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ORIGINAL ARTICLE

Assessment of post-traumatic arthritis and functional outcome in patients treated operatively and non-operatively for distal radius Fractures – a 2-year cohort study

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Abstract

Objective. This study aims to compare operative and non-operative treatments for Distal Radius Fracture (DRF) in elderly patients, and to monitor the prevalence of Post-traumatic Arthritis (PA) over a period of 2 years. Despite numerous guidelines for the treatment of DRF, there remains a lack of consensus on the first line of treatment for elderly patients.

Materials and Method. The prospective cohort study included a 2-year follow-up of 70 patients aged 65 years or older, with low-energy distal radial fractures (DRF), managed either surgically or non-surgically. All patients were screened for the onset of post-traumatic arthritis (PA) and its risk factors were assessed using standardized scores: QuickDASH, Mayo, and PRWHE for the evaluation of functionality, pain, and other risk factors associated with PA. Logistic regression and ROC curve were employed to evaluate the significance of classifiers.

Results. Over 24 months, no significant differences were found between operative and non-operative treatments in PA development. Pain was a significant early indicator after 6 months of DRF (p 0.05). QuickDASH, Mayo, and PRWHE scores consistently assessed outcomes (Cronbach Alpha=0.848).

Conclusions. For senior patients, non-operative management should be the first choice for DRF. Pain, though subjectively measured, may indicate early PA development before it shows on RTG. Treatment should be individualized, based on patient needs and other health conditions.

Key words

elderly patients, Distal Radius Fractures management, Posttraumatic Arthritis, QuickDASH, Mayo, PRWHE

INTRODUCTION

Distal radius fractures (DRFs) are the most common orthopaedic fractures in the western world [1]. The choice of treatment in each specific case is dependent on both fracture and patient characteristics. The optimal treatment for different types of DRFs and patient categories is still debated [2, 3]. Previous studies have highlighted major changes in the treatment regimens of DRFs in the past 2 decades. DRFs in elderly patients can be treated non-operatively with good functional results after 1 year [4]. In the studies that only included patients aged 60 years or older, a significant difference in complication rates favoured non-operative treatment. Operative treatment of distal radius fractures was associated with an improvement in functionality measured by standard scores (DASH and or PRHWE), compared with non-operative treatment in adults [5].

The distribution of DRFs in the general population is bi-modal with incidence peaks in young men and in post-menopausal women [3]. In younger patients with good bone stock, distal radius fractures (DRFs) are typically caused by high-energy trauma. Conversely, in older patients with osteopenia or osteoporosis, DRFs usually result from low energy falls from standing positions [1].

Post-traumatic arthritis (PA) may occur after fractures and even more so after intraarticular fractures [6]. PA was observed in 31% of wrists after low-energy, non-operatively treated DRFs in patients older than 65 years of age after a minimum follow-up of 3 years [6]. A small number of patients with PA complained about any, i.e., mild pain, and their good functional outcomes after 1 year did not deteriorate over time. Literature data indicate that radiological signs, including PA and malunion, do not necessarily result in symptoms. Moreover, it underpins that non-operative treatment of these

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patients results in good functional outcomes after 1 and 3 years [1].

OBJECTIVE

The aims of this study are to compare the pathoanatomical and functional outcomes in patients with DRFs treated surgically versus non-operatively, to provide insights into the effectiveness of these approaches. Additionally, the study aims to evaluate the prevalence of post-traumatic arthritis in patients over a 2-year follow-up period. In order to improve knowledge of the etiology of PA and possible prevention measures, this study also aims to identify the major risk factors that contribute to its development.

The study hypothesizes that the non-operative treatment of DRFs results in good functional outcomes within a 2-year follow-up period. Additionally, it is expected that radiological signs of PA do not necessarily correlate with patients' symptomatic complaints. Finally, for elderly patients aged 65 years and above, non-operative treatment is hypothesized to be the preferable first-line option, given its effectiveness and lower associated risks.

MATERIALS AND METHOD

Study Design. A prospective cohort study included 70 patients with a minimum of 2 years of follow-up. All patients older than 65 years of age with a low-energy DRF were screened for eligibility and observed under 1 of 2 groups: Group 1 – who did not fulfill the radiologic criteria for surgical treatment, and Group 2 – who needed surgical treatment. The criteria were aligned with the guidelines established by the American Academy of Orthopedic Surgeons (AAOS) and the Orthopedic Trauma Association (OTA) for distal radius fractures.

If necessary, closed reduction/manipulation was performed under local anesthesia. The patient was approved as eligible for this study by a member of the investigation group. Exclusion criteria were secondary displacement of the fracture at a 2-week follow-up, high-energy fractures, open fractures, concomitant injuries (e.g., multiple fractures), not being capable of giving written consent, and previous DRF or forearm fracture on the same arm.

Study Setting. The study was conducted in the University Clinical Centre of Serbia in the Clinic for Orthopaedic Surgery and Traumatology in Belgrade under the Healthcare System of the Republic of Serbia, operating within the government-funded system of Serbia, which provides free and equal access to the citizens and residents of the Republic of Serbia. The University Clinical Centre is linked to the School of Medicine at the University of Belgrade.

Ethical consideration. Approval to conduct this study was obtained from the Institutional Review Board (IRB) of the University Clinical Centre of Serbia in January 2021. Informed consent was obtained from all participants prior to the intervention and study. The anonymity and confidentiality of participants were maintained at all times. Participants were screened for the study from January 2021 – July 2022, and those who were followed for a period of a minimum of 2 years were recruited for the study. Data collection was completed and analyzed in November 2024.

Recruitment and intervention. A total of 139 patients were included in the original study; 12 were excluded due to fracture dislocation or insufficient data, leaving 70 patients in the study cohort. After a detailed examination, 40 patients were eligible for non-surgical treatment, and 30 needed surgical intervention. During the follow-up period from 6 weeks to 24 months, all patients were examined in a control examination. The patients were always given an appointment for the next visit to the Outpatient Clinic. Informed consent was signed by all patients included in the study before the intervention. Following an early intervention, all patients were evaluated at intervals of 6 weeks, 6 months, 12 months, and 24 months, using clinical examinations and composite scoring systems; these included: QuickDASH Score [7], Mayo Score [7], and PRWHE Score [8], which assess functionality, pain, and other dimensions related to distal radius fractures (DRF). Additionally, pain was measured using the Numeric Pain Rating Scale (NPRS/NRS). Controlled X-rays were performed to monitor the early onset of post-traumatic arthritis (PA).

Loss of follow-up was noted for various reasons – being out of reach, relocation, lack of interest in a follow-up, or death. The study ended after 2 years of follow-up with full data available for the remaining 30/25 (Group 1/Group 2) patients who had at least 2 years of follow-up (Fig. 1).

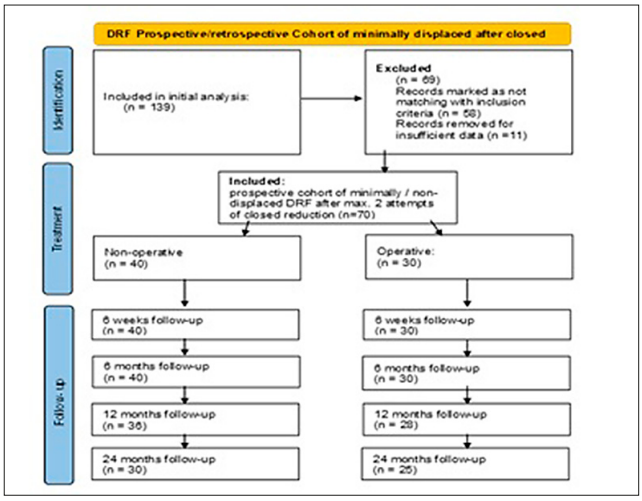

Figure 1. Recruitment of Patients and Follow-Up of the Cohorts

Data Analysis. All data have been carefully entered into SPSS 27.0 software for databases and for data analysis. According to the type of variable, descriptive statistical methods were applied to summarize, describe, and present data. An extensive statistical analysis was performed to compare groups, and to follow-up on variables and patients value through the period of 2 years. Most of the variables were non-parametric, and patients' values are measured by composite score; thus, non-parametric statistical analysis was deployed, including Chi-square test, Mann-Whitney U-test, and the Friedman test for repeated measures. Cronbach Alpha tested the internal consistency of these scores. Logistic regression and ROC curve analysis identified early PA (Predictive Analytics) predictors after Distal Radial Fracture (DRF).

RESULTS

Demographic characteristics of participants Seventy patients were followed for 24 months regarding their treatment. The demographic variables and DRF details of the group were compared at the start of the study. No significant differences (p>0.05) were found between Group 1 (non-operative) and Group 2 (operative) (Tab. 1).

Table 1. Demographic and DRF Characteristics of participants

Descriptive parameters at the beginning of the study on first visit		Group 1 (n=40)	Group 2 (n=30)
Age [range: 66–79]	Mean (± SD)	70.93 (±3.55)	70.57 (±3.35)
Gender	Female/Male	32/8	21/9
ASA classification	1/2/3/4/5/6	14/23/3/0/0/0	5/20/5/0/0/0
Working status	Retired/working	32/8	28/2
Smoker	Yes/No	23/17	16/14
Alcohol above limits	Yes/No	5/35	2/28
Injured side	Right/Left	11/29	8/22
Pain NRS scale [0–10]	4/5/6/7	12/18//8/2	7/14/8/1
Mechanism of trauma	Fall/ Fall from a height Work trauma Others	24 11 4 1	18 3 6 3
DRF class (OTA classification)	A1/A2/A3 B1/B2	14/8/6 9/2/1/	10/6/4 6/2/2
There was no significant difference between the groups for observed parameters (p>0.05)			

Post-intervention details for the 2 Groups were observed and analysed for early complications – pain, physiotherapy, and need for hospitalization. There was no significant difference between the groups for frequency and presence of complications (p>0.05). However, there was a significant association between the group and the type of physiotherapy. In the non-operative group, only 20% received physiotherapy with a professional therapist, while in the operative group, 44% received therapy with a professional therapist (p<0.05). Non-operative patients were treated in the Outpatient Department (OPD), whereas surgical patients required hospital admission with a stay of 3–5 days. There was a highly significant difference in the average duration of hospitalization (p<0.01).

Table 2. Post-intervention details for the two groups

Early post-treatment		Group 1 (n=40)	Group 2 (n=30)
Early complications	No complications Infection Corrective surgery Extreme swelling Others	36 (90%) 0 (0%) 1 (2.5%) 1 (2.5%) 2 (5%)	27 (90%) 1 (3.4%) 0 (0%) 0 (0%) 2 (6.6%)
Pain NRS scale [0–10]	4/5/6/7	25/40//25/10 (in percent)	16/37/33/14 (in percent)
Physiotherapy*	Self-exercise with therapist	32 (80%) 8 (20%)	17 (57%) 13 (43%)
Hospitalization**	OPD In-patient [hospital days]	39 1	0 30 [3–5]
* [Chi-square- 4,568; p<0.05]; ** [Mann-Whitney U-test p<0.01]			

Median scores and status of Post-traumatic Arthritis (PA) After 6 weeks, 6 months, 12 months and 24 months After 6 weeks and 6 months of follow-up, there was no significant difference in the Scores: QuickDASH, Mayo, or PRWHE between the 2 groups (p > 0.05). No post-traumatic arthritis (PA) cases were recorded in either group at 6 weeks. Early PA development was noted in both groups by 6 months, remaining stable. PA progressed between 12 – 24 months, with both cohorts decreasing in size (Tab. 3).

Table 3. Median Scores and Status of Post-traumatic Arthritis (PA) by Group After 6 weeks, 6 months, 12 months and 24 months.

Week 6 measurements	Group 1 [n=40]	Group 2 [n=30]	Statistics
QuickDASH Score	62.2 [61.4–75.0]	68.2 [65.9–75.0]	Non-parametric Mann-Whitney U-test (p>0.05); no significant difference between groups
Mayo Score	35.0 [30.0–45.0]	37.5 [30.0–45.0]	
PRWHE Score	63.5 [55.0–70.0]	63.0 [55.0–67.0]	
Posttraumatic Arthritis PA [Grade 0]	40	30	PA not registered after 6 weeks; Chi-square = 1.000; p>0.05; no significant difference between groups
Months 6 measurements	Group 1 [n=40]	Group 2 [n=30]	Statistics
QuickDASH Score	59.1 [50–63.6]	61.4 [52.3–63.6]	Non-parametric Mann-Whitney U-test (p>0.05); no significant difference between groups
Mayo Score	57.5 [45–65.0]	57.5 [45.0–65.0]	
PRWHE Score	53.5 [44–59.0]	49.0 [44.0–57.0]	
Posttraumatic Arthritis PA [Grade 0] PA [Grade 1]	 38 2	 29 1	Chi-square= 0.128; p>0.05; no significant difference between groups
Months 12 measurements	Group 1 [n=36]	Group 2 [n=28]	Statistics
QuickDASH Score	36.4 [27.3–40.9]	37.5 [27.3–47.7]	Non-parametric Mann-Whitney U-test (p>0.05); no significant difference between groups
Mayo Score	65.0 [55.0–70.0]	65.0 [60.0–70.0]	
PRWHE Score	40.5 [37.0–44.0]	39.0 [37.0–42.0]	
Posttraumatic Arthritis PA [Grade 0] PA [Grade 1] PA [Grade 2]	 26 8 2	 18 8 2	Chi-square= 0.462; p>0.05; no significant difference between groups
Months 24 measurements	Group 1 [n=30]	Group 2 [n=25]	Statistics
QuickDASH Score	20.5 [15.9–25]	20.5 [18.2–25]	Non-parametric Mann-Whitney U-test (p>0.05); no significant difference between groups
Mayo Score	85.0 [80.0–90]	85.0 [80.0–90]	
PRWHE Score	23.0 [21.0–30]	22.0 [19.0–25]	
Post-traumatic Arthritis PA [Grade 0] PA [Grade 1] PA [Grade 2] PA [Grade 3]	 12 9 6 3	 10 8 4 3	Chi-square= 0.980; p>0.05; no significant difference between groups

Frequency of Post-traumatic Arthritis (PA). Observed in both the operative and non-operative groups and compared using the chi-square test at each time point. No significant difference was found between the 2 groups throughout the follow-up period.

During the 24 months of follow-up, a visible trend of increased post-traumatic arthritis was observed in each

group. In Group 1, 60% of patients (18/30) developed post-traumatic arthritis after 24 months, while in Group 2, the percentage was the same – 60% (15/25). Figure 2 shows examples of PA in both groups. No severe sclerosis cases were reported in either group.

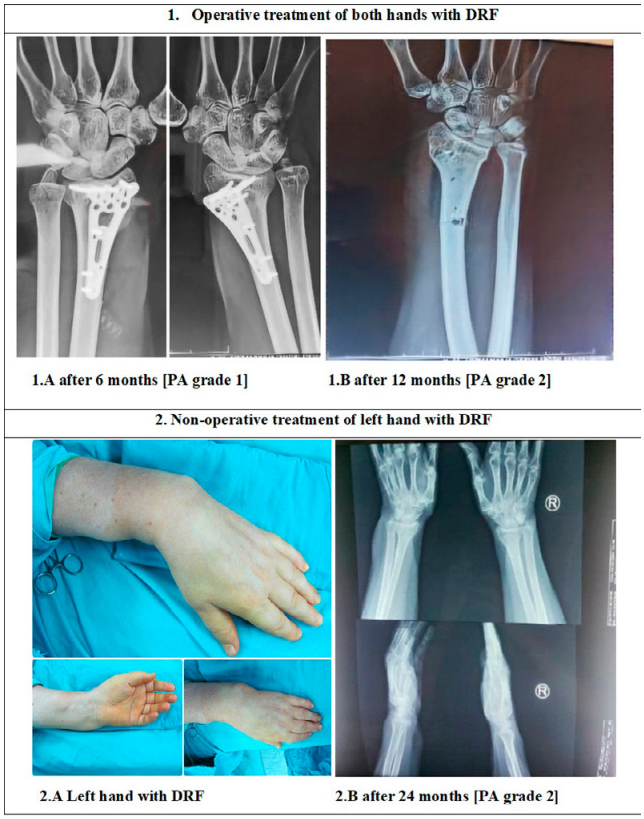

Figure 2. Example of PA after operative and non-operative treatment of DRF

Scores during the follow-up period. Across all follow-up periods (6 weeks, 6 months, 12 months, and 24 months), there was a significant improvement in the QuickDASH score, as indicated by the Friedman 2-way analysis of variance by ranks, with a p-value of less than 0.01 for both groups. Both Groups showed substantial improvements in the QuickDASH scores, reflecting reduced disability over time. Similarly, Mayo and PRWHE scores remained stable with high scores – indicating favourable outcomes – in both groups at the 12- and 24-month follow-ups. There was no significant difference between the 2 groups at each time point (Tab. 4).

Internal consistency of QuickDASH, Mayo and PRWHE Scores. Evaluated using Cronbach's Alpha. The scores contain 11, 4, and 15 items, respectively. Cronbach's Alpha values are 0.834 or 0.848 for standardized items, indicating high reliability and internal consistency. This suggests that future research could use just one of these highly correlated scales to reduce redundancy.

The assessment of classifiers (predictors of PA) were analyzed by logistic regression. The model uses a binomial outcome variable to indicate PA status (present or absent) after 24 months. Variables included are group, gender, age, DRF classification, side of injury, ASA classification, pain, and early complications. None of these variables alone significantly predicts PA (p>0.05). Treatment type (non-operative vs. operative) is not linked to PA development. However, pain at 6 and 12 months significantly predicts PA. Pain is an early indicator for post-traumatic arthritis. The logistic regression model showed an overall correct prediction rate of 74.5%. For cases where post-traumatic arthritis (PA) was absent, the model correctly predicted 67% of these cases. For cases where PA was present, the model showed a higher prediction accuracy, correctly classifying 85% of these cases. Thesresults confirm the predictive value of pain as a classifier for the development of post-traumatic arthritis. The results of logistic regression are shown in Table 5.

Table 4. Median scores during follow-up period

Score (median)	Period of follow-up: 6 weeks	6 months	12 months	24 months	Statistics
QuickDASH*					Friedman 2-way analysis of variance by ranks shows significant differences over time in both groups. For all measured scores, there was a highly significant improvement (p<0.01) during follow-up time.
Group 1	62.2	59.1	36.4	20.5	
Group 2	68.2	61.4	37.5	20.5	
Mayo Score**					
Group 1	35	57.5	65	85	
Group 2	37.5	57.5	65	85	
PRHWE score***					
Group 1	63.5	53.5	40.5	23	
Group 2	63	49	39	22	

*QuickDASH range: 0 – no disability to 100 – severe disabilit; **Mayo Score range: 100 – excellent range of motion and grip to 0 – dysfunctional; ***PRHWE Score range: 0 – no pain, full functionality to 100 – more pain, less functional.

Table 5. Logistic regression equation parameters and classification summary

Variable in equation	B	S.E.	Wald	DF	Significance	Exp(B)
Gender	0.814	0.854	0.907	1	0.341	2.256
Mayo wrists score at 6 weeks	0.121	0.087	1.923	1	0.165	1.129
Pain NRS 6 Months	-0.231	0.692	0.111	1	***0.039***	0.794
Pain NRS 12 Months	1.836	0.641	8.209	1	***0.004***	6.272

Significant classifier to predict onset of PA is **PAIN from 6 months onwards**.

Classification summary of Logistic Regression

Observed	Predicted outcome: Absent PA	Present PA	Total cases after 24 months	Percentage of correct predictions
Absent PA	9	13	22	67%
Present PA	5	28	33	85%
Overall percent of correct predictions				**74.5%**

The ROC Curve and the Area Under the Curve (AUC) as calculated by the Prognostic Model for Post-traumatic Arthritis (PA) are derived through ROC curve analysis.

This analysis aims to assess the contribution of various variables as classifiers for post-traumatic arthritis (PA). The curve demonstrates the model's sensitivity and specificity in predicting PA at different cut-off points (Fig. 3).

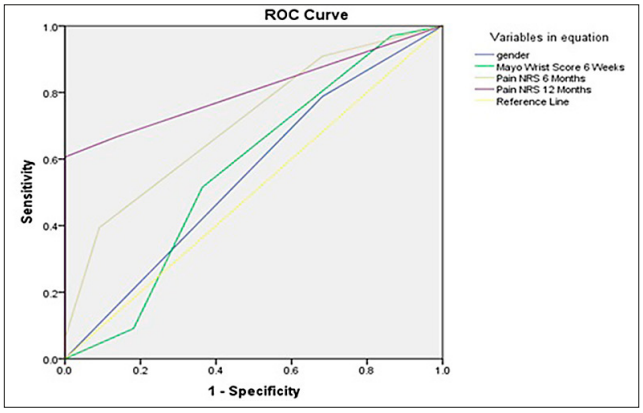

Figure 3. ROC Curve Showing the Classifier for Post-Traumatic Arthritis (PA)

ROC Analysis. The area under the curve (AUC) for each variable in the model was assessed to determine its accuracy in predicting the onset of posttraumatic arthritis (PA).

- *Gender* had an AUC of 0.553 (p = 0.508), indicating no significant predictive value.
- *Mayo Wrist Score at 6 Weeks* showed an AUC of 0.569 (p = 0.390), which was also not statistically significant.
- *Pain NRS at 6 months* demonstrated a moderate predictive ability with an AUC of 0.709 (p = 0.009), making it a significant early indicator for the development of PA.
- *Pain NRS at 12 months* had the highest AUC of 0.806 (p = 0.000), indicating a highly significant predictive value for the onset of PA.

The findings suggest that female gender is a risk factor for the development of PA. The Mayo wrist score at 6 weeks is an early indicator of PA, with lower scores correlated to the condition. Additionally, higher values of pain, particularly measured by the NRS scale after 6 and 12 months, are significant predictors for PA.

DISCUSSION

In the current study, different, but few complications were observed in operative and non-operative patients. Patients in the study did not report sensory disturbances. However, tendon rupture and carpal tunnel syndrome, as well as chronic pain, were noted in other studies focusing on non-operative treatment and follow-ups [9]. As in the current study, the number of complications between operative and non-operative groups was not significant, with no major discrepancies [10].

Operative treatment has a high rate of resource utilization and should be considered, yet it did not show improved long-term outcomes and only a slight decrease in complication rates as per the current findings. This aligns with a study examining 97 operative patients with intra-articular DRF that noted a high hardware removal rate, but a significantly low rate of tendon ruptures, although the study had a 7-year follow-up period [11]. This might indicate that although both operative and non-operative treatments are similar to a certain degree, operative management can yield higher results in the very long term for a minority of patients.

A study published in 2024 also identified pain to be one of the major complications of DRF, and related it to long-term immobilization and stiffness of muscles. The authors explained how addressing pain early would make it easier for older patients, where diabetes caused significantly slower rates of improvement in functional ability. Of course, this underlines the need for a specialized rehabilitation protocol in geriatric cases [12].

Pain plays a major role in management and understanding the risk of complications in addition to individualizing treatment options. Pain was a common finding in the current study, which is in alignment with most other studies. For instance, a study on long-term outcomes found that pain syndromes are the most common complication in patients with DRF [13]. In addition, no major significance was found between the operative and nonoperative groups with respect to pain syndromes, with non-operative patients having a slightly higher prevalence than in the presented study [14]. Similarly, this study found that non-operative patients had a slightly higher pain level. These findings were most notable in early treatment, while it was comparable to operative patients after 24 months of follow-up.

This study found that 44% of the operative group received therapy with a professional therapist, compared to 20% of the non-operative group, due to the complexity of their conditions. Therapist-led physiotherapy improved pain levels in the operative group over the long term. Similar findings in case reports noted a better range of motion, and reduced pain in patients undergoing therapist-led physiotherapy [12–14]. Early indicators, such as persistent pain at 6 and 12 months, are significant for the development of PA. This highlight monitoring pain as a potential marker for early intervention [10].

Regarding the development of arthritis, Marchewka et al. reported that 80% of the non-operative patients developed PA, while only 34% of the operative patients developed it. This corresponds with the logistic regression analysis in the current study showing that pain at 12 months was also a significant predictor of PA. Thus, this again underlines the importance of pain management for the long-term outcome [12, 15].

In this regard, Thorninger et al. detected that only 10 of 21 elderly patients with DRFs developed PA after 3 years of follow-up, and none of the patients had radiological signs of PA in the first 5 weeks. They observed that intra-articular fractures, especially type B fractures, had a higher rate of developing PA, while the current study did not analyze fracture types in this context. The findings of Thorninger et al. align with the broader understanding of fracture patterns influencing PA development. However, Thorninger et al. also noted the limited clinical impact of PA, given that only 2 out of 10 with radiological PA reported any pain. This aligns with the findings of the current study that functional outcomes remained stable over time, with pain identified as a significant predictor of PA rather than a direct consequence of its presence [16, 17].

Only a few studies had a follow-up rate of more than 3 years, but reported more detailed and descriptive findings [17]. Although some studies reported no significant changes in complications between the 12-month and 36-month

periods, other studies did report unique findings in some patients that would be worth understanding [15, 18]. Future research studying larger samples in a more randomized manner, along with a more in-depth follow-up session, is essential in understanding the complex management of PA. A study on outcomes of non-osteoporotic patients focusing on young patients noted the prevalence of PA is significant after a 5-year follow-up period (32%) [18, 13]. The presented study would have benefited from having a longer follow-up period to study the complications that can arise, especially in older patients.

The role of therapist-led rehabilitation was emphasized in a study regarding conservative management playing a role in DRFs treatment, revealing that therapist-led physiotherapy and counselling were most effective in treating severe complications, such as complex regional pain syndrome, stiffness, and severe pain, in a small selection of patients [19]. Moreover, the viability of non-operative management for elderly patients with low-energy DRFs shows good functional results and low complication rates, even after 3 years of follow-up [20].

Research from 2023 indicated that individuals with PA had lower levels of functioning and satisfaction, suggesting PA impacts more than just pain, it also affects daily life and long-term rehabilitation needs. The study highlights the necessity for personalized physiotherapy, particularly for those with PA, as it is linked to reduced wrist motion. Physiotherapy interventions are therefore crucial for maximizing motion range and patient satisfaction after an injury [13].

The current study did find that using QuickDASH and Mayo Score are a critical tool in terms of assessing pain and functional scores alongside PRWHE [21]. This multi-measure approach demonstrated sensitivity for long-term assessment over the 24-month period.

On the other hand, a study by Yassine Ochen et al. showed that in adults, at medium-term follow-up after operative treatment for distal radius fractures, DASH scores and grip strength showed a significant improvement. Their complication rate did not differ in the overall analysis, although their findings align with the improved functional outcomes in the operative group in the current study. Accordingly, in comparison, among patients aged 60 years or over, their meta-analysis did not present a significant difference in the medium-term DASH score, which was consistent with the current results showing similar functional outcomes for older patients. Indeed, this could indicate the presence of something related to aging factors that influence recovery in the elderly, as was observed in the older cohort in the current study [5].

In a systematic review by Nielsen et al., patient-reported outcome measures (PROMs) were evaluated for assessment of functional outcomes, and besides a lot of benefits and alignment, the authors recognized the need for a standardized, simplified method [22].

CONCLUSION AND CLINICAL IMPLICATIONS

Non-operative management should be the primary treatment for DRF in elderly patients, because the current study found no significant difference in PA or functionality between the operative and non-operative groups. Recognizing warning signs and managing pain early can prevent complications and improve the quality of life. Older patients may benefit more from non-operative management. The self-reported outcome measures for functionality and quality of life in the study are reliable and straightforward.

However, the study has limitations: the small sample size (70 participants) affected generalizability, the small operative group may have missed variability in outcomes, and factors like specific fracture patterns and radiographic characteristics, were not taken into consideration.

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