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Surgical management of distal radius fractures using ligamentotaxis – A prospective study

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ABSTRACT

Background: Distal radius fractures are among the most prevalent fractures, particularly in older adults. These fractures can lead to significant functional impairment if not managed appropriately. Various treatment modalities exist, but surgical interventions such as ligamentotaxis and external fixation have gained prominence in managing comminuted distal radius fractures. **Aims and Objectives:** The primary objective of this study was to evaluate the functional outcomes of surgical management of comminuted distal radius fractures using ligamentotaxis and external fixation. **Materials and Methods:** This prospective study included a cohort of 30 patients who underwent surgical management of comminuted distal radius fractures. The fractures were classified using the AO classification system, and ligamentotaxis was performed using external fixators over a 2-year period. Post-operative functional outcomes were assessed through clinical evaluations, range of motion measurements, and the Gartland and Werley score at regular intervals up to 6-month post-surgery. **Results:** The findings revealed that 84% of the patients achieved excellent to good functional outcomes, while 16% experienced fair to poor results. The suboptimal outcomes were primarily attributed to complications such as residual pain and stiffness. In addition, a marginal of cases exhibited complications including malunion, restricted wrist movement, and finger stiffness. **Conclusion:** This prospective study demonstrates that ligamentotaxis using external fixation is an effective method for managing comminuted distal radius fractures, with most patients achieving excellent to good functional outcomes.

Key words: Distal radius fracture; Ligamentotaxis; External fixation; Surgical outcomes

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INTRODUCTION

Distal radius fractures are among the most frequent injuries seen in orthopedic practice, accounting for a significant proportion of fractures, especially in the elderly population. These fractures can lead to substantial functional impairment if not properly treated, particularly when the fracture is comminuted or intra-articular.[1] Comminuted distal radius fractures involve multiple bone fragments, making their management more complex due to the challenges in achieving and maintaining anatomical alignment.[2] The primary goal in treating distal radius fractures is to restore normal wrist function by ensuring anatomical reduction and stable fixation until the fracture heals.[3] Non-surgical management with closed reduction and immobilization is typically reserved for less severe fractures, whereas more complex fractures often require surgical intervention. One of the most common and effective surgical techniques for managing comminuted fractures is external fixation using the principle of ligamentotaxis,

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where the reduction is achieved through ligamentous tension.[4,5]

Ligamentotaxis involves applying a distraction force through the intact ligaments surrounding the fracture site, enabling fracture fragments to realign anatomically without direct manipulation.[6] This method is particularly useful for comminuted fractures, as it minimizes the risk of further fragment displacement or shortening of the radius.[7] Despite the advantages of ligamentotaxis, complications such as pin tract infections, residual pain, and restricted range of motion are common and can affect long-term outcomes.[8]

This study aims to assess the functional outcomes of patients with comminuted distal radius fractures treated using ligamentotaxis with external fixation. The study also seeks to evaluate the complications associated with this technique and to identify factors that may influence the success of the procedure.

Distal radius fractures are among the most frequent injuries seen in orthopedic practice, particularly in older adults and individuals with osteoporosis. While numerous studies have evaluated various surgical techniques, ligamentotaxis using external fixation remains a widely used method due to its ability to restore anatomical alignment with minimal soft tissue disruption. However, most studies have primarily focused on radiological outcomes, with limited emphasis on functional recovery, postoperative rehabilitation, and complication management.

Aims and objectives

This study aims to address these gaps by providing a comprehensive functional assessment of patients undergoing ligamentotaxis for comminuted distal radius fractures, with longitudinal follow-ups at 6 weeks, 12 weeks, and 6 months using the Gartland and Werley score. In addition, this study analyzes postoperative complications in detail and evaluates the role of early mobilization and rehabilitation protocols in optimizing patient recovery. Unlike previous research, which often reports complications without an in-depth discussion, this study provides a comparative analysis of complication rates and management strategies.

1. To assess the surgical outcome of ligamentotaxis by distraction force in comminuted distal end radius fracture

2. To findout the complications associated with the surgical outcome.

3. To compare the functional outcome of treatment of distal end radius fracture by ligamentotaxis by distraction force.

MATERIALS AND METHODS

This study was designed as a prospective observational study conducted at a tertiary healthcare center over a 2-year period. The study population comprised patients admitted to the Orthopaedics Department with comminuted distal radius fractures, all of whom were treated surgically using ligamentotaxis and external fixation.

Inclusion criteria

- All adult patients diagnosed with comminuted distal radius fractures according to the AO classification system
- Patients who consented to participate and adhered to follow-up protocols.

Exclusion criteria

- Patients with skeletally immature bones, pathological fractures, or polytrauma (Injury Severity Score >16)
- Patients with distal neurovascular deficits or compound distal radius fractures.

Data collection procedure

Patients underwent preoperative assessments, including X-rays and clinical evaluations. Surgical treatment involved the application of an external fixator using the principle of ligamentotaxis, with Schanz pins inserted in the second metacarpal and the radial shaft, connected by distraction rods. The aim was to maintain fracture reduction through distraction, stabilizing the wrist joint while promoting fracture healing.

Patients were encouraged to begin active finger movements on the 1st postoperative day, and the limb was elevated to prevent edema. Parenteral antibiotics were administered for 2 days, followed by oral antibiotics. Pin sites were regularly inspected for infection, and radiographs were obtained at regular intervals to monitor fracture healing.

Patients were followed up at 6-week, 12-week, and 6-month intervals. Clinical evaluations assessed wound healing, pain, range of motion, and fracture union, while radiographs confirmed fracture consolidation.

Functional outcomes were measured using the Gartland and Werley score, which assesses pain, deformity, and wrist movement. Complications such as infection, malunion, and restricted movement were documented.

Statistical analysis

Qualitative data were presented as frequencies and percentages, while quantitative data were presented as mean±standard deviation (SD). Statistical analysis was performed using SPSS software version 24.

Clinical pictures

Pre-operative X-ray

RESULTS

The mean age of male participants was 36.50±7.46 years, while female participants had a slightly higher mean age of 39.15±7.89 years. The results indicate that this difference is not statistically significant (P=0.38), suggesting that age distribution between males and females in this study is comparable.

A higher proportion of males (90%) had a hospital stay of <7 days, compared to 70% of females. Conversely, a longer hospital stay (more than 7 days) was observed in 30% of females, while only 10% of males experienced an extended hospitalization. However, the results indicate that this difference is not statistically significant (P=0.23), implying that sex does not significantly influence the length of hospital stay in this dataset (Table 1).

The fractures were classified according to the AO classification system. The most common fracture type was AO Type A3, observed in 40% of cases, followed by Type A2 at 20%, while more complex fractures like Type C2 accounted for 16.7% of cases (Figure 1).

The right side was more commonly affected (63.3%), with road traffic accidents (RTA) being the leading cause of injury (50%), followed by falls on an outstretched hand (36.7%) (Figure 2).

Table 1: Patient demographic

Characteristics	Male (n=10)	Female (n=20)	P-value
Age (in years)	36.50±7.46	39.15±7.89	0.38
Hospital stay (days)			
<7 days	9 (90)	14 (70)	0.23
>7 days	1 (10)	6 (30)	

Table 2: Complications

Complications	Number	Percentage
Residual pain	5	16.7
Malunion	1	3.3
Restricted wrist movements	1	3.3
Finger stiffness	1	3.3
Shoulder hand syndrome	1	3.3

Table 3: Functional outcomes

Gartland and Werley score grading	Number	Percentage
Excellent	17	55
Good	9	29
Fair	3	10
Poor	1	3

Complications were observed in a minority of cases. Residual pain was the most common, affecting 16.7% of patients, while malunion, restricted wrist movement, finger stiffness, and shoulder-hand syndrome were each noted in 3.3% of cases (Table 2).

At the final follow-up, 84% of patients had excellent to good outcomes based on the Gartland and Werley score. Specifically, 55% of patients achieved excellent results, while 29% had good outcomes. Fair and poor outcomes were noted in 10% and 3% of patients, respectively, often due to complications like residual pain or stiffness (Table 3 and Figures 3-6).

There is no significant difference between males and females for functional outcomes (P=0.55); 84% had good to excellent results. There is no significant difference in overall rates for complications (P=0.17); females had more residual pain (25%), while males had slightly higher malunion and finger stiffness (10%). Ligamentotaxis

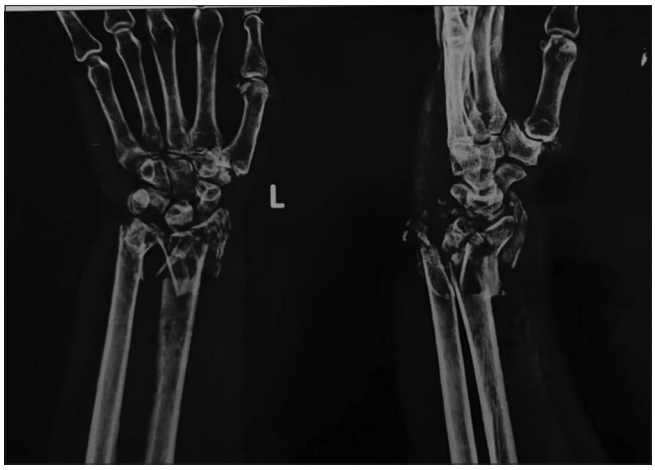

Figure 1: X-ray wrist anteroposterior and lateral view

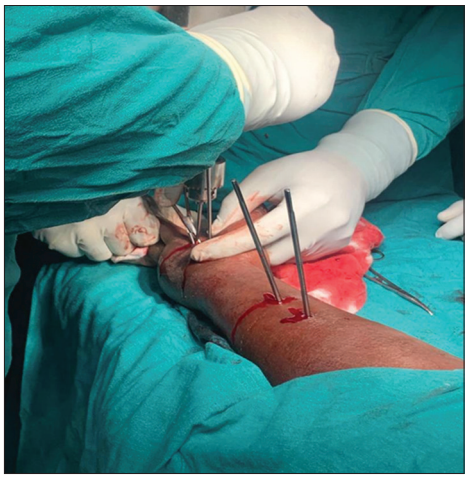

Figure 2: Intraoperative image showing schanz pin in radial shaft and 2nd metacarpal

provides similar functional recovery and complication rates in both sexes (Table 4).

The analysis of functional outcomes across different age groups indicates that excellent outcomes were more frequent in all groups, with the highest proportion observed in the 31–40-year age group. Good outcomes were also observed in all groups, while fair and poor outcomes were reported only in the 31–40-year age group. There is no statistically significant difference in functional outcomes across age groups, implying that age does not significantly influence recovery (P=0.053). However, it is close, indicating a possible trend that may be significant with a larger sample size.

Regarding complications, the 21–30-year age group exhibited no reported complications, whereas the 31–40-year and 41–50-year age groups showed a higher incidence of complications, particularly residual pain. There is no statistically significant difference in the occurrence of complications among age groups (P=0.22). This suggests that age does not have a major impact on the likelihood of developing complications after treatment (Table 5).

Table 4: Functional outcomes and complications by sex

Variable	Male (n=10)	Female (n=20)	P-value
Functional outcomes			
Excellent	5 (50)	12 (60)	0.55
Good	3 (30)	6 (30)	
Fair	2 (20)	1 (5)	
Poor	0	1 (5)	
Complications			
No complications	8 (80)	13 (65)	0.17
Residual pain	0	5 (25)	
Malunion	1 (10)	0	
Restricted wrist movements	0	1 (5)	
Finger stiffness	1 (10)	0	
Shoulder hand syndrome	0	1 (5)	

DISCUSSION

The findings of this study demonstrate that ligamentotaxis using external fixation is an effective surgical technique for treating comminuted distal radius fractures, with 84% of patients achieving excellent to good functional outcomes. These results are consistent with other studies that have reported similar success rates for ligamentotaxis in managing complex distal radius fractures.[9]

In the present study, the most common age group among study population was 31–40 years (53.3%) followed by 41–50 years (33.3%). Similarly, in the study conducted by Singh et al., the mean age was 44.71±11.66 years.[8] In the present study, mean age of the patients was found to be 49.74 years.[8]

In the present study, there was female predominance (66.7%) among study population. Similarly, in the study conducted by Maruthi and Shivanna, out of 170 patients, 105 (61.8%) were female and 65 (38.2%) were male.[7]

In the present study, the distribution of fracture types among the study population is based on the AO classification system. The most common fracture type is AO Type A3, comprising 40.0% of cases (12 out of 30), followed by AO Type A2 at 20.0% (6 cases). AO Type C2 fractures make up 16.7% (5 cases), while AO Type B3 accounts for 10.0% (3 cases). The least common fracture types are AO Types B2 and C3, each representing 6.7% (2 cases). Similarly, in the study conducted by Maruthi and Shivanna, A3 type was 40%, according to AO classification.[7]

In the present study, the most common side of injury among study population was right (63.3%) followed by left (36.7%). Similarly, in the study conducted by Singh et al., right side involvement occurred in 64% of the patients (16 patients) while left side involvement occurred in 36% of the patients (9 patients). Right side preponderance might be due to the fact that majority of the

Table 5: Functional outcomes and complications by age

Variable	21–30 years (n=4)	31–40 years (n=16)	41–50 years (n=10)	P-value
Functional outcomes				
Excellent	4 (100)	7 (44)	6 (60)	0.053
Good	0	5 (31)	4 (40)	
Fair	0	3 (19)	0	
Poor	0	1 (6)	0	
Complications				
No complications	4 (100)	9 (56)	8 (80)	0.22
Residual pain	0	3 (19)	2 (20)	
Malunion	0	1 (6)	0	
Restricted wrist movements	0	1 (6)	0	
Finger stiffness	0	1 (6)	0	
Shoulder hand syndrome	0	1 (6)	0	

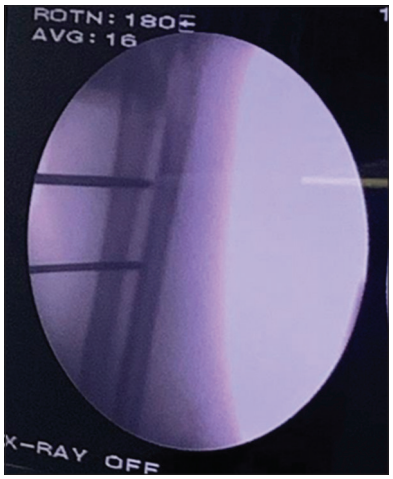

Figure 3: Intraoperative image showing distractor rod being connected to pins with help of clamps

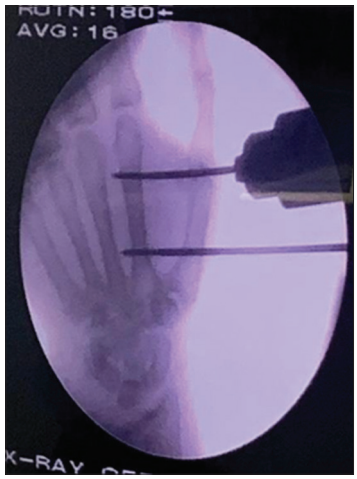

Figure 4: Intraoperative C Arm images showing schanz pins placed in radial shaft (3.5 mm) and 2nd metaccarpal (2.5 mm)

Figure 5: Intraoperative image showing distal end radius

proportion of the population is right handed, so as a reflex, right side is usually exposed first to harsh environmental stress. Furthermore, India being a left hand drive country,

Figure 6: Immediate post-operative X-ray

there are more chances of injuries involving the right side of the person during RTA.[8] In the present study, the most common mode of injury among study population was RTA (50%) followed by fall on outstretched hand (36.7%).

In the present study, comorbidities such as anemia, diabetes, and hypertension were present in 33.3%, 16.7%, and 33.3% of study population. Similarly, in the study conducted by Arunkumar et al., two patients were no diabetic and two were hypertensive, there were no medical problems in others.[10]

The principle of ligamentotaxis offers several advantages in treating comminuted fractures, particularly using the intact ligaments to maintain fracture reduction without the need for extensive soft tissue dissection.[11] This reduces the risk of complications such as radial shortening or further displacement of fracture fragments.[12] The overall complication rate in this study was low, with pin tract infections being the most common issue, followed by residual pain and wrist stiffness. These complications were managed conservatively, and no cases required additional surgical intervention.[13]

Functional outcomes

The use of the Gartland and Werley score allowed for a comprehensive assessment of both objective and subjective outcomes, providing insights into the patients' pain levels, wrist function, and deformity. The majority of patients reported excellent results, with full recovery of wrist motion and minimal pain. However, patients with poor outcomes were generally those with pre-existing comorbidities, delayed mobilization, or inadequate postoperative rehabilitation.[14]

In the present study, most of the study population had Excellent to Good (84%) Gartland and Werley score followed by Fair (10%) and Poor (3%). Similarly, in the

study conducted by Singh et al., Mean Gartland and Werley score was found to be 4.72. According to Gartland and Werley score grading, excellent results were obtained in 24% of the patients (6 patients), while good results were seen in 64% of the patients (16 patients). Fair results were obtained in 12% of the patients (3 patients).[8] In a study conducted by Tontanahal et al., overall, we obtained "excellent" results in 37.14%; "good" in 46% cases; "fair" in 15.14%, and "poor" in 1.72% cases with a mean G and W score of 6.35. Therefore, a satisfactory result was obtained in 83.14% cases.[15]

The success rates reported in this study align with those of other researchers. For instance, Maruthi and Shivanna reported excellent outcomes in 88% of cases, while Singh et al., observed similarly high success rates using ligamentotaxis.[7,8] These findings suggest that ligamentotaxis remains a valuable option for managing distal radius fractures, particularly in cases of severe comminution.

While the complication rate was relatively low, it is important to acknowledge the impact of pin tract infections and residual pain on patient outcomes. Previous studies have highlighted the risk of infections with external fixators, which can be minimized through meticulous surgical technique and postoperative care.[16] In this study, infections were managed with antibiotics and did not necessitate hardware removal. Similarly, in the study conducted by Arunkumar et al., other complications, including malunion, restricted wrist movements, finger stiffness, and shoulder-hand syndrome, each occur in 3.3% (1 case) of the patients.[10]

However, complications such as pin tract infections and residual pain remain challenges that require careful management to ensure optimal recovery. Future studies should explore long-term outcomes and evaluate strategies to minimize complications and enhance functional recovery. Despite these challenges, ligamentotaxis remains a valuable option for treating complex distal radius fractures, particularly when early mobilization and appropriate postoperative care are implemented.

The findings of this study demonstrate that ligamentotaxis using external fixation is an effective surgical technique for managing comminuted distal radius fractures, with 84% of patients achieving excellent to good functional outcomes. These results align with prior studies by Maruthi and Shivanna[7] and Singh et al.,[8] which reported comparable success rates using similar techniques.

Although ligamentotaxis provides reliable fracture stabilization, postoperative complications remain a concern. In this study, 16.7% of patients experienced residual pain, while malunion (3.3%), restricted wrist movement (3.3%), finger stiffness (3.3%), and shoulder-hand syndrome (3.3%) were observed less frequently.

Pin tract infections

Previous studies have reported pin tract infections as the most common complication, with rates varying between 5% and 25% depending on surgical technique and post-operative care.[13,14] This study recorded a low infection rate, suggesting that strict pin-site care protocols were effective in preventing infections.

Residual pain and wrist stiffness

The incidence of residual pain and wrist stiffness (16.7%) in this study aligns with reported outcomes in Knirk and Jupiter,[12] where post-fracture stiffness was linked to delayed mobilization. The early initiation of active finger movements on postoperative day 1 in this study may have contributed to improved functional outcomes.

Malunion and restricted wrist movement

The low incidence of malunion (3.3%) compared to other studies[11,16] suggests that ligamentotaxis effectively prevents major misalignment when combined with appropriate postoperative care.

Complication prevention

Early mobilization

Patients in this study were encouraged to begin active finger movements on the 1st postoperative day, which likely contributed to the low rates of stiffness and malunion. This highlights the importance of early rehabilitation protocols in improving functional recovery.

Pin-site care and infection prevention

Regular pin-site cleaning and prophylactic antibiotics minimized the risk of pin tract infections, supporting the notion that postoperative care is as crucial as surgical technique in achieving optimal outcomes.

Future research should focus on long-term follow-ups to evaluate whether early functional recovery translates into sustained improvements. In addition, exploring alternative fixation techniques or hybrid approaches could further refine the management of complex distal radius fractures.

Limitations of the study

Long-term complications like arthritis and stiffness were not assessed; extended follow-up is required. Variations in physiotherapy adherence could affect recovery but were not analyzed. Conditions like osteoporosis and diabetes were not fully considered, which may influence healing.

Risk factors for complications like malunion and stiffness were not explored in depth.

CONCLUSION

This prospective study demonstrates that ligamentotaxis using external fixation is an effective method for managing comminuted distal radius fractures, with most patients achieving excellent to good functional outcomes. The use of external fixation allows for adequate fracture reduction and stabilization while minimizing soft tissue disruption.

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Authors' Contribution:
SSD- Definition of intellectual content, literature search, prepared first draft of manuscript, implementation of study protocol, data collection, data analysis, manuscript preparation and submission of article; **ACD**- Concept, design, clinical protocol, manuscript preparation, editing, and manuscript revision; **RPC**- Design of study, statistical analysis and interpretation; **MCV**- Data collection, data analysis, review manuscript; **SSJ**- Review manuscript, manuscript revision.

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