements, mean ± SD was calculated. The 95% confidence intervals (CIs) were calculated for the selected outcome measures. The linear correlation between two continuous outcome measures was evaluated using Pearson's correlation coefficients (CCs). The association between baseline characteristics (age, sex, dominant handedness, and fracture side) and PRWE score was also analysed with Pearson's correlation. Statistical analyses were performed using SPSS software, version 25 (IBM, Armonk, NY, USA), and *P*-values <0.05 were considered statistically significant.

Results

A total of 752 patients with DRF were treated at TAUH during the study period. Based on medical records, 84 patients were excluded due to multiple trauma, distal antebrachium fracture, previous fracture in the same upper extremity, or no radiologically confirmed fracture. In addition, 68 patients were living outside the TAUH catchment area or had died before study commencement and were therefore excluded. Study questionnaires were sent to the 600 remaining patients. In total, 214 patients (36%) returned all the questionnaires. Radiographs were analysed and a further 13 patients were excluded due to fracture morphology (Barton fracture, open fracture, distal antebrachium fracture or no fracture in radiographs). Thus, 201 patients with DRF, aged between 18 and 65 years, who were treated at TAUH between 1 January 2013 and 31 December 2014, were included in the final study sample (Figure 1).

Baseline characteristics of the study patients are listed in Table 1. A total of 179 patients (89%) were primarily treated non-operatively with a five-week cast and 22 patients (11%) were primarily operatively treated. Open reduction and internal fixation with a volar locking plate was the most common operative fixation method (19 patients). Of primarily non-operatively treated patients, 24 (13%) received surgical treatment during follow-up. Of these, 22 were surgically treated between 1 and 3 weeks after the fracture. The most

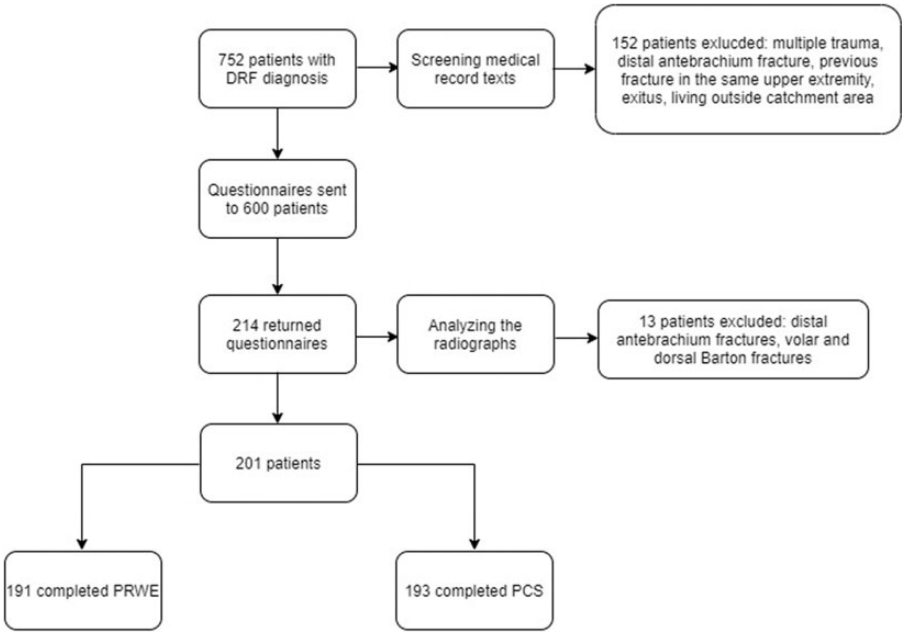

Figure 1. Flow chart showing study population selection.

Table 1. Baseline characteristics in 201 patients with distal radius fracture.

Characteristic	Study population
Age, years	49.4 ± 12.5
Male/female	46 (23)/155 (77)
Injury to dominant/ non-dominant hand	95 (47)/106 (53)
Handedness, right/left	179 (89)/22 (11)

Data presented as mean ± SD or *n* (%) prevalence.

common reason for delayed surgery was loss of alignment (19 patients). One patient received surgery due to carpal tunnel syndrome symptoms and one due to severe finger stiffness during the cast treatment. There was one osteotomy due to pain in the distal radioulnar joint and poor range of movement and one revascularization of the os trapezium after a non-union leading to severe complex regional pain syndrome. The mean follow-up was 60 months.

PRWE

The primary outcome measure, the PRWE questionnaire, was completed by 191 patients. Of these, 63 patients (33%) reported a PRWE score of 0 points and the overall distribution of PRWE score was heavily weighted towards zero (Table 2). The mean PRWE score was 10.9 (95% CI 8.4, 13.4) and the median score was 3.5 (IQR 0.0–13.0). In non-operatively treated patients, the mean PRWE score was 10.8 (95% CI 8.1, 13.5) and the median score was 2.5 (IQR 0.0–12.8), whereas in primarily operatively treated patients, the mean PRWE score was 11.3 (95% CI 4.8, 17.9) and the median score was 4.25 (IQR 1.0–21.0). In patients who were primarily treated non-operatively and changed to operative treatment within 3 weeks of the fracture, the mean PRWE score was 16.2 (95% CI 5.7, 26.7) and the median score was 2.5 (IQR 0.0–29.3). Overall, 2/22 (9%) primarily

Table 2. Patient-rated wrist evaluation (PRWE) and pain catastrophizing scale (PCS) scores in 201 patients with distal radius fracture treated with or without surgery, and in all study patients.

	Treatment group		
Measure	Non-operative	Operative	All
PRWE			
N	169	22	191
Mean ± SD	10.8 ± 17.9	11.3 ± 14.8	10.9 ± 17.5
95% CI	8.1, 13.5	4.8, 17.9	8.4, 13.4
Median (IQR)	2.5 (0.0–12.8)	4.25 (1.0–21.0)	3.5 (0.0–13.0)
PCS			
N	173	20	193
Mean ± SD	9.1 ± 10.2	4.4 ± 7.5	8.6 ± 10.0
95% CI of mean	7.6, 10.7	0.8, 7.9	7.2, 10.1
Median (IQR)	6.0 (0.5–13.5)	0.5 (0.0–6.5)	5.0 (0.0–13.0)

CI, confidence interval; IQR, interquartile range.

operated patients and 25/169 (15%) primarily non-operated patients reported a PRWE score >30. Of patients who received surgical treatment at 1–3 weeks following the fracture, 6/22 patients (27%) reported a PRWE score >30. Patient age did not correlate with PRWE score (CC 0.05). Moreover, patient sex, fracture side or fracture relation to dominant hand had no correlation with PRWE score (Supplemental Table S1).

Radiographs

Radiographs before fracture reduction were available in 184 patients. Primarily, the mean dorsal angulation was 14.7°, radioulnar inclination was 18.3° and radioulnar shortening was 1.6 mm. A total of 103 (51%) patients had an intra-articular fracture, of which 71 (69%) only had a fracture fissure to the radiocarpal joint line. In patients who received operative treatment either primarily or later on during follow-up, mean dorsal angulation preoperatively was 8.0°, radioulnar inclination was 18.0°, radioulnar shortening was 2.6 mm, and articular step-off was 0.4 mm. On average, the final radiographs were taken 72 days after fracture (95% CI 50, 96 days). At this time point, the mean dorsal angulation was 0.4°, radioulnar inclination was 19.2° and radioulnar shortening was 1.0 mm. Furthermore, 52 patients (28%) had suboptimal fracture alignment (>15° dorsal angulation, >20° volar angulation, >3 mm positive ulnar variance, <15° radioulnar inclination angle, or >1 mm step-off or gap on the joint line) in the final radiographs. Radiographic measurements are summarized in Table 3.

PRWE versus radiographs

There was a minor correlation between the final PRWE score and dorsal angulation measured after fracture reduction (CC 0.2, $P = 0.02$; Table 4). A similar correlation was also observed at one-week follow-up assessment (CC 0.23, $P = 0.04$; not shown in Table 4). Between the other radiographic measurements (radioulnar inclination, radioulnar shortening, articular step-off) and the PRWE score, correlation coefficients varied between 0.03 and 0.10, of which none were statistically significant at any assessment time point (Table 4).

In 63 patients with a PRWE score of 0 points, the mean dorsal angulation before

Table 3. Radiographic measurements at different follow-up time points in patients with distal radius fracture treated with or without surgery.

	Radiographic time-point				
X-ray parameter	Primary ($n = 184$)	After reduction ($n = 160$)	1 week (non-op) ($n = 89$)	Final radiograph ($n = 127$)	Pre-surgery ($n = 46$)
Dorsal (+)/ volar (−) angulation, °	14.7 ± 16.4	2.0 ± 7.9	2.9 ± 8.3	0.4 ± 9.4	8.0 ± 13.0
Inclination angle, °	18.3 ± 5.6	20.0 ± 4.0	18.6 ± 4.6	19.2 ± 5.0	18.0 ± 4.9
Ulnar variance (+ ulnar), mm	1.6 ± 3.2	0.0 ± 2.2	0.9 ± 0.4	1.0 ± 2.5	2.6 ± 2.7
Articular step-off, mm	0.4 ± 0.7	0.2 ± 0.5	0.1 ± 0.4	0.1 ± 0.3	0.4 ± 0.9

Data presented as mean ± SD.
Non-op, non-operative treatment.

Table 4. Correlation between patient-rated wrist evaluation score and radiographic measurement in patients with distal radius fracture treated with or without surgery.

	Radiographic time-point					
	Primary		After reduction		Final radiograph	
X-ray parameter	Correlation coefficient	Statistical significance	Correlation coefficient	Statistical significance	Correlation coefficient	Statistical significance
Dorsal/volar angulation	–0.03	NS	0.20	$P = 0.02$	0.02	NS
Inclination angle	–0.05	NS	–0.03	NS	–0.03	NS
Ulnar variance	0.03	NS	0.10	NS	0.09	NS
Articular step-off	0.09	NS	0.05	NS	0.09	NS

NS, no statistically significant correlation ($P > 0.05$; Pearson's correlation coefficient).

fracture reduction was 14.2°, radioulnar inclination was 18.9° and radioulnar shortening was 1.0 mm. In the same patient group, the mean dorsal angulation after fracture reduction was 0.4°, radioulnar inclination was 20.4° and ulnar variance was –0.5 mm. In 52 patients with suboptimal fracture alignment in the final radiographs, the mean PRWE score was 11.9 points (95% CI 6.9, 16.8).

PCS

The PCS questionnaire was completed by 193 patients (Table 2). The mean PCS score was 8.6 (95% CI 7.2, 10.1) and the median score was 5 (IQR 0.0–13.0). In total, 53 patients reported a PCS score of 0. There was a minor correlation between PCS and PRWE scores at the follow-up assessment time point (CC 0.3, $P < 0.01$). There was no statistically significant correlation between age and PCS.

Complications

The most common complication of non-operative treatment was loss of fracture alignment and subsequent operative treatment (observed in 19 patients [11%]). Two non-operatively treated patients had symptomatic malunion and one patient received

Table 5. Complications in 201 non-operatively and operatively treated patients with distal radius fracture.

Complication	Treatment group	
	Non-operative	Operative
Loss of alignment	19	–
CRPS	2	2
Malunion	2	–
Stiffness of fingers	1	–
ENMG due to low sensitization	1	–
Median nerve injury	–	1
Arthrosis	–	1
Scar tissue affecting DRUJ	–	1
Screw penetration to joint	–	1

Data presented as *n* incidence.
CRPS, complex regional pain syndrome; ENMG, electroneuromyography; DRUJ, distal radioulnar joint.

operative treatment because of finger stiffness during the cast treatment. In the operated group, there was one screw penetration into the radiocarpal joint and one scar tissue problem that affected the function of the distal radioulnar joint. Complex regional pain syndrome was found in two operatively treated patients (2/46 [4%]) and in two non-operatively treated patients (2/155 [1%]). All complications are listed in Table 5.

Discussion

The main finding of the present study was that the long-term treatment outcomes of DRF in working-aged patients are excellent when measured with PRWE score. Both non-operatively and operatively treated patients seem to regain normal function of the wrist when treatment is chosen pragmatically by following national guidelines. A minority of the patients in both treatment groups did not achieve normal wrist function at a minimum four-year follow-up.

In the present study, the mean PRWE score was 10.9 ± 17.5 (95% CI 8.4, 13.4) and the median was 3.5 (IQR 0.0–13.0). As a score of zero is the best possible score in the PRWE, these results can be interpreted as excellent. The minimal clinically important difference of the PRWE is reported to be between 10 and 14 points.[11,27–29] In the present cohort, no significant difference was found in mean PRWE score between the non-operative and operative treatment groups (10.8 versus 11.3, respectively). In total, 2/22 (9%) primarily operated patients and 25/169 (15%) primarily non-operated patients reported a PRWE score of more than 30, which can be considered to be a rather poor result. In addition, 6/22 patients (27%) who received an operation between one and three weeks after the fracture also reported a PRWE score of more than 30. This supports the findings of a previously published study, in which a probably clinically significant difference was found between early and delayed surgery groups measured with Disabilities of Arm, Shoulder and Hand (difference of means, –9; 95% CI –19, –0.3) in patients aged over 50 years.[30] Another retrospective study reported excellent functional results in 67% of operatively treated patients,[5] and in a study of mid-term (6–12 months post-injury) functional outcome in adult patients with DRF between operative and non-operative treatment, no significant difference was found between operative and non-operative groups.[31] The main results of the previous studies are summarized in **Supplemental Table S2**. Both operatively and non-operatively treated patients managed well at a minimum of four years after DRF in the present analyses.

Radiographs of the fractured limb have traditionally had a major impact on deciding the course of treatment, however, several published studies have suggested that the correlation between fracture alignment and

functional outcome is limited, particularly in older individuals.[14,15,32–35] In younger patients, a better functional result has been reported to correlate with fracture displacement,[12,14–17] although these studies are limited due to small sample and effect sizes, yielding clinical uncertainty. In the present study, a minor correlation was found between the final PRWE score and dorsal angulation of the fracture measured after closed reduction (CC 0.20, $P = 0.02$) and in one-week control radiographs (CC 0.23, $P = 0.04$). However, between any other radiographic measurement (radioulnar inclination, radioulnar shortening, articular step-off) and PRWE score, correlation coefficients of less than 0.1 were observed. Neither primary nor 3-month post-fracture follow-up radiographs appeared to correlate with wrist function measured with PRWE. It should be noted, however, that selection of the primary treatment (surgical or non-operative) was heavily based on primary displacement.

The role of psychological factors in the fracture recovery process remains unclear. Certain patient characteristics, such as fear related to pain and depression, are known risk factors for developing chronic pain, such as chronic low-back pain.[36–38] However, in acute traumas, such as limb fractures, the significance of psychological factors is poorly understood. A study investigating pain catastrophizing after acute wrist or ankle fractures revealed that persons with high or increasing pain catastrophizing were at a substantially higher risk for developing intense pain or poor recovery after the fracture.[39] In the present study, a positive correlation was noted between PCS and PRWE scores (CC 0.3, $P < 0.01$), supporting the previously published findings.[39]

Similar levels of correlation were found between pain catastrophizing and long-term PRWE and between dorsal angulation of the fracture and long-term PRWE in the present study. This partly supports the findings of Bot et al.,[40] who studied the long-term functional results of distal antebrachium fracture and found psychosocial factors, such as pain and pain catastrophizing, to be more closely associated with functional outcome than objective measurements.[40] In a cohort of 65 patients with DRF, no strong predictors were found for a worsening of functional outcome measured with PRWE between 1 and 11 years of follow-up.[6]

There are several strengths and limitations to the present study. First, the study was retrospective, and thus, it is difficult to draw solid conclusions on the causality of poor functional outcome in patients with a high PRWE score. In addition, the PRWE score was only measured at one follow-up time point, and therefore changes during the recovery process could not be determined. Secondly, other factors possibly affecting the PRWE score, such as radiocarpal arthrosis, rheumatoid arthritis, previous hand/wrist injuries and soft-tissue injuries, were not evaluated. Thirdly, despite sending the study questionnaires to 600 patients several times, only 214 patients responded, which may have resulted in selection bias. Although from a single centre, this study comprises one of the largest published cohorts of working-aged patients with DRF. The study data were collected in Finland that has a public healthcare system and unique personal social security numbers that enable long-term follow-up of individual patients. Moreover, the PRWE scores recorded in the present sample correspond to those reported in previously published patient samples, suggesting good generalizability of the results.

Conclusions

Working-aged patients seem to recover nearly normal function of the wrist in

longer follow-up after a distal radius fracture. The significance of fracture malalignment on the final functional results remains, however, unclear. In the present study, high pain catastrophizing measured with PCS was found to correlate with functional outcome measured with PRWE. Further research on working-aged patients with distal radius fracture is required to improve the treatment guidelines for this common injury.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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Supplemental material

Supplemental material for this article is available online.

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