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Original Research Article

Comminuted Intraarticular Distal Radius Fractures: Functional Outcome and Short-term Follow-up after Surgical Treatment with Spanning External Fixation

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Abstract

Background: Treating a severely comminuted distal radius intraarticular fracture is challenging as it can lead to disability, unless the alignment of the fractured bones is restored as accurately as possible and maintained in an anatomical position.

Objective: This study aims to assess the efficacy of utilizing an AO spanning external fixator in the treatment of comminuted distal radius intraarticular fracture.

Methods: Between January 2020 and September 2022, 38 individuals with isolated closed comminuted intraarticular distal radius fractures (DRFs) were enrolled in this research. The patients underwent clinical and radiological evaluations using the AO classification system in the emergency department. The patients were taken to the operating theatre, where closed reduction techniques and a stable mini-AO spanning external fixator were employed to restore the radiological parameters of the distal radius. The functional status of the patients was assessed at 3, 6, and 12 months using the modified Green and O'Brien scale. The collected data were then analyzed to evaluate treatment outcomes.

Results: 32 (84%) patients were males with an average age of 32. Among the cases, 45% of the patients had AO-23C3 fractures, while 55% had AO-23C2 fractures. The procedure duration ranged from 15 to 25 minutes. The external fixator was removed after a median period of seven weeks. Additional percutaneous K-wires were used in 6 patients for enhanced stability. Three

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patients experienced pin tract infections during treatment. Radiographic measures of the distal radius showed normal values. Functional outcomes were favorable; with 55% of patients had excellent results, 29% experienced good outcomes, and 11% and 5% presented fair and bad outcomes respectively.

Conclusion: Severely comminuted DRFs can be effectively treated with minimally invasive spanning external fixation, restoring anatomical and radiological parameters and achieving favorable functional outcomes

Keywords: Distal Radius Fracture, External Fixation, Radiological Parameters, Anatomical Parameters, Surgical Treatment

Introduction

Distal radius fractures (DRFs) are among the most common orthopedic injuries, accounting for approximately 17% of all fractures in adults. Comminuted DRFs, characterized by multiple bone fragments, present unique challenges due to their inherent instability and risk of malunion, which can lead to chronic pain, reduced wrist function, and diminished quality of life [1]. While treatment options range from conservative casting to open reduction and internal fixation (ORIF), severely comminuted fractures often require advanced stabilization techniques [2]. Spanning external fixation (SEF), which bridges the wrist joint to maintain alignment while allowing soft tissue recovery, has emerged as a viable option [3].

SEF is a well-established technique for managing unstable and highly comminuted distal radius fractures [3]. It provides indirect fracture reduction by ligamentotaxis, stabilizes the fracture fragments, and maintains the wrist in a functional position during the healing phase. Compared to open reduction and internal fixation (ORIF), external fixation offers the advantage of minimal soft tissue disruption, making it particularly useful in cases with compromised soft tissue conditions or polytrauma patients. However, concerns remain regarding its efficacy in achieving anatomical reduction, long-term functional outcomes, and the risk of complications such as joint stiffness and pin tract infections [3,4].

Previous studies have reported variable results, with some suggesting that SEF provides satisfactory functional recovery, while others highlight limitations in regaining wrist motion and grip strength. Moreover, the comparative advantages of SEF over volar plating or hybrid fixation strategies remain unclear [5]. Given these uncertainties, there is a need for further investigation into the clinical efficacy, radiological outcomes, and complication rates associated with SEF in the treatment of comminuted DRFs.

This study hypothesizes that SEF provides adequate stabilization, satisfactory radiological reduction, and acceptable functional outcomes with a manageable complication profile, making it a viable treatment option for comminuted DRFs. Accordingly, the aim of the study is to evaluate the functional outcomes of SEF in

comminuted DRFs, assess the radiographic parameters postoperatively, including radial height, radial inclination, volar tilt, and articular step-off, and determine the complication rates associated with SEF, including pin tract infections, stiffness, and malunion.

Methods

This retrospective analysis was conducted at the Orthopedic and Trauma Department of Al Thawra Modern General Teaching Hospital in Sana'a, Yemen. The study included 38 patients with severe intra-articular comminuted DRFs treated between January 2020 and September 2022. Data were retrospectively retrieved from medical records, surgical reports, and admission databases using a standardized data collection form. Data were entered into a structured electronic database. Double-data entry verification was performed to minimize transcription errors and missing or ambiguous entries were cross-referenced with original source documents.

To ensure demographic and clinical homogeneity, exclusion criteria comprised:

- Concomitant neurovascular injuries or compartment syndrome,
- Ipsilateral fractures of the hand, forearm, elbow, or humerus,
- Pathological fractures or open fractures (Gustilo-Anderson type III), and
- Patients aged <20 years.

The patients were evaluated clinically and radiologically. The fractures were classified according to the AO classification system in the emergency department to ensure that only patients with fractures meeting the inclusion criteria were included in the study. Subsequently, the patients underwent a surgical procedure in the operation theater. Closed reduction was performed, and a stable mini-AO spanning external fixator was applied to the wrist joint to restore the radiological and anatomical parameters of the distal radius. The mini-AO spanning external fixator is employed in the management of intra-articular comminuted DRFs due to its ability to address the biomechanical challenges posed by severe fragmentation and joint instability. Unlike internal fixation, which risks further disrupting compromised bone or soft tissues, the spanning fixator utilizes ligamentotaxis—applying traction across the wrist joint to indirectly realign displaced articular fragments through tensioned ligaments and capsular structures. This minimally invasive approach preserves periosteal blood supply critical for healing, reduces infection risk, and avoids hardware failure in osteoporotic or highly comminuted bone.

The distal pins were inserted into the second metacarpal proximally at the transition from the head to the shaft and distally at the transition from the shaft to the metacarpal base. The pins achieved good cortical stability. The proximal pins were inserted perpendicular to the transverse section of the radius, proximal to the muscle bellies of abductor pollicis longus (APL) and extensor pollicis brevis (EPB). The pins insertion technique was applied according to AO principles.

Postoperative control X-rays were obtained immediately after the surgery and were

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repeated during the first postoperative visit after one week. Routine follow-up appointments were scheduled for the patients at 6, 9, and 12 weeks, during which a physiotherapist was consulted. The external fixation device was removed once the radiological and clinical signs of fracture healing were observed. The functional evaluation of the patients was conducted at 3, 6, and 12 months of follow-up.

The outcomes were assessed using the Modified Green and O'Brien functional score (**Table 1**).

Table 1: Modified Cooney Green and O'Brien Functional score for wrist

Variables	Findings	Score
Pain	No pain	25
	Mild Occasional	20
	Mild, regular, no significant effect on activity	15
	Moderate, activity reduced, no pain at rest	10
	Severe pain at rest	0
Range of Movements (arc)	>140°	25
	100-140°	20
	70-99°	15
	40-69°	10
	<40°	0
Hand Grip (compared to normal side)	Normal	25
	75-90°	20
	50-74°	15
	25-49°	10
	<24°	0
Activity	No limitations	25
	Normal duties, some medication	20
	Light duties due to wrist pain	15
	Unable to work	0
Results	Excellent	90-100
	Good	80-89
	Fair	65-79
	Poor	<65

It is a functional assessment tool originally designed to evaluate outcomes of wrist injuries, particularly DRFs. It combines objective measurements (e.g., range of motion, grip strength) and subjective patient-reported outcomes (e.g., pain, functional limitations) to generate a composite score. While less commonly used today, compared to alternatives, but it provides a comprehensive assessment as it integrates both objective biomechanical parameters (e.g., radial deviation, supination) and subjective patient experiences; providing a holistic view of wrist function. In addition to strongly correlates with radiographic alignment, it is useful in prioritizing anatomical outcomes.

The statistical analysis of data was performed using a recent version of SPSS program, with frequencies and percentages used for categorical variables.

Results

This study included a total of 38 cases, with the majority being males, accounting for 32 cases (84%), while the remaining 6 cases (16%) were females **(Figure 1).**

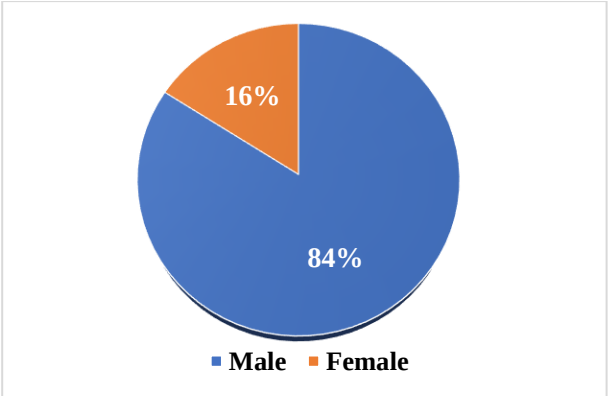

Figure 1: Gender of the presented cases

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The age distribution of the patients showed that 18 cases (47%) fell within the age range of 31-40 years, followed by 10 cases (26%) in the age range of 41-50 years, 6 cases (16%) in the age range of 20-30 years, and 4 cases (11%) over 50 years of age. The mean age of the patients was 32.16 ± 7.46 years, with a mean BMI of 24.7 ± 4.39 kg/m2. Among the cases, 22 (58%) were affected on the right side, while 16 (42%) had fractures on the left side. According to the AO classification, 21 cases (55%) were classified as AO 23C2, and 17 cases (45%) were classified as AO 23C3 (**Table 2**).

Table 2: Detailed information on the included cases

Characteristics	Findings	Frequency (N)	Percentage %
Age (years)	20-30	6	16
	31-40	18	47
	41-50	10	26
	>50	4	11
Affected Side	Left	16	42
	Right	22	58
AO Classification of fracture	AO 23C2	21	55
	AO 23C3	17	45

Falling was found to be the primary cause of fracture, accounting for 32 cases (84%), while 6 cases (16%) were attributed to road traffic accidents (**Table 3**).

Table 3: Causes of injury based on the collected data

Causes	Frequency (N)	Percentage %
Fall down	32	84
RTA	6	16
Total	38	100

Table 4: Time for EX FIX removal with percentage

Variables	Frequency (N)	Percentage %
4 weeks	1	3
6 weeks	8	21
8 weeks	19	50
>8 weeks	10	26
Meantime (weeks)	7.4 ± 10.59	

Among all the cases, postoperative complications were observed in 6 patients, representing a frequency of 15.8%. The most common complication was pin tract infection, which occurred in 3 patients (7.9%). Additionally, 2 cases (5.35%) experienced loss of reduction, and 1 patient (2.6%) sustained tendon or nerve injury **(Figure 2).**

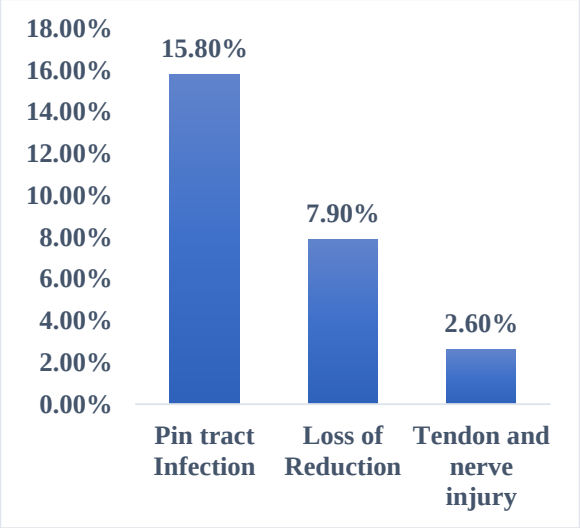

Figure 2: Common Complications after spanning EX. Fix for distal radius

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All patients included in the study exhibited nearly normal values in the radiographic parameters of the distal radius, as indicated in **Table 5.**

Table 5: Postoperative radiological parameter

Postoperative Radiological parameters	Frequency	Percentage %	Mean Value
Radial Height or Length (PA view)			
<11 mm	11	28.9	12.5 ± 2
>11mm	27	71.1	
Radial Inclination (PA view)			
<20	17	44.7	21 ± 3
>20	21	55.3	
Palmar TILT (Lateral View)			
<15	24	63.2	10 ± 3
>15	14	36.8	
Intraarticular Step Off	We tried to keep the step equal to or less than 2mm for all the cases.		

Based on the modified Green and O'Brien clinical rating system, the treatment outcomes were assessed, and the results are summarized in **Table 6**. Among the cases, 21 (55%) were classified as having an excellent result, 11 cases (29%) were rated as good, 4 cases (11%) as fair, and 2 cases (5%) as poor.

Table 6: Outcome assessment using Modified Green and O'Brien score

Modified Green and O'Brien Score	Frequency	Percentage %
Excellent	21	55
Good	11	29
Fair	4	11
Poor	2	5

Discussion

DRFs pose significant challenges in terms of treatment and are commonly encountered by orthopedic surgeons [6]. Surgical management of these fractures can benefit from using ligamentotaxis in conjunction with external fixators as it allows for fracture alignment, preservation of radial length, and adequate reduction under fluoroscopy. However, it is essential to note that achieving anatomical repair of the articular surface may not always be feasible with this approach. Late metaphyseal collapsing and the time required for new bone development to fill the fracture voids can limit the ability to achieve precise anatomical restoration [7]

The current study presented 38 patients with comminuted intraarticular DREs. Most of the patients in this study were males, accounting for 84% (32 cases), with a mean age of 32 years (range 20-50 years). The fractures were classified as AO-23C3 in 17 cases (45%) and AO-23C2 in 21 cases (55%). Falling was identified as the most common cause of fracture, occurring in 32 cases (84%), while road traffic accidents accounted for 6 cases

(16%). Advanced age and severe comminution were identified as predictors of unexpected outcomes in DRFs treated with SEF. The results of this study are compatible with the results of a study made by [8], which reported that most of the patients were males and depended on AO on fracture classification. This study is also congruent with the study of [9]in the sense that the most common cause of DRFs was falling down.

Maintaining radial inclination and volar tilt in the wrist joint is essential, as even minor deviations in these angles can significantly impair wrist flexion and other movements [10]. Research has demonstrated a positive correlation between the preservation of radial height and functional outcomes, with a radial height of 6 mm or less being considered suboptimal [11]. In the present study, 71% of patients achieved a post-treatment radial height of 11 mm or less, which aligns with the desired target in the surgical management of distal radius fractures (DRFs) and is associated with favorable functional outcomes. In contrast, a comparison of functional and radiological outcomes between DRFs treatment, utilizing bone marrow injection combined with ligamentotaxis versus ligamentotaxis alone, revealed that both techniques effectively preserved radial height, radial inclination, and volar tilt throughout the application of the external fixator [12] Moreover, all patients in the current study exhibited distal radius radiographic parameters within or near the normal range, in association with the favorable outcomes recommended in previous studies.

In this study, the average duration of the operation was 15 minutes, ranging from 15 to 25 minutes, which is considered a fast time when compared with the time reported in the study made by Attia et al. (2022)[13]. The external fixator was typically removed after an average of seven weeks, which lasted two weeks more when compared with the results of the study done by Leung et al. (1990)[14]. In the present study, excellent outcomes were observed in 55% of cases, while 29% achieved good results. Additionally, 11% and 5% of cases reported fair and poor outcomes respectively, based on the modified Green and O'Brien score. These results are lower than those reported by Bradway et al. [15], who documented an excellent outcome rate of 65%. However, our study demonstrated a lower percentage of fair and poor outcomes. The variation in scores between studies may be attributed to differences in fracture severity, which could influence treatment outcomes and overall functional recovery.

In cases where the fracture involves the articular or metaphyseal surfaces or is accompanied by significant periarticular damage, external fixation alone may be insufficient to achieve proper alignment of fracture fragments and maintain reduction stability [16]. To address this limitation, Rectenwald et al. [17] demonstrated that the combination of external fixation with Kirschner wires (K-wires) enhances stability and preserves the achieved reduction until bone callus formation. In the present study, K-wire fixation was frequently utilized alongside spanning external fixation to ensure optimal alignment and secure fixation. This approach aligns with the recommendations of

previous studies, supporting its efficacy in managing complex DRFs.

In the present study, postoperative complications were reported in 6 cases (15.8%). Pin tract infection was observed in 3 patients (7.9%), loss of reduction occurred in 2 cases (5.35%), and tendon or nerve injury was noted in 1 case (2.6%). These findings are consistent with previous studies that reported similar complication rates [18,19]. Additionally, long-term patient complaints were primarily associated with intraarticular fragments and osteopenia, which were attributed to prolonged implant use.

A 32-year-old patient experienced a closed comminuted right distal radius fracture following a road traffic accident (RTA). The fracture was managed through closed reduction and external fixation, further reinforced by the addition of K-wires within the spanning external fixation.

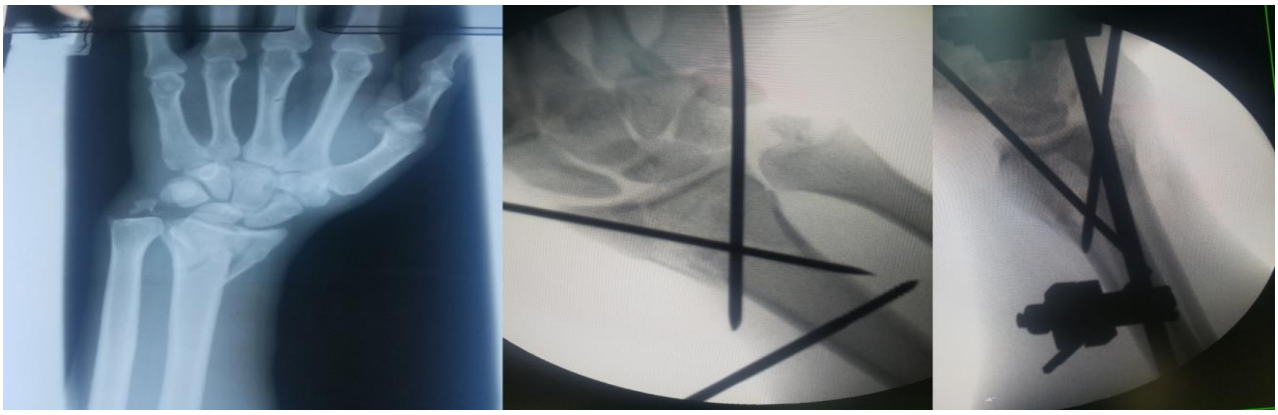

Figure 3: Closed reduction & Ex. Fix. augmented by cross K-wires done by spanning EX. FIX

Similarly, a 48-year-old patient suffered multiple trauma, including a closed comminuted right distal radius fracture due to RTA. The fracture was treated through closed reduction followed by applying spanning external fixation and K-wire.

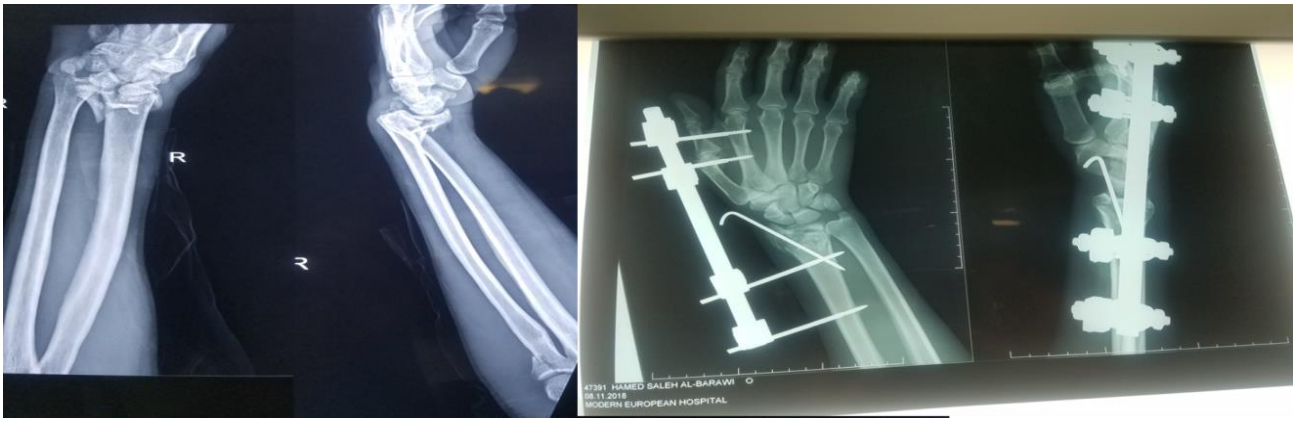

Figure 4: Closed reduction and spanning Ex. Fix. and K-wire

Existing literature indicates that comminuted intraarticular DRFs present significant challenges in achieving articular congruity when managed solely with external fixation [8,20,21] . This limitation arises from the inability of external fixation to function without soft tissue hinges or to restore the volume of compressed cancellous bone. Consequently, supplementary techniques are often required to enhance the effectiveness of external fixation in treating these fractures. These adjunctive approaches may include the use of Kirschner wires (K-wires) [8,22], limited open reduction with or without bone grafting [23] and arthroscopically assisted reduction [24].

Conclusion

SEF is an effective and minimally invasive treatment modality for comminuted distal radius fractures which successfully restores key radiological parameters of the distal radius while providing satisfactory clinical and functional outcomes.

Limitations and Future Directions

This study confirms that SEF is an effective and minimally invasive approach for the treatment of comminuted DRFs, restoring key radiological parameters and providing satisfactory clinical outcomes. However, certain limitations should be acknowledged. First, the relatively small sample size may limit the generalizability of the findings of this study, necessitating larger-scale studies to validate these results. Second, the retrospective study design introduces potential biases in data collection and interpretation. Prospective, randomized controlled trials would provide stronger evidence regarding the efficacy of spanning external fixation compared to other treatment modalities. Additionally, longer follow-up periods are needed to assess long-term functional outcomes and complication rate

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