The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 3, Issue 8, 2025

EVALUATING THE EFFICACY AND DETERMINANTS OF SUCCESS IN CLOSED REDUCTION PROCEDURES FOR DISPLACED DISTAL RADIAL FRACTURES: A MULTIDIMENSIONAL ANALYSIS

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DOI: https://doi.org/10.5281/zenodo.16839990

Keywords
Distal Radial Fractures, Closed Reduction, Manual Traction, Fracture Union, Orthopedic Outcomes

Article History
Received on 12 May 2025
Accepted on 31 July 2025
Published on 13 August 2025

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Abstract

Displaced distal radial fractures (DDRFs) comprise an ordinary upper extremity injury and closed reduction along with casting is the initial management choice, especially in resource restricted condition. The proposed study will also measure the success rate of such an intervention as well as determine the demographic and clinical factors that can affect outcomes among adult patients. This is a descriptive cohort study that was done at the Department of Orthopedics Jinnah Postgraduate Medical Center, Karachi, Pakistan that was carried out between April 2019 and October 2019. Ninety adults (18 60 years) with DDRFs less than 1-week old were subjected to closed reduction under manual traction by the consultant orthopedic surgeons. Success was definitely described as union of the fracture on plain radiographs at 6 weeks and 3 months. Data on variables such as the age, gender, body mass index (BMI), fracture side were analysed using the SPSS software V20 and Chi-square tests were performed to establish association ($p<0.05$). Mean age of the cohort was 42.58+ 10.98 years with 66.67, % (60/90) of the sample being female. The percentage of success recorded was 93.33 (84/90). Age ($p=0.647$), gender ($p=0.370$), BMI ($p=0.609$), nor fracture side ($p=0.091$) were shown to be of any statistical significance to the outcomes. Conclusively, it is evident that closed reduction as well as manual traction has great effectiveness in treatment of DDRFs with a success rate of 93.33 %. Clinical and demographic factors had no significant effect on outcomes, which makes it an effective non-invasive methodology.

INTRODUCTION

The DRFs comprise a significant part of reported musculoskeletal trauma with around 16 percent of all reported fractures and are the only upper-extremity fracture that is most commonly experienced in orthopedic practice. Although such injuries are found at various ages, they occur much more frequently among the elderly-namely, postmenopausal women-as a result of age-related decline of the bone mineral density (Clayton et al., 2009; Verywell Health, 2023). In younger groups, the precipitating factor is usually road traffic accidents/sports-related trauma because the injury is often high-energy related (Rundgren et al., 2020).

Over recent decades open reduction and internal fixation (ORIF) has become the most common method of surgery with volar locking plates being recommended due to their benefits of early mobilization and restoration of the anatomy. However, several meta-analyses and RCT show that surgical treatment does not always lead to better long-term functional outcomes compared to conservative therapy, e.g., closed reduction and cast immobilization, at one-year follow-up (Bartl et al., 2014; S osborg- Wurtz et al., 2018; JAMA Network Open, 2019). Despite the fact that ORIF can produce a slight benefit in both general quality-of-life outcomes assessed over time and by the patient, these improvements are not always maintained in the longer-term in terms of grip strength or radiographic measures (JAMA Network Open, 2023; meta-analysis by Wang, Weiss, et al., 2020).

This leads to the fact that closed reduction remains one of the main means of treatment, especially in places where access to modern surgical equipment and specific knowledge is restricted, since without surgical facilities, treatment is possible through this method (Stirling et al., 2018; Rundgren et al., 2020). The effectiveness of closed reduction depends on numerous factors, such as the technical abilities of the surgeon and their clinical experience, the complexity of the fracture and the displacement pattern, which is unique to each individual patient, the quality of bones in general, comorbid problems, and patient compliance, observance of the post-reduction procedures (Holkenborg et al., 2013; Kodama et al., 2014; Earnshaw et al., 2002; Bozkurt et al., 2018). The multifactorial variability, which is well depicted by the success rates of about 68 to even 97.5 percent, highlights on the significance of thorough assessment of the patient before the procedure (Holkenborg et al., 2013; Kodama et al., 2014; Earnshaw et al., 2002; Bozkurt et al., 2018).

The current research thus tests the clinical effectiveness of (i) closed reduction; manual traction on dorsally displaced distal radial fractures (DDRFs). Besides the general success rates, it examines the effect of demographic and anthropometric factors, such as the age, gender, body mass index (BMI), and laterality of the injured limb on success in treatment. The population of the study involves patients who attend a tertiary-care teaching hospital in Karachi, Pakistan, and are willingly from adults, thereby making it beneficial in getting answers on how DRF is dealt with in a resource-limited but a high-volume orthopedic practice settings. The results should draw implications regarding clinical practice and guidelines development in the future, especially in similar environments where it is important to optimise non operative care (Stirling et al., 2018).

Literature Review

Dorsal displaced distal radial fractures (DDRFs) representing the most common fracture, closed reduction is one of the well-utilized, low cost, and easily available techniques of treatment, especially in healthcare facilities having limited surgical facilities or in cases when a patient is ill. The success rates related to this technique are inconsistent and primarily dependent upon methodology of the procedures, experience of the professional and patient-related aspects. According to Earnshaw et al. (2002), traditional manual manipulation yielded an impressive 87 % success rate in the management of Colles fractures, which is an indicator of the fact that the provision of satisfactory alignment can be viewed as a possibility achieved without the application of higher end imaging technologies. In comparison, Bozkurt et al. (2018) reported the use of ultrasound-assisted fracture surgery with a success rate of 97.5 % which is much higher, thus, indicating the better accuracy of alignment, the reduced risk of malunion, and that use of ultrasound-assisted fracture surgery might result in a reduction in the time needed to perform the procedure. The relatively smaller success

rate at 68 % stated by Kodama et al. (2014) may be attributable to more elaborate structures of the fracture, lower bone quality, or procedures done by less skilled practitioners. The weight of evidence as a whole drives home the fact that technical skill and selective patient choice are significant factors in maximizing the success of closed reduction in DDRFs, and even that adjunct imaging techniques have great promise to increase precision and clinical success, as well.

Prognosis loss: Fracture stability is a key independent determinant of prognosis following management of distal radial fracture (DRF). Where random instability exists, secondary displacement, loss of reduction and reduced functional recovery is more probable which may require intervention in most instances. Lafontaine et al. (1989) made the first systematic identification of the factors predicting instability, such as dorsal angulation greater than 20 degrees, dorsal comminution associated with significant cortical loss, and age older than 60 years, which still forms the basis of the orthopedic decision-making. By adding to this evidence base, Mackenney et al. (2006) extended the instability criteria with more radiographic and morphological parameters, particularly radial shortening in the presence of distal radioulnar joint disruption, and volar comminution, which impairs palmar structural integrity. All of this comes together to form an evidence-based scheme that guides clinicians in the stratification of patients and choice of treatment, allowing the defining of whether the treatment application of closed reduction and immobilization would be correct or early surgery could provide stronger stability and functional results (Fernandez, 1993).

Epidemiologic reports paint a unique demographic pattern with DRFs indicating a larger occurrence with females and more specifically postmenopausal women. This difference in gender can be largely explained by the bone mineral density having declined due to the effect of hormonal changes and as such it will increase vulnerability of low-energy fractures even with low trauma (Clayton et al., 2009). Despite the well-documented biological processes associated with increased likelihood of fracture in osteoporosis, poor high-quality research has been done describing the effect of disease and demographic factors affecting the success and stability of closed-reduction, factors such as gender, body mass index (BMI), and affected side. These factors can combine with biomechanical features and technical reduction variables, and eventually can influence radiological and functional outcomes. This is an area of knowledge that should be re-explored, particularly on diverse populations, where closed reduction is the main modality as a result of availability and affordability. Identification of these associations would have utility in selecting patients and developing prognosis and focusing treatment planning in resource limited and resource rich environments.

Materials and Methods

Study Design and Setting

This was conducted in the department of Orthopedics in Jinnah Postgraduate Medical Center, Karachi, Pakistan, between 25 April and 24 October 2019.

Procedure

Closed reduction in hematoma block or regional anesthesia was carried out by consultant orthopedic surgeons. After procedures, a long-arm below the elbow cast was used. At baseline, 6-week and 3-month follow-up, plain radiographs (anteroposterior and lateral projections) were acquired; radiographic union was considered complete when there was full overlap of articular cortices. Some of the variables sampled were age, gender, and BMI together with fracture side.

Sample and Sample Size Selection

In the calculation of the sample size the formula $N = Z^2 \times (P(100-P)/d^2)$, with P = 87% (Earnshaw et al., 2002); Z = 1.96; d = 7%; and 95 percent confidence interval was used. Non-probability sampling of consecutive sampling was used. Participants were fulfilled using the inclusion criteria that requires being adult (18 - 60 years old) presenting distal radius fracture within its first week, which requires closed reduction, but those that require surgery were not equally included.

Data Analysis:
SPSS V20 was used to carry out analyses. Mean age, height, weight, and BMI were reported as a means SD. Descriptive statistics were used to summarize categorical variables (gender, right or left side of the fracture, success rate) in terms of frequencies and percentages. Chi-square tests were used to evaluate relationships between the success rate and the possible effect modifiers and a two-tailed p-value of <0.05 was regarded to be significant.

Ethical Considerations
This study was approved by the institutional ethics committee, and informed consent obtained both in written form by all the participants.

Results
The average age of the 90 pa-tients was 42.58+10.98 (range 18 60). The females were 66.67 percent (n=60) and the males 33.33 percent (n=30). The average BMI was 24.32 mg / m 2 (3.94), (range 18.10-39.10). Fractures were also random on either side with left and right hands having 50 percent each (n= 45). In the 84 patients with successful union patients, six patients (6.67%) developed non-union. The success rate among adult patients whose distal radius fractures lasted a short time (1 week or less) and closed reduction was applied was 93.33%. The data did not provide any statistical differences against variables of age, gender, BMI, and side of fracture.

SPSS Tables and Interpretations
Table: Descriptive Statistics of Age

Variable	Mean	S.D.	Minimum	Maximum
Age (Years)	42.58	10.98	18	60

Together with a standard deviation of 10.98, the mean age of 42.58 years shows that the age division is quite broad and includes participants of young adulthood to middle age. This range of ages shows that the cohort represents the heterogeneous adult population and hence increasing the external validity of the results on the patients in the age group of 18 to 60.

Table: Descriptive Statistics of Height, Weight, and Body Mass Index (BMI)

Variable	Mean	S.D.	Minimum	Maximum
Height (cm)	166.84	8.38	143	182
Weight (kg)	67.32	10.54	47	90
BMI (kg/m²)	24.34	3.94	18.10	39.10

The average BMI of 24.34kgm 2 is normal and standard deviation of 3.94 is moderate. The range of observation (18.10-39.10 kg/m 2) includes normal, overweight, and obese patients therefore resembling the representative sample. Further, the distributions of weight and height justify why a heterogenous cohort has been included, which makes the data relevant to assess the relationship between BMI and clinical outcomes.

Table: Stratification of Age to Determine Association with Successful Outcome

Successful Outcome	18–45 Years	46–60 Years	P-value

Yes	50	34	0.647
No	3	3	

The non-significant p-value of 0.647 presents no relationship between the age categories and the positive results. The difference of the expected mean value was also small in both younger patients (18-45 years) and older patients (46-60 years) and this indicates that age frame of 18-60 does not affect the effectiveness of the closed reduction.

Table: Stratification of Gender to Determine Association with Successful Outcome

Successful Outcome	Male	Female	P-value
Yes	29	55	0.370
No	1	5	

A p-value of 0.370 shows failure to significantly associate gender and positive outcome. Female patients of the cohort (66.7 %) showed equally higher rates of success, regardless of gender, which means that gender does not have any impact on closed reduction efficacy.

Table: Stratification of BMI to Determine Association with Successful Outcome

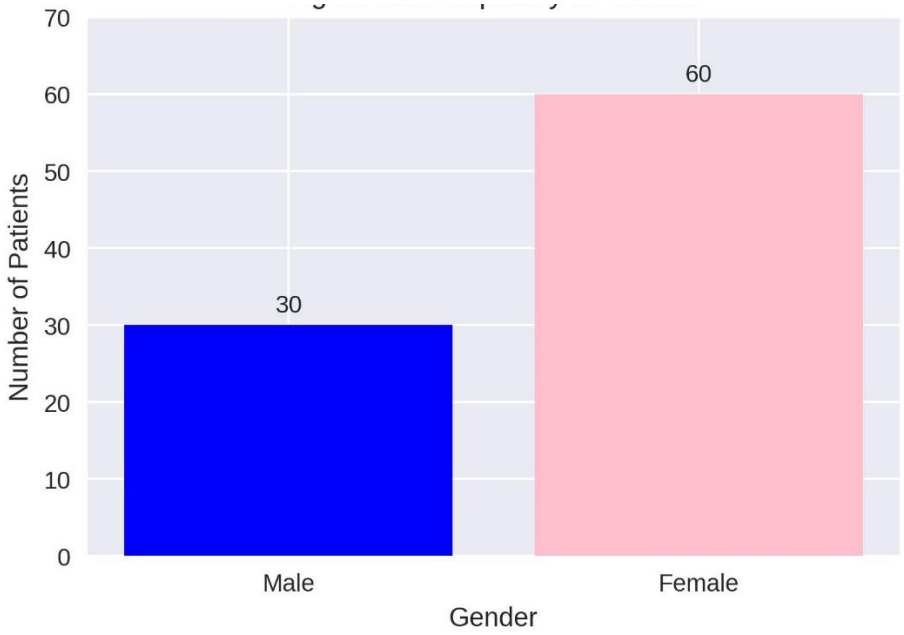
Successful Outcome	≤24.99 kg/m²	≥25.00 kg/m²	P-value
Yes	47	37	0.609
No	4	2	

Since the p-value of 0.609, the association between BMI and successful reduction is not significant, and therefore, BMI is not a confounder matter that alters the likelihood of the successful outcome. On dividing the BMI into normal (< 24.99kg m-2) and overweight/obese cohort (> 25.00kg m-2), there is no difference in the success rate of the two groups, implying that there is no predictable effect of BMI on the outcome of closed reduction.

Table: Stratification of Side of Fracture to Determine Association with Successful Outcome

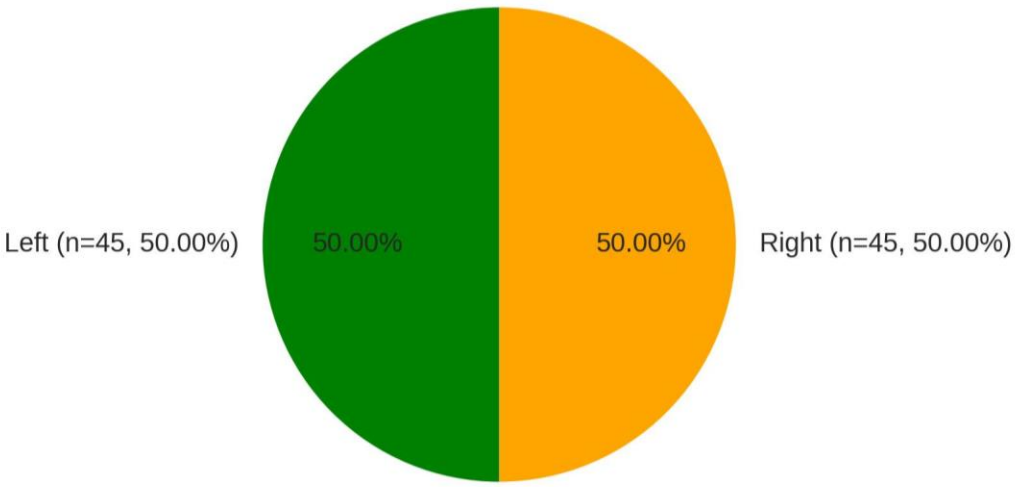
Successful Outcome	Left Side	Right Side	P-value
Yes	40	44	0.091
No	5	1	

This p of 0.091, which is slightly higher than 0.05, known conventional level of significance, points out that side of fracture and successful outcome are not associated which are significant. However, the difference in the non-union rate between the left side (5%) and right side (1%) is good enough reason to investigate further with a larger sample since the current sample is small. Existing evidence thus indicates that the factor of fracture side has little or no effect on the chances of achieving a positive clinical outcome



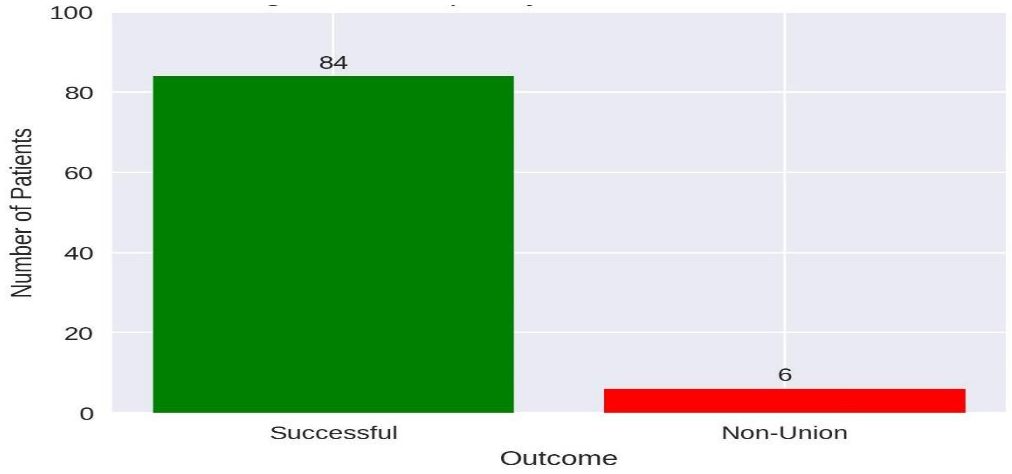
Frequency of Gender

The information in this graph shows that the proportion of female and male patients amounts to 60 patients (66.67%) and 30 patients (33.33%) respectively. Gender signifies points that run along the horizontal axis and the overall number of patients along the vertical.



Frequency of Side of Fracture

As seen in the following illustration, there is a fair distribution of hand fractures with 50 percent (n=45) on the left hand and the other 50 percent (n=45) on the right hand. Every anatomical area is marked with the respective percent and all the patients.



Frequency of Successful Outcome

The statistic presented in the table reveals that 84 out of 90 fixations of the implants (93.33%) experienced successful outcomes and six (6.67%) non-union. There are categories of outcomes, shown on the x-axis, and numbers of patients, shown on the y-axi

Discussion

The 93.33 percent success rate of closed reduction in the sample indicates a close similarity in success rates as achieved in previous studies which have shown high success incorporating high percentages as done by Bozkurt et al. (2018) who achieved 97.5 percent success when using ultrasound-guided continuous manual distraction in their closed reduction series and 87 percent success using manual manipulation in closed reduction of Colles fractures as used by Earnshaw et al. (2002). The above result also exceeds the relatively low achievement of Kodama et al., of 68 percent (2014) which may have been affected by other aspects such as slightly increased difficulty with the fracture patterns, unfavorable methods of reduction, or the presence of practitioners at a lower experience level. The excellent results of the current study can probably be related to the standardization of closed reduction measures carried out by verified orthopedic surgeons and the attentive post-removal management aimed at preserving the alignment. Notably, the non-existence of statistically significant correlations between the treatment success and demographic or clinical data such as age, gender, BMI, and fracture laterality would only indicate that closed reduction with manual traction is a universally applicable method, which has reliable results regardless of the wide variations in adult patients. This complements its use as the first-line management option in areas with limited resources in healthcare setting where surgical facilities might not necessarily be on-hand.

The fact that most of the patients in this group are females (66.67%) followed established epidemiological trends that indicated that lower mineral density of bone in women was directly related with distal radial fractures especially among women in postmenopausal age ranges, which is predisposed based on hormonal alterations compounding into fragility fractures (Clayton et al., 2009). It is interesting to point out that no notable gender influence on treatment outcome was observed in the present study suggesting that the precision of a particular process and local properties of the fracture could be more critical in dictating treatment success than demographic factors. On the same note, there is no significant outcome difference by age which is contrary to studies like Lafontaine et al. (1989) who listed older age as a predictor of fracture instability. This difference could be attributed to the fact that patients who are over 60 years were eliminated in the current study; hence a high-risk group was eliminated in the research.

Concerning the laterality of fractures, the similarity in the number of successful and unsuccessful outcomes

between left and right wrists and insignificance of success rates on these sides implies that the leading factor of outcome of closed reduction is not the side dominance. However, the fact that the non-union rate turns out to be a little bit higher on the left side, as it can be also seen in Table 9, deserves further research in order to find out whether it could be caused by the bi mechanical or activity-related factors that make a slightly more evident non-union rate more likely.

In spite of these advantages, it is necessary to consider some drawbacks. Single-center design can restrict the possibility of applying the findings to wider population with variations of fracture patterns or access to treatment. In addition, there was an absence of functional outcome evaluations, including long-term results to assess whether the patient is able to use the arm again, measured using the Disabilities of the Arm, Shoulder and Hand (DASH) scores, as well as the measurement of grip strength, as well as the patient-reported quality of life, which is essential to understand the overall effect of treatment and radiographic union hypertrophic repair. The future studies should be focused on the attempts to integrate these patient-centered outcome measures and provide the comparative analysis of closed reduction and surgical interventions in the case of distal radial fractures to improve the treatment choice and provide the optimization of the care paths in this condition.

Recommendations

Clinical Practice: Orthopedic surgeons ought to use closed reduction as a foremost mode of treatment of a DDRF of an adult (between ages 18 years and 60 years). Empirical data show that the approach has high success rates and it is not affected largely by any demographic variables like gender, body mass index, or injury side of the body. In order to optimize the outcome of this practice, healthcare facilities are supposed to develop standard clinical procedures that will clearly map out procedures on how to execute manual traction, acceptable criteria of post reduction alignment, and acceptable time scale on follow-up radiographic evaluation. Moreover, the introduction of systematic follow up of post-reduction of the arm, i.e. periodic check-ups in one week and four weeks, may assist in early diagnosis of displacement and subsequent intervention, which eventually improves patient outcomes.

Training and Resources: There should be more emphasis in learning or mastering of the manual areas of traction in training curriculum of orthopedic residents and practitioners. Procedural execution needs to be consistent, especially in health care settings where sophisticated surgical tools, implants, or anesthesia services might be hard to come by. The tactile skills and confidence among surgeons and emergency physicians, to achieve effective closed reductions, may be formalised through using simulation-based training, peer-to-peer workshops and supervised sessions in clinical practice. Also, resource-constrained hospitals ought to have simple yet effective traction equipment and immobilization supplies to back this mode of treatment.

Research: Future research ought not just to provide assessment regarding the short term radiographic success of closed reduction but also lay an emphasis on the long term functional outcome, such as grip strength, range of motion in wrist, pain levels and patient-reported quality of life. Comparative research studies on closed reduction and surgical fixation of different patients groups may assist in the decision as to which method is more effective to specific subgroups than the other. It is also conceivable that this observation, as well as larger, multicenter studies need to have sufficient statistical power to explain their preliminary findings as a one or two-sided effect like finding that the number of non-union was greater in left sided fractures than in right sided fractures.

Imaging Guidance: Ultrasound or fluoroscopy might also provide the possibility to procedural accuracy since it enables the real-time reflection of the fracture alignment during the process of closed reduction as shown by Bozkurt et al. (2018). This has the potential of mitigating an occurrence of malreduction and redoing of manipulations. The potential advantages of a routine imaging-assisted reduction in regard to feasibility and cost-effectiveness and outcomes of patients, including particularly high-volume trauma centers, should be studied in future clinical trials.

Conclusion

Closed reduction, using manual traction, has been established as not only one of the most successful but also very practical means of treatment in dorsally displaced distal radial fractures (DDRFs), and the current study has displayed a respectable success rate

of 93.33 percent. This great effectiveness adds weight to its ability as a core solution strategy especially where surgical operation might not be available at hand imminently or even necessary. Another significant discovery in this study is that other important demographic and clinical factors such as the age of the patient, sex, body mass index (BMI), laterality of the fracture, had no statistically significant impact on the results of treatment. This implies that closed reduction and manual traction produces consistently good outcomes with a large range of adult patients, regardless of their personal demographic parameters, when it is conducted with standardized methods.

Other benefits of the non-invasive nature of this approach are a decrease in the risk of the procedure, quicker times of recovery, and lower costs of this treatment method, in comparison to its surgical counterparts. These advantages have seen it as being especially useful with resource-constrained medical settings and scenarios whereby comorbidity of patients or personal preference excludes surgery. Nevertheless, the best outcomes occur when following all established procedural protocols, careful post-reduction immobilization, and close post-reduction follow-up are observed to quickly notice any form of secondary displacement.

Although the short-term radiographic results of such an approach are undoubtedly positive, it remains important to conduct further studies to evaluate the long-term functional recovery of examined patients, both in terms of their wrist mobility, grip strength, pain levels, and patient-reported satisfaction. Multicenter studies that can encompass large samples and have a long-term follow-up would also aid in confirming the sustainability of the early achieved results and find out any insidious predictors of lesser outcomes. In general, this study provides substantial evidence of the success of the closed reduction with manual traction techniques as the safe, economical, and broadly applicable form of treatment of DDRFs, which, again, can only be applied to with the technical precision and evidence-based follow-up care.

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