

Patient-Reported Outcomes and Factors Associated with Non-Operatively Treated Distal Radius Fractures in Adults: A Retrospective Cross-Sectional Study at a Tertiary Referral Hospital in Ethiopia

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Abstract

Background: Distal radius fractures (DRFs) are among the most common orthopedic injuries worldwide; however, evidence on patient-reported functional outcomes following non-operative management in low-resource settings remains limited. This study assessed functional outcomes and associated factors among patients with non-operatively treated DRFs at Addis Ababa Burn, Emergency and Trauma (AaBET) Hospital, Ethiopia.

Methods: A retrospective cross-sectional study was conducted among 103 adults with DRFs managed non-operatively between March 2024 and March 2025. Data were obtained through medical record review and telephone-administered Patient-Rated Wrist Evaluation (PRWE) questionnaires. Descriptive statistics, bivariate analyses, and quantile regression were employed to identify factors associated with functional outcomes across different levels of disability.

Results: The median PRWE score was 26.0 (IQR: 14.0-46.0), indicating moderate residual disability. In quantile regression analyses, intra-articular fracture type was associated with worse median functional outcomes ($\beta = 23.67$, $p = 0.001$), while formal rehabilitation was associated with significantly lower disability among patients with milder impairment ($\beta = -13.82$, $p < 0.001$). Older age and female sex were associated with higher PRWE scores, whereas comorbidity significantly worsened outcomes among patients with severe disability. Nearly one-quarter (23.3%) of participants reported visiting a traditional bone setter before seeking hospital care.

Conclusion: Non-operative management of DRFs achieved generally favorable functional outcomes; however, recovery was strongly influenced by fracture type, rehabilitation access, age, sex, and comorbidity status. Expanding access to early rehabilitation, strengthening comorbidity management, and promoting timely evidence-based fracture care may improve functional recovery and reduce disability in resource-limited settings.

Background

Distal radius fractures represent a common injury in general population, despite a higher risk observed in pediatric and elderly populations(1). They account for approximately 18% of all fractures in adults, with a bimodal distribution affecting both young (high-energy trauma) and elderly (low-energy fragility fractures) populations (2). Approximately 65% are extra-articular, 12% partial articular, and 23% are complete articular. Lifetime risk is estimated as 15% in women and around 2% in men (1,3). Osteoporosis is the single most important risk factor in distal radius fractures, particularly in women greater than 50 years old. DEXA scan is recommended for older patients with DRFs with lower energy mechanisms (4,5). For older patients with low-energy injury mechanisms, fall on an outstretched hand is the commonest mechanism of injury; whereas high-energy mechanisms like motor vehicle accidents are more common in younger individuals (4). Acute presentations usually include pain and wrist deformity for isolated trauma; clinical features mainly depend on involvement of other site injuries

(6). Furthermore, a proportion of patients present with delayed complications, especially those visiting traditional bone setters as a primary treatment option, leading to complications (7)

Management of DRFs starts with careful patient evaluation and thorough assessment of radiologic imaging and fracture patterns (8). Considering multiple factors, including clinician's judgment, individual characteristics, and fracture type, either non-operative or operative management can be chosen (9). Non-operative treatment remains the cornerstone of management in the majority of cases, while surgical management has gained popularity in recent years (10). Non-operative treatment mainly includes manual reduction and plaster immobilization. Achieving good reduction can be checked with post-manipulation X-ray. Indicators of good reduction include radial height and inclination, volar or dorsal angulation, and articular step-off or gap (particularly for intra-articular fractures). Serial radiologic follow-ups are mandatory to check for loss of reduction (11)

Some patients experience early or late reduction loss, and certain fracture patterns have higher loss rates. Age, initial dorsal angulation, radial shortening, severe osteoporosis, intra-articular extension, associated ulnar fracture, ulnar variance, and dorsal comminution are common predictors of post-immobilization loss of reduction (12,13).

Surgical management may be primary or secondary after failed reduction. Open reduction and internal fixation (ORIF) with locking plates are widely used. Other options include percutaneous pinning, external fixation, and bridging plate osteosynthesis (14).

Although secondary displacement after closed reduction are not uncommon, and usually increases with age, international guidelines has no strong recommendations against non-operative treatment for displaced DRFs with adequate reduction. The goal is proper alignment, avoidance of secondary displacement requiring surgery, and optimal functional outcomes (2,15).

The comparison of outcomes between operative and non-operative treatment of DRFs is a key focus in many publications (9). Selecting the ideal management approach requires balancing factors such as quality of reduction, minimizing overall surgical risk, cost, and long-term patient satisfaction, particularly in achieving pain-free functionality (16,17). In low-resource settings like Ethiopia, where economic constraints and limited healthcare infrastructures exist, choosing the optimal treatment is further complicated by a lack of population-specific evidence. The high burden of DRFs in emergency departments, alongside overall trauma caseloads, underscores the need for evidence-based practice (EBP) guided by short- and long-term outcome measures (18).

An outcome measure is a tool used to evaluate a patient's current functional status. With growing emphasis on Evidence-Based Practice (EBP) in healthcare, these measures provide reasonable and reliable explanation for treatment decisions at both individual and systemic levels (19). Most literature uses either patient-reported outcome measures (PROMs) or clinician-assisted examinations to assess DRF outcomes. PROMs are directly reported by the patient without clinician interpretation, by assessing their health status, quality of life, or functional ability related to treatment. After many years of use in

clinical trials, there is now growing interest in using PROMs to support improvement in healthcare delivery (20,21).

Multiple patient-reported functional outcome measurement tools have been developed to evaluate the impacts of DRFs on patients' lives: Michigan Hand Questionnaire (MHQ), Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, Patient-Rated Wrist Evaluation (PRWE), and EQ-5D questionnaire are some examples. Among these, PRWE and DASH are the most widely used PROMs for DRF functional assessments (22). This paper prioritizes PRWE due to its wrist-specific focus, making it ideal for isolated DRFs. Recent studies increasingly favor PRWE, especially for non-operative cohorts (23), though DASH remains the most common tool in published literature, allowing for broader comparisons.

PRWE is a highly sensitive, wrist-specific tool that outperforms DASH in detecting functional changes and pain related to DRFs. Unlike DASH, which assesses general upper extremity conditions, PRWE's specificity makes it more responsive to wrist-related outcomes [44]. PRWE has 15 items divided into Pain (5 items, 0–50 points) and Function (10 items, 0–50 points) sections. A low score towards 0 indicates minimal wrist pain and excellent function, while a high score towards 100 suggests significant pain and severe difficulty with wrist function (24–26).

Distal radius fractures (DRFs) are among the most common orthopedic injuries and frequently result in persistent wrist pain, functional limitations, and reduced quality of life despite non-operative treatment. Patient satisfaction and recovery are influenced by multiple factors, including fracture severity, rehabilitation access, pain management, and individual patient characteristics. In Ethiopia, where DRF-related trauma is commonly associated with road traffic accidents, falls, and occupational injuries, evidence regarding patient-reported functional outcomes remains scarce (27). The absence of context-specific data has limited the development of evidence-based treatment protocols and has compelled clinicians to rely on recommendations derived from high-income settings that may not adequately reflect the country's demographic profile, healthcare infrastructure, and rehabilitation capacity (27,28). Furthermore, delayed presentation and the continued utilization of traditional bone setters (TBSs) remain major challenges, often contributing to preventable complications such as malunion, chronic pain, and disability (29,30). Generating robust local evidence on functional outcomes and their determinants is therefore essential to guide clinical decision-making, optimize patient recovery, and promote evidence-based fracture care. Addressing this evidence gap also has important implications for health policy and resource allocation. Without reliable local data on the outcomes of non-operative DRF management, healthcare planners face challenges in prioritizing rehabilitation services, developing training programs, and designing interventions to improve fracture care delivery (28). The long-term socioeconomic consequences of persistent disability following DRFs, particularly among economically productive adults, remain largely undocumented in Ethiopia. This study seeks to provide actionable evidence that can support the development of contextually appropriate clinical guidelines, strengthen rehabilitation services, and inform strategies aimed at reducing disability and improving musculoskeletal health outcomes. Ultimately, establishing local evidence will help advance patient-centered, cost-effective, and

sustainable orthopedic care while contributing to broader efforts to improve trauma services in resource-limited settings. This study provides some of the first comprehensive evidence on patient-reported functional outcomes following non-operative management of distal radius fractures in Ethiopia. By utilizing the validated Patient-Rated Wrist Evaluation (PRWE) instrument, the study establishes locally relevant outcome benchmarks and addresses a critical gap in the Ethiopian orthopedic literature. The findings offer valuable insights into how demographic characteristics, fracture patterns, rehabilitation access, and healthcare-seeking behaviors influence recovery in a resource-constrained setting.

Methods

Study Area, Period, and Design

This study was conducted at Addis Ababa Burn, Emergency and Trauma (AaBET) Hospital, a major trauma center located in Addis Ababa, Ethiopia. Established in 2015 as part of St. Paul's Hospital Millennium Medical College, AaBET serves patients from Addis Ababa and across Ethiopia. The hospital provides specialized services in orthopedics, neurosurgery, plastic and reconstructive surgery, emergency medicine, and critical care. It manages approximately 20,000–30,000 emergency visits annually and offers outpatient care, emergency services, elective and emergency surgeries. The Department of Orthopedics and Traumatology is one of the key units providing fracture management, complex reconstructive procedures, and joint replacement surgeries.

A hospital-based retrospective cross-sectional study was conducted among patients with distal radius fractures who were managed non-operatively at AaBET Hospital between March 2024 and March 2025. Data collection was carried out from November 2025 to January 2026 to ensure a minimum follow-up period of six months after treatment. Eligible patients were identified through hospital logbooks and morning duty report records. Functional outcomes were assessed using the Patient-Rated Wrist Evaluation (PRWE) score, which was administered either during follow-up clinic visits or through telephone interviews conducted by the treating physician or principal investigator.

Study Population and Eligibility Criteria

The source population comprised all patients with distal radius fractures treated at AaBET Hospital. The study population included patients with distal radius fractures who were managed non-operatively during the study period, had a minimum follow-up duration of six months, and fulfilled the inclusion criteria without meeting any exclusion criteria.

Patients were eligible for inclusion if they were aged 18 years or older, had sustained a distal radius fracture, received non-operative treatment, and completed at least six months of follow-up. Patients were excluded if they had incomplete follow-up records, lost or incomplete medical charts, refused to participate in the study, had pre-existing wrist pathology or cognitive impairment, presented more than three weeks after injury, or had conditions that could influence functional outcomes, including

polytrauma, bilateral distal radius fractures, open fractures, pathological fractures, or concomitant upper-limb fractures.

Sample Size Determination and Sampling Procedure

The sample size was determined using the single population proportion formula based on a confidence interval approach. Because no previous study had reported the proportion of functional outcomes among patients with distal radius fractures treated non-operatively in a similar setting, a population proportion (p) of 50% was assumed to obtain the maximum sample size. Using a 95% confidence level ($Z_{\alpha/2} = 1.96$) and a margin of error of 5% ($d = 0.05$), the initial sample size was calculated as 384. Since the total number of patients with distal radius fractures treated non-operatively during the study period was 133, as identified from the morning duty activity reports, a finite population correction formula was applied, resulting in a final required sample size of 99 participants.

To increase the statistical power and representativeness of the study, all eligible patients who met the inclusion criteria during the study period were considered for recruitment. A total of 133 patients were initially identified. Of these, 23 patients were excluded because of incomplete medical records or missing identification details ($n = 7$), unreachable contact information ($n = 9$), subsequent surgical intervention following initial conservative management ($n = 3$), loss to follow-up or discontinuation of treatment ($n = 3$), and death ($n = 1$). This left 109 eligible participants for contact and assessment.

Among the eligible patients, 103 provided complete responses and were included in the final analysis, yielding a response rate of 93.6%. Seven eligible patients (6.4%) were classified as non-respondents because complete outcome data could not be obtained. Consequently, the final study sample consisted of 103 patients, representing 77.4% of the original cohort identified from hospital records. Figure 2 illustrates the participant selection and sampling process.

Measurements and Study Variables

The primary outcome variable in this study was the functional outcome of the wrist following non-operative management of distal radius fractures, which was assessed using the Patient-Rated Wrist Evaluation (PRWE) score. The PRWE is a validated patient-reported outcome measure designed to evaluate wrist pain and disability, with higher scores indicating poorer functional outcomes.

A range of demographic, clinical, and treatment-related independent variables were assessed to determine their association with functional outcomes. These variables included age, sex, educational status, occupation, fracture type and initial fracture pattern based on the AO/OTA classification system, presence of comorbidities, duration from injury to presentation, mechanism of injury, receipt of rehabilitation services, and use of vitamin D or calcium supplementation. These variables were selected based on their potential influence on fracture healing, recovery, and long-term functional outcomes among patients with distal radius fractures.

Data collection tools

Data were collected using two electronic questionnaires developed and administered through KoboToolbox: (1) a study-specific questionnaire developed by the research team for this study and (2) the Patient-Rated Wrist Evaluation (PRWE) questionnaire, a previously validated and widely used patient-reported outcome measure for assessing wrist pain and function. An English-language version of the study-specific questionnaire has been provided as Supplementary File 1.

The PRWE is a validated, self-administered 15-item questionnaire comprising two subscales: pain (5 items) and function (10 items). The pain subscale score is calculated as the sum of the five pain items, while the function subscale score is obtained by summing the ten function items and dividing the total by two. The overall PRWE score is the sum of the pain and function subscale scores, ranging from 0 to 100, with higher scores indicating poorer wrist function and greater disability (23, 25). A copy of the PRWE questionnaire is provided in Supplementary File 2, and details of its development and validation have been published previously (23, 25).

Initially, patients' radiographs were reviewed, and fracture characteristics were documented according to fracture pattern and the AO/OTA classification system. Clinical and demographic data were subsequently extracted manually from patients' medical records using the study-specific questionnaire. Functional outcomes were assessed using the standardized PRWE questionnaire during routine orthopedic outpatient follow-up visits by orthopedic residents or through telephone interviews conducted by the examiner. For incomplete PRWE responses, missing items were replaced with the mean score of the corresponding subscale, as recommended in the PRWE user manual.

Operational Definitions

Patient-Rated Wrist Evaluation (PRWE) Score: A validated, self-administered, 15-item questionnaire comprising two subscales: pain (5 items) and function (10 items). The pain subscale score is calculated as the sum of the five pain items, while the function subscale score is obtained by summing the ten function items and dividing the total by two. The overall PRWE score is the sum of the pain and function subscale scores, ranging from 0 to 100, with higher scores indicating poorer wrist function and greater disability (23, 25).

Distal Radius Fracture: A fracture occurring within approximately 3 cm proximal to the distal articular surface of the radius, at the metaphyseal region where cortical bone transitions to trabecular bone(43).

Non-operative treatment: Management involving closed manual reduction under local anesthesia or procedural sedation, followed by immobilization using a cast or splint for 6–8 weeks or until radiographic union is achieved (44)

Rehabilitation protocol: A structured program of wrist and hand range-of-motion (ROM), strengthening, and functional exercises initiated after immobilization or cast removal. Rehabilitation status was categorized as "Yes" for patients who commenced and consistently continued ROM exercises until satisfactory recovery was achieved, either independently or under professional supervision. Patients who

did not initiate rehabilitation, discontinued exercises prematurely, or experienced persistent painful restriction of motion were categorized as “No.”

Data Quality Assurance

To ensure data quality, all questionnaires were translated from English into Afaan Oromo and Amharic and subsequently back-translated into English to verify linguistic consistency and accuracy. Data collectors received two days of training on the study objectives, data collection procedures, and ethical considerations before the commencement of data collection. Daily supervision was conducted, and completed questionnaires were reviewed for completeness, accuracy, and consistency. In addition, the principal investigator provided continuous supportive supervision throughout the study to ensure adherence to the study protocol. All collected data were securely stored within the Kobo Toolbox platform and were accessible only to the principal investigator.

Data processing & analysis

Following data collection and cleaning, data were exported and analyzed using IBM SPSS Statistics version 27.0.1. The distribution of continuous variables was assessed using histogram visualization with normal curve overlays, Q–Q plots, skewness and kurtosis z-scores, and the Kolmogorov–Smirnov test with Lilliefors correction. The PRWE score exhibited significant right-skewness (Skewness = 0.833; Z = 3.50; $p = 0.001$), which was confirmed through graphical and statistical assessments.

Given the non-normal distribution of the outcome variable, quantile regression was selected as the primary multivariable analytical approach. Models were fitted at the 25th, 50th (median), and 75th percentiles to explore predictor effects across different points of the outcome distribution. Quantile regression was chosen because it does not require normality assumptions and is robust to outliers. Descriptive statistics were presented as means with standard deviations for approximately normal variables and medians with interquartile ranges for non-normally distributed variables. Bivariate associations were examined using Spearman’s correlation, Mann–Whitney U, or Kruskal–Wallis tests, as appropriate. Variables with a p -value <0.20 in bivariate analyses were entered into multivariable models. Model performance was evaluated using pseudo R^2 for quantile regression and conventional R^2 and F -statistics for ordinary least squares regression. Statistical significance was declared at a two-tailed p -value <0.05 .

Results

Socio-Demographic characteristics

The socio-demographic and clinical characteristics of the participants are presented in Table 1. The mean age of the patients was 47.13 ± 15.82 years, with a median age of 47 years (IQR = 25; Q1 = 35, Q3 = 60), ranging from 18 to 77 years. Females comprised 49.5% of the study population. Most participants were urban residents (75.7%). According to the AO fracture classification, Type a fractures were the most

common (69.9%). Regarding fracture duration, 53.4% of patients had sustained their fracture 6–12 months prior to assessment, while 41.7% had experienced the fracture for more than 12 months. More than one-third of the patients (36.9%) reported at least one comorbidity, with hypertension being the most prevalent condition (20.3%). Additionally, nearly one-quarter (23.0%) of participants reported seeking care from a traditional bone setter before, or instead of, consulting formal orthopedic services. See details in Table 1.

Table 1. Socio-demographic and Clinical Characteristics of Participants (N = 103)

Characteristic	Category	n (%)
Age group (years)	18–50	63 (61.2)
	51–65	23 (22.3)
	>65	17 (16.5)
Sex	Female	51 (49.5)
	Male	52 (50.5)
Residence	Addis Ababa	78 (75.7)
	Oromia	22 (21.4)
	Amhara	3 (2.9)
Mechanism of injury	Fall	76 (73.8)
	Road traffic accident	22 (21.4)
	Other	5 (4.8)
Fracture type (AO classification)	Type A	72 (69.9)
	Type B	13 (12.6)
	Type C	18 (17.5)
Time from injury to reduction	Day 1	68 (66.0)
	Days 2–3	19 (18.4)
	Days 4–6	10 (9.7)
	1–2 weeks	3 (2.9)
	>2 weeks	3 (2.9)
Fracture duration	<6 months	5 (4.9)
	6–12 months	55 (53.4)
	>12 months	43 (41.7)
Vitamin D/Calcium supplementation	Yes	49 (47.6)
	No	54 (52.4)
Rehabilitation received	Yes	17 (16.5)
	No	86 (83.5)
Comorbidity	Yes	38 (36.9)
	No	65 (63.1)

Visited traditional bone setter (TBS)	Yes	24 (23.3)
	No	79 (76.7)
Educational status	No formal education	20 (19.4)
	Can read and write	35 (34.0)
	Above high school	48 (46.6)
Occupation	Unemployed	39 (37.9)
	Daily worker	22 (21.4)
	Regular employment*	42 (40.8)

*Regular employment includes government, private, and NGO sectors.

PRIMARY OUTCOME and PRWE DISTRIBUTION

Distribution of Patient-Rated Wrist Evaluation (PRWE) Scores were not normally distributed. Both the Kolmogorov–Smirnov test with Lilliefors correction ($D = 0.123$, $p < 0.001$) and the Shapiro–Wilk test ($W = 0.919$, $p < 0.001$) indicated significant deviation from normality. The distribution was moderately right-skewed (skewness = 0.833, SE = 0.238, $Z = 3.50$, $p < 0.001$), which was also evident from the histogram and Q–Q plot (Figure 1). Consequently, the median and interquartile range (IQR) were used as the primary measures of central tendency and dispersion.

Table 2. Functional outcome (PRWE score) of Patients who are non-operatively treated for Distal radius fracture

Category	Frequency	Percent	Valid Percent	Cumulative Percent
Excellent	39	37.9	37.9	37.9
Good	32	31.1	31.1	68.9
Fair	22	21.4	21.4	90.3
Poor	10	9.7	9.7	100.0
Total	103	100.0	100.0	

The median PRWE score was 26.0 (IQR: 14.0–46.0), with scores ranging from 4 to 90. The mean score was 31.51 ± 19.94 , reflecting the influence of the positively skewed distribution. The 5th and 95th percentiles were 9.2 and 66.8, respectively, indicating substantial variability in patient-reported wrist pain and function. No ceiling effect was observed, as no participant achieved the maximum possible score.

Overall, visual and statistical assessments confirmed moderate non-normality in the distribution of PRWE scores.

Table 4: Distribution characteristics of PRWE score (N=103)

Measure	Value	Statistical test	Sig
Median (IQR)	26.0 (14-46)	-	
Mean $\pm$ SD	31.51 $\pm$ 19.94	-	
Range	4-90	-	
Kolmogorov-Smirnov D	0.123	Kolmogorov-Smirnov test	p<0.001
Shapiro-Wilk W	0.919	Shapiro-Wilk test	P<0.001
Skewness (SE)	0.833(0.238)	Z-test of Skewness	Z=3.50, p<0.001
Kurtosis (SE)	-0.063(0.472)	Z-test of Kurtosis	Z= -0.13, p=0.90
5 th percentile	9.2	-	
95 th percentile	66.8	-	
Interquartile Range	32.0	-	

Visual inspection of the histogram and Q–Q plot further supported the statistical findings, revealing a moderately right-skewed distribution with departures from the reference line at both tails, particularly among lower and higher PRWE scores. No ceiling effect was observed, as none of the participants achieved the maximum possible score of 100. Overall, the findings suggest moderate non-normality and substantial heterogeneity in wrist-related pain and functional outcomes among study participants.

Bivariate Associations

Bivariate analyses identified several factors significantly associated with Patient-Rated Wrist Evaluation (PRWE) scores (Table 5). Spearman’s rank correlation revealed a moderate positive association between age and PRWE score ($\rho = 0.308$, $p < 0.001$), indicating that older patients tended to report worse wrist pain and functional outcomes.

Sex was significantly associated with PRWE scores. Female patients reported higher PRWE scores than males, with a median score of 30.0 (IQR: 21.0-50.0) compared with 18.0 (IQR: 13.0-38.3), respectively. The Mann-Whitney U test confirmed this difference ($U = 951.0$, $Z = -2.48$, $p = 0.013$), with a small-to-moderate effect size ($r = 0.24$). The broader interquartile range among females suggests greater variability in self-reported wrist pain and disability.

PRWE scores also differed significantly across fracture types based on the Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) classification system ($H = 12.50$, $p = 0.002$). Post hoc pairwise comparisons using Dunn's procedure with Bonferroni correction demonstrated significantly higher PRWE scores among patients with intra-articular fractures (AO/OTA types 23B and 23C) than those with extra-articular fractures (AO/OTA type 23A) ($p = 0.004$). No significant difference was observed between AO/OTA type 23B and type 23C fractures.

The presence of comorbidities was also significantly associated with poorer patient-reported outcomes. Patients with at least one comorbidity had significantly higher PRWE scores than those without comorbidities (mean rank: 63 vs. 45; $p = 0.003$). However, comparisons across specific comorbidity types did not reveal statistically significant differences in PRWE scores.

Overall, older age, female sex, intra-articular fracture patterns, and the presence of comorbidities were significantly associated with higher PRWE scores, reflecting greater pain and poorer wrist function following distal radius fracture treatment.

Table 5. Bivariate associations between participant characteristics and PRWE scores.

Variable	Test Metric	Result	p-value
Age	Spearman's ρ	$r_s = .308^*$	.002**
Duration from injury to reduction	"	$r_s = .131$	.188
Total duration on follow-up	"	$r_s = -.022$	.823
Gender	Mann-Whitney U test	U= 951.0, Z= -2.475, Female 30(21-50) Male 18(13-38.25)	.013*
Rehabilitation status	"	U=883, Z= 1.35	.175
TBS visit	"	U=709, Z= -1.86	.063'
Comorbidity	"	U= 800, Z= -2.97	.003**
Vitamin D/Ca ⁺²	"	U=1234.50, Z= -.585	.559
Mechanism of injury	Kruskal-Wallis	H=4.25, $df=2$	.119
AO/OTA type of fracture	"	H=12.50, $df=2$	.002**
Occupation	"	H=4.564, $df=2$	.102
Educational status	"	H= 4.11, $df=2$	.128
Residence	"	H=1.52, $df=2$	.467

Note: ⁺ $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$.

Multivariate Association

Quantile Regression Analysis of Factors Associated with PRWE Scores

Quantile regression analysis was conducted to identify factors associated with Patient-Rated Wrist Evaluation (PRWE) scores at the 25th, 50th (median), and 75th percentiles of the outcome distribution. Variables with a p -value < 0.20 in the bivariate analyses were included in the multivariable model. These variables comprised demographic characteristics (age, sex, and educational status), clinical factors (time from injury to reduction, mechanism of injury, AO/OTA fracture classification, history of traditional bone setter [TBS] visit, rehabilitation status, and comorbidity), and occupational category.

Model performance increased across higher quantiles of the PRWE distribution. The pseudo- R^2 values were 0.155, 0.244, and 0.339 at the 25th, 50th, and 75th percentiles, respectively, indicating that the model explained a larger proportion of variability among patients reporting more severe wrist disability. Corresponding mean absolute errors were 15.09, 12.06, and 15.20.

The determinants of PRWE scores varied across different levels of disability. At the median (50th percentile), AO/OTA fracture classification was the only statistically significant predictor. Patients with AO/OTA Type B fractures had PRWE scores that were, on average, 23.67 points higher than those with Type C fractures ($\beta = 23.67$, $p = 0.001$). Although not statistically significant, increasing age ($\beta = 0.30$, $p = 0.061$) and male sex ($\beta = 7.89$, $p = 0.082$) showed borderline associations with higher PRWE scores.

At the 25th percentile, representing patients with relatively mild disability, rehabilitation was strongly associated with lower PRWE scores ($\beta = -13.82$, $p < 0.001$), suggesting a substantial protective effect. Conversely, older age ($\beta = 0.39$, $p < 0.001$) and male sex ($\beta = 5.92$, $p = 0.035$) were significantly associated with higher PRWE scores.

At the 75th percentile, reflecting patients with more severe disability, the presence of comorbidity was associated with significantly higher PRWE scores ($\beta = 12.17$, $p = 0.020$). In contrast, AO/OTA Type A fractures ($\beta = -16.76$, $p = 0.003$) and lower educational status ($\beta = -13.93$, $p = 0.047$) were associated with lower PRWE scores. Rehabilitation also demonstrated a clinically meaningful protective effect at this quantile; however, the association did not reach statistical significance ($\beta = -10.51$, $p = 0.059$).

Overall, the findings demonstrate substantial heterogeneity in factors associated with PRWE scores across the outcome distribution. Rehabilitation appeared most beneficial among patients with milder disability, fracture type exerted the greatest influence on median PRWE outcomes, and comorbidity had the strongest impact among patients with severe disability. These findings highlight the value of quantile regression for identifying predictors of wrist pain and functional impairment across varying levels of severity that may not be detected using conventional mean-based regression approaches.

Table 6. Multivariable quantile regression analysis of factors associated with PRWE scores across severity levels (25th, 50th, and 75th percentiles).

Predictors		Q=0.25	Q=0.5	Q=0.75
		(SE)	(SE)	(SE)
Age		0.39*** (0.10)	0.30 (0.16)	0.37* (0.16)
Gender (Female)		5.92* (2.77)	7.89 (4.48)	6.44 (4.69)
Duration from injury to reduction		0.108 (1.52)	0.03 (2.45)	2.17 (2.56)
Extraarticular fracture		-7.56* (3.23)	-6.46 (5.21)	-16.76** (5.45)
Intraarticular Fracture		-2.25 (4.33)	23.67*** (7.00)	10.51 (7.32)
Rehabilitation		-13.82*** (3.25)	-7.38 (5.24)	-10.51+ (5.49)
Comorbidity		-0.84 (3.03)	4.36 (4.89)	12.17* (5.12)
Lower level Educational		-0.08 (4.09)	4.61 (6.60)	-13.93* (6.90)
TBS visit		1.28 (3.47)	1.42 (5.60)	7.68 (5.86)
Occupation	Un-employed	-7.05* (3.46)	-0,82 (5.59)	-1.27 (5.85)
	Daily laborer	-3.18 (3.48)	-5.00 (5.62)	-3.88 (5.88)

Note: + p< .10, * p<.05, ** p<.01, *** p<.001. SE: standard errors

Comparison of Ordinary Least Squares and Quantile Regression Models

Ordinary least squares (OLS) regression explained 29.6% of the variation in Patient-Rated Wrist Evaluation (PRWE) scores ($R^2 = 0.296$, $F(10,92) = 3.87$, $p < 0.001$). In the OLS model, increasing age ($B = 0.33$, $p = 0.023$) and AO/OTA fracture type ($B = 8.26$, $p < 0.001$) were identified as significant predictors of wrist pain and functional outcomes. However, because OLS estimates the average effect of predictors across the entire outcome distribution, it may mask clinically important variations among patients with different levels of disability.

In contrast, quantile regression provided a more detailed assessment of factors associated with PRWE scores across different severity levels. While OLS identified fracture type as a significant predictor overall, quantile regression showed that this association was predominantly concentrated around the median of the PRWE distribution. Specifically, patients with AO/OTA Type B fractures had median PRWE scores that were 23.67 points higher than those with Type C fractures ($\beta = 23.67$, $p = 0.001$), indicating a substantially stronger effect than that estimated by the OLS model.

Quantile regression also revealed important associations that were not identified by OLS. At the 25th percentile, representing patients with relatively mild disability, rehabilitation was strongly associated with lower PRWE scores ($\beta = -13.82$, $p < 0.001$), suggesting a substantial protective effect on pain and functional limitation. This relationship was not detected in the OLS model. Similarly, comorbidity emerged as a significant predictor only at the 75th percentile, where patients with comorbid conditions had PRWE scores that were 12.17 points higher than those without comorbidities ($\beta = 12.17$, $p = 0.020$). This finding indicates that the adverse impact of comorbidities becomes more evident among patients with greater disability.

Furthermore, the effects of sex, educational status, and rehabilitation varied across different quantiles of the PRWE distribution, emphasizing the limitations of relying solely on mean-based regression estimates. By accounting for heterogeneity across outcome levels, quantile regression provided a more comprehensive understanding of factors associated with wrist pain and functional impairment following distal radius fracture treatment.

Overall, the comparison demonstrates that quantile regression offers additional clinically relevant insights beyond those obtained from OLS regression. Whereas OLS identifies predictors associated with average outcomes, quantile regression captures variations in predictor effects across the spectrum of disability severity. These findings underscore the value of quantile regression for identifying factors that differentially influence patients with mild, moderate, and severe wrist dysfunction, thereby supporting more targeted clinical management and rehabilitation strategies.

Table 7. Comparison of OLS and Quantile Regression Coefficients for Factors Associated with PRWE Scores.

Predictor	OLS B (SE)	Q=0.25 (SE)	Q=0.50 (SE)	Q=0.75 (SE)
Age	0.33** (0.143)	0.390*** (0.097)	0.297 (0.156)	0.366* (0.164)
Intra-articular Fracture type	8.257*** (2.311)	-2.246 (4.331)	23.669** (6.996)	10.512 (7.320)
Rehabilitation	5.185 (4.878)	-13.819** (3.247)	-7.381 (5.244)	-10.512 ⁺ (5.487)
Comorbidity	-7.472 (4.519)	-0.844 (3.027)	4.356 (4.889)	12.171* (5.116)

Note: ⁺ p<.10, * p,.05, ** p<.01, *** p<.001. SE: standard errors.

Discussion

This retrospective cross-sectional study assessed patient-reported functional outcomes among 103 adults with non-operatively managed distal radius fractures (DRFs) at AaBET Hospital, Addis Ababa, Ethiopia. The median age of participants was 47 years, with most patients (61.1%) aged 18 to 50 years. This age distribution is comparable to studies from England and India, which reported mean ages of 42.3 and 45.6 years, respectively (46,47). However, our cohort was substantially younger than those reported in studies from the Netherlands and the United Kingdom, where mean ages ranged from 54 to 62 years (48, 49). These differences likely reflect demographic variations, injury patterns, and population structures across settings. In low- and middle-income countries (LMICs), Distal radius Fractures (DRFs) frequently affect economically productive adults because of occupational injuries, road traffic accidents, and falls, whereas fractures in high-income countries predominantly occur among older adults with osteoporosis.

The median PRWE score of 26.0 (IQR: 14.0-46.0) indicates moderate residual pain and disability at a median follow-up of 6 to 12 months. Overall functional outcomes were favorable, with 37.9% of patients achieving excellent outcomes and 31.1% achieving good outcomes, while 21.1% and 9.7% experienced fair and poor outcomes, respectively. These findings compare favorably with a Nigerian study that reported excellent, good, fair, and poor outcomes in only 8.9%, 21.8%, 33.5%, and 35.8% of patients, respectively, although functional assessment in that study was based on the DASH rather than the PRWE instrument (35). Nevertheless, our findings suggest that non-operative treatment can achieve acceptable outcomes in most patients, even in resource-constrained settings.

Despite these encouraging results, the median PRWE score observed in our study was higher than the mean score of 10.9 reported by Hevonkorpi et al. in Finland after five years of follow-up (31). Several contextual factors may explain this difference. Patients in the Finnish study benefited from earlier presentation, standardized treatment pathways, and universal access to rehabilitation services. In contrast, more than one-third of our patients presented after three days of injury, only 16.5% received formal rehabilitation, and nearly one-quarter had sought treatment from traditional bone setters (TBSs) before attending hospital. Similar challenges have been reported in other African settings. For example, a Nigerian study demonstrated significantly poorer functional outcomes among patients who initially sought care from traditional bone setters compared with those who presented directly to hospital services (31). These findings suggest that delays in accessing evidence-based fracture care remain important determinants of patient outcomes in LMIC settings (35). Although direct comparisons should be interpreted cautiously because of differences in patient characteristics and follow-up duration, this observation suggests that non-operative treatment may provide satisfactory outcomes for appropriately selected patients. Conversely, the somewhat poorer outcomes observed among our comparatively younger cohort imply that factors beyond fracture characteristics, such as delayed presentation, occupational demands, socioeconomic constraints, and limited access to rehabilitation services, may substantially influence recovery(38).

Fracture classification emerged as a significant predictor of functional outcome. Patients with intra-articular fractures (AO/OTA types 23B and 23C) experienced significantly worse outcomes than those with extra-articular fractures. This finding is consistent with the established understanding that articular involvement adversely affects functional recovery because of cartilage injury, residual joint incongruity, and post-traumatic arthritis (46)(41). Notably, our quantile regression analysis demonstrated that the impact of fracture type was most prominent around the median of the PRWE distribution rather than at the lower or upper extremes. This finding suggests that fracture severity may exert its greatest influence among patients with moderate disability, highlighting a level of heterogeneity that is often overlooked in conventional analyses.

One of the most important findings of this study was the strong protective effect of rehabilitation among patients with lower levels of disability. Patients who received rehabilitation had significantly lower PRWE scores at the 25th percentile ($\beta = -13.82$, $p < 0.001$), indicating substantially better functional outcomes. This finding is supported by systematic reviews showing that supervised rehabilitation programs improve pain, range of motion, grip strength, and overall function following DRFs (47). However, only 16.5% of participants in our study received formal rehabilitation services. This highlights a considerable treatment gap and suggests that expanding access to rehabilitation could substantially improve patient outcomes. The diminished effect observed at higher disability levels further suggests that rehabilitation may be most effective when initiated early before severe functional limitation becomes established.

Comorbidity was significantly associated with poorer outcomes at the upper end of the PRWE distribution, where patients with at least one comorbid condition had substantially higher disability scores. This finding is consistent with reports from Chung et al. and Shariatzadeh et al., who identified

comorbid conditions as important predictors of poor functional recovery following DRFs (40)(48). Our findings extend previous evidence by demonstrating that the adverse impact of comorbidities is not uniform across patients but is particularly pronounced among those already experiencing severe disability. Consequently, comprehensive management of chronic health conditions may play an important role in improving recovery among high-risk patients. Increasing age was consistently associated with higher PRWE scores across multiple quantiles, indicating poorer functional outcomes among older adults. This finding agrees with studies from Malaysia and multinational investigations by Chung et al., which identified younger age as a predictor of better recovery (40, 41). However, not all studies have reported similar associations. Thorninger et al. found no significant differences in functional outcomes among older patients with minimally displaced DRFs managed non-operatively (32), while reported that chronological age alone was not significantly associated with functional demand among participants in the WRIST trial (49). These discrepancies may reflect differences in healthcare systems, rehabilitation availability, social support, and patient expectations. In settings such as ours, where access to rehabilitation and long-term follow-up services is limited, advancing age may amplify the effects of comorbidity and delayed recovery

Female patients also reported poorer functional outcomes than males in the bivariate analysis. This finding is consistent with previous studies that have identified female sex as a predictor of poorer recovery following DRFs (41). Potential explanations include differences in bone density, pain perception, baseline functional status, and social roles. However, because the association varied across quantiles and was not consistently significant in multivariable analyses, further investigation is warranted.

An important methodological contribution of this study is the comparison between ordinary least squares (OLS) and quantile regression approaches. Most previous DRF studies, including large multicenter investigations and meta-analyses, have relied on mean-based analytical methods such as OLS regression, t-tests, or ANOVA (40) (37). Our findings demonstrate that patient-reported outcome measures such as the PRWE possess considerable heterogeneity across their distribution and may therefore benefit from analytical approaches that capture differential effects across severity levels. Quantile regression provides a more comprehensive understanding of outcome determinants and may aid clinicians in identifying patient subgroups that require targeted interventions. This approach aligns with growing calls for more robust statistical methods in orthopedic outcomes research, particularly when outcome measures exhibit skewed or non-normal distributions (42). Overall, our findings demonstrate that functional recovery following non-operatively managed DRFs in Ethiopia is influenced by a combination of fracture characteristics, rehabilitation access, comorbidity burden, age, and sex. Improving timely access to hospital care and rehabilitation services may substantially enhance outcomes for patients with DRFs in resource-limited settings.

Limitations and Strengths

This study is limited by its retrospective cross-sectional design, which precludes causal inference, potential recall bias from telephone interviews, the relatively small sample size that restricted subgroup

analyses, and the absence of baseline PRWE measurements to assess recovery over time. Despite these limitations, it provides one of the first comprehensive evaluations of patient-reported outcomes following non-operative DRF management in Ethiopia. Its high response rate (93.6%), systematic data collection, and application of quantile regression strengthened the reliability of findings and revealed severity-specific associations that conventional analyses may overlook.

Conclusion and Recommendations

This study demonstrated that non-operative management of distal radius fractures (DRFs) in a resource-limited Ethiopian setting can achieve generally favorable functional outcomes. However, recovery was significantly influenced by fracture type, rehabilitation access, comorbidity status, age, and sex. Importantly, quantile regression revealed that these factors exert different effects across levels of disability, highlighting the heterogeneity of patient outcomes.

The findings underscore the need for targeted, patient-centered management strategies. Expanding early rehabilitation services, optimizing comorbidity management, ensuring timely referral of complex intra-articular fractures, and promoting early healthcare seeking could substantially improve functional outcomes. Overall, these results provide context-specific evidence to guide DRF management and support the development of more effective fracture care pathways in low-resource settings.

Abbreviations

AaBET.....	Addis Ababa Burn Emergency and Trauma center
AO/OTA.....	Arbeitsgemeinschaft für Osteosynthesefragen/ Orthopedic Trauma Association
DASH.....	Disabilities of the Arm, Shoulder, and Hand
DEXA	Dual Energy X-ray Absorptiometry
DRF.....	Distal radius Fractures
EBP.....	Evidence Based Practice
ETB.....	Ethiopian Birr
MHQ.....	Michigan Hand Questionnaire
MVA.....	Motor Vehicle Accident
PROM.....	Patient Reported Outcome Measurement
PRWE.....	Patient Rated Wrist Evaluation
SPHMMC.....	Saint Paul’s Hospital Millennium Medical College

SPSS..... Statistical Package for Social Science

WHO.....World Health Organization

Declarations

Ethics Approval and Consent to Participate

Ethical approval for this study was obtained from the Research Ethics Committee of St. Paul's Hospital Millennium Medical College (SPHMMC), Addis Ababa, Ethiopia (Reference No. PM23/406) prior to the commencement of data collection. All participants provided informed verbal consent before participating in the study. Participation was entirely voluntary, and participants were informed of their right to decline participation, refuse to answer any question, or withdraw from the study at any stage without any consequences. No financial incentives or compensation were provided for participation.

The study was conducted in accordance with the Declaration of Helsinki and other relevant ethical guidelines and regulations governing research involving human participants. Confidentiality and privacy were strictly maintained throughout the study. Participants were informed that all information collected would be kept confidential, securely stored, and used solely for research purposes. Personal identifiers were not included in the data analysis or reporting of findings to ensure participant anonymity.

Consent for Publication

Not applicable. No individual person's data, images, or other identifiable information are included in this manuscript.

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Competing Interests

The authors declare that they have no competing interests.

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Author Contributions

T.A. conceived and designed the study, participated in data collection, data analysis, and manuscript drafting. S.W. contributed to the study design, data collection, interpretation of the findings, and critical revision of the manuscript. T.D. assisted with study conceptualization, supervised the research process, contributed to data analysis, and critically reviewed the manuscript. D.B.D. contributed to study design, methodological guidance, data interpretation, manuscript writing, and overall supervision of the study. All authors read and approved the final manuscript. T.A. and T.D. contributed equally to this work.

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Figures

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Figure 1

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Figure 2

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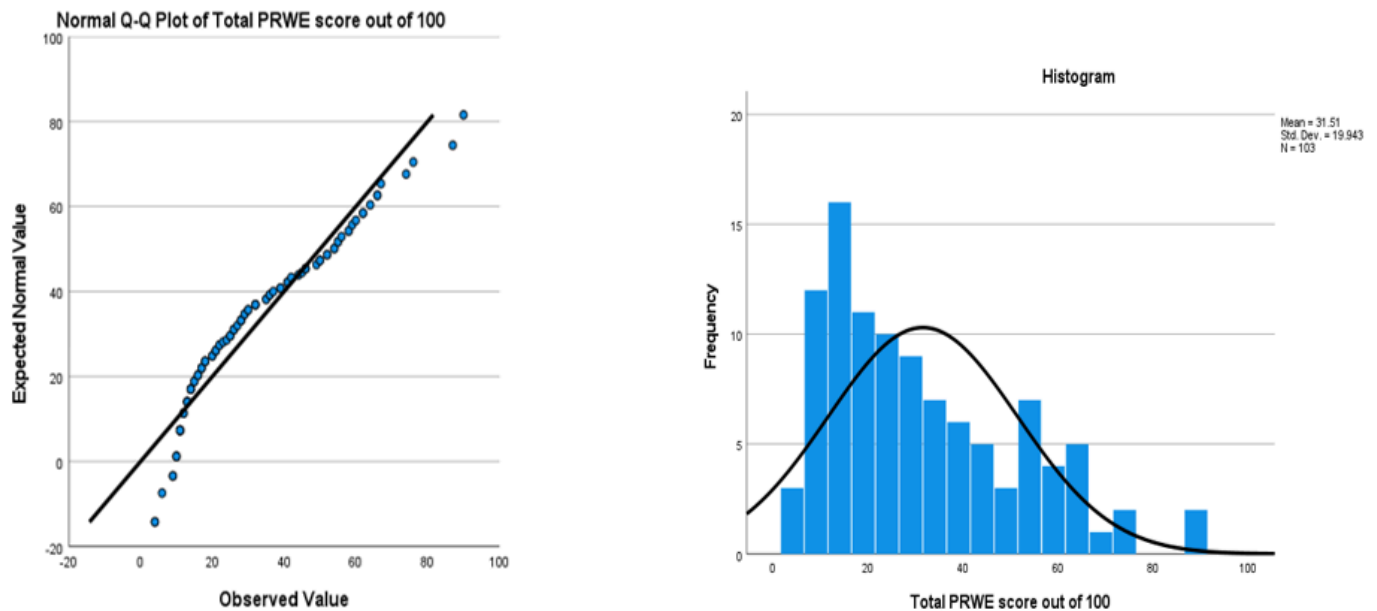


Figure 3

Distribution characteristics of PRWE, Q-Q plot and histogram

Supplementary Files

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