Fragment Specific Fixation for Intraarticular Fractures of the Distal Radius

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Abstract:

Background: Distal radius fractures in younger patients are most often due to high-energy trauma. For long-term clinical outcomes, open reduction and stable fixationis the preferred treatment option for intraarticular displaced fractures. **Objective**: The present study aimed to evaluate the clinical outcome and radiological results of open reduction internal fixation of intraarticular distal radius fractures using fragment specific fixation principles. **Patients and methods**: This is a prospective clinical study which involved 32 patients recruited from the Police Hospital Nasr City and Beni Suef University Hospital Unilateral for displaced intra- articular fractures of the distal radius in patients with closed physis. plain X ray and DASH score were used for follow-up. **Results**: fragment-specific fixation showed a high rate of union and a good functional outcome on follow-up. **Conclusion**: fragment-specific fixation is a successful approach for intra-articular distal radius fractures.

Keywords: Distal radius fractures, DASH score, fragment-specific fixation.

Abbreviations: range of motion; ROM, Disability of Arm, Shoulder and Hand; DASH

INTRODUCTION:

Distal radius fractures in younger patients are most often due to high-energy trauma, whereas distal radius fractures in the elderly are usually caused by low to moderate-energy trauma with a background of osteopenia or osteoporosis [(1)].

The treatment of distal radius fractures is dependent on a number of factors. Well-known factors influencing treatment selection include fracture morphology and stability, age, hand dominance, and patient comorbidities. Conservative treatment is most effective for non-intraarticular, non comminuted and stable fractures. For long-term clinical outcomes, open reduction and stable fixation is the preferred treatment option for intraarticular displaced fractures.In well-planned and selected patients, fragment-specific fixation is a valuable technique for intra-articular distal radius fractures. It achieves a high rate of union **[(2)].**

Numerous clinical studies have found that volar plating produces better functional results than dorsal plating, external fixation, and percutaneous pinning; however, volar plating has a 15% complication rate, primarily tendon ruptures and tenosynovitis from prominent screws. Precise volar plate placement on the distal radius's metaphyseal area may alleviate flexor tendon irritation and eventual rupture **[(3)].** The present study aimed to evaluate the clinical outcome and radiological results of open reduction internal fixation of intraarticular distal radius fractures using fragment specific fixation principles.

PATIENTS AND METHODS:

This is a prospective clinical study. It was done within 12 months. This study involved 32 patients. recruited from the Police Hospital Nasr City and Beni Suef University Hospital. A Written consent was taken from every participant in the study according to the ethical committee of the faculty of medicine, Beni Suef University, Egypt.

- **Inclusions criteria:**

Unilateral displaced intra- articular fractures of the distal radius in patients with closed physis.

- **Exclusion criteria:**

  Pathological fractures, Pre- existing arthritis compromising wrist function, Open fractures, and Fractures in poly- trauma patients.

OPERATIVE DETAILS

I. Preoperative evaluation

a. **Detailed history:** All patients had a thorough history taken, with special attention paid to the mode of trauma, time of trauma, hand dominance, occupation, any previous surgery, and history of prolonged medical problem.

b. **Complete clinical examinations** including general and local examinations. Evaluation of the influenced extremity's peripheral arterial pulsation was done and identification of any potential radial artery insult. A full neurological examination was conducted.

c. Preoperative routine laboratory investigations included a complete blood count, random blood glucose level, bleeding profile, and liver and kidney function tests for all patient population.

d. **Radiological evaluation:** plain x- ray: antero-posterior (AP), and lateral radiographs. Computed tomography (CT) if indicated.

II. Operative management:

Anesthesia: All patients in the study were given general anesthesia. A prophylactic antibiotic was administered **Position:** All patients are placed in supine position putting the forearm on side table and with turning the forearm in pronation while using the dorsal approach and in supination while using the volar approach.

1. **Tourniquet:** tourniquet had done for all patients. First exsanguinate the limb by applying a soft rubber bandage and then inflate a tourniquet.
2. **Surgical approaches:**

I. The volar approach

The modified Henry approach

The modified Henry approach using the interval between the flexor carpi radialis and radial artery was used when access to the volar distal radial cortex , and sometimes fixation of radial column can be done through the same incision. It was used in 14 cases. The incision is made along the length of the flexor carpi radialis tendon. approximately 7-8 cm long. To maximize release and entry through the tendon sheath floor, the flexor carpi radialis tendon should be fully mobilised and retracted ulnary. The flexor pollicis longus tendon, as well as the flexor digitorum superficialis and profundus tendons, are swept ulnarly using blunt dissection. The best retractors for retraction are reverse or right angle retractors (fig. 1).

Figure (1): The modified Henry approach; isolation and elevation

The pronator quadratus is released along its distal radius radial border and raised ulnarly .A cuff of pronator quadrates may also be left attached to facilitate repair after closure. The brachioradialis tendon inserts along the lateral aspect of the distal radius, deep to the first dorsal compartment, and which released in some cases to remove its deforming influence. Then exposing distal radius fracture fragments, the carpal tunnel can be released through the same incision by identifying and releasing the transverse carpal ligament distally. The FPL tendon is then retracted ulnarly, revealing the deep slip of the transverse carpal ligament for subsequent release.

II. The volar extensile approach

The volar extensile approach incorporated a carpal tunnel release and allowed direct visualization and fracture reduction of the volar –ulnar corner of the distal radius. It was used in 3 cases

- The incision should be placed between Palmaris longus and flexor carpi ulnaris tendons.across the wrist to include a carpal tunnel release incision if needed.The fascia is released between the flexor carpi ulnaris and palmaris longus. expose the volar –ulnar corner of the distal radius and the floor of the carpal tunnel (figure 2).

Figure (2): Volar extensile approach showing plamaris longus, median nerve retracted ulnary and the pronator quadratus muscle over volar ulnar corner of distal radius.

III. The dorsal approach or The trans-EPL approach

The dorsal approach to the distal radius can be used for fracture fixation with a dorsal plate and fragment-specific fixation (especialy dorsal,radial, intraarticular fragments). Approaching the distal radius along its dorsal surface necessitates identification and navigation between the wrist's dorsal compartments. To approach the distal radius dorsally, multiple intervals between the various dorsal extensor compartments may be used.

The trans-EPL approach, also known as the "universal dorsal approach," provides extensile exposure to much of the distal radius's dorsal aspect.it was used in 10 cases
The Trans-EPL Approach
-Lister's tubercle must be identified and marked; a 7-8-cm longitudinal incision was made along the third metacarpal, just ulnar to Lister's tubercle. Raising full thickness skin flaps after dissecting down to the extensor retinaculum. Determine the extensor pollicis longus tendon, which emerges from the extensor retinaculum just distal to Lister's tubercle.

- A full thickness incision was made through the roof of the third dorsal compartment across the extensor retinaculum, Raise the second and fourth compartments subperiosteally in opposite directions to expose the distal radius's dorsal surface.
- The posterior interosseous nerve is located on the proximal floor of the fourth dorsal compartment. dorsal capsular denervation was done in 2 cases, via neurectomized the nerve proximally by excising a 2-cm segment of the nerve. Injury to the scapholunate ligament, which is typically located 1.0-1.5 cm distal to Lister's tubercle, must be avoided.

A radially based ligament sparing dorsal capsular flap can be raised which allow visualization of the radiocarpal and mid-carpal joints (figure 3).

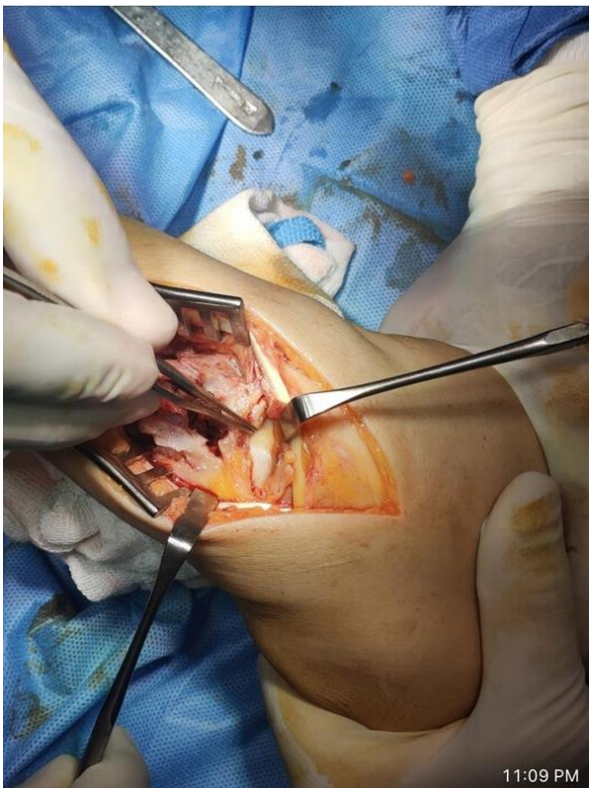

Figure (3): Dorsal approach showing skin incision over the third extensor compartment and the extensor pollicis longus tendon (EPL) is freed and retracted ulnary and the second compartment retracted radially.

IV. **Combined approach** was used in 5 cases

Technique of fragment reduction

By using pointed reduction forceps and K- wires as a joystick and preliminary fixation (figure 4).

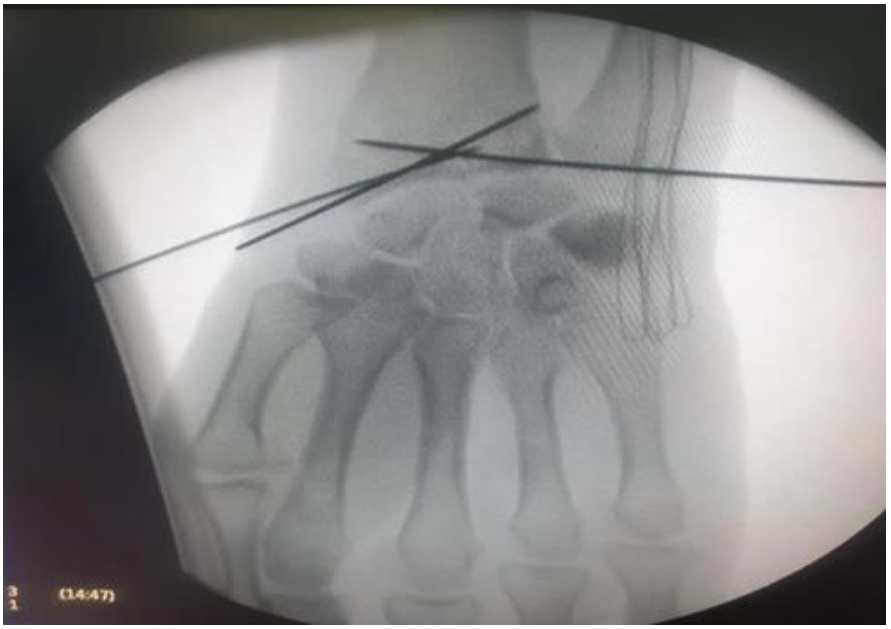

Figure (4): Intra-operative anterio-posterior plain x-ray showing reduction of dorso ulnar fragment by K- wires

Implants 2.4, 2.7 mm locking plates(T,L), 2.4, 2.7 mm locking adaptation plate 2.4, 2.7 mm locking mini condylar plate, 2.4, 2.7 mm variable angle distal radial plate kirschner wire.

Figure (5): 2.4, 2.7 mm locking plates

Fixation of the fracture

After direct reduction of the fragment an appropriate plate is inserted and a cortical screw is inserted through the oblong hole then the most proximal screw is inserted and then the locking screws are inserted into the distal transverse limb (figure 6).

Figure (6): Plate fixation on dorsal lunate fragment

Wound closure: In volar approach, the pronator quadrates placed over plate with every attempt should be made to reattach the horizontal limb of muscle and if possible the radial attachment of muscle should be reattached. In dorsal approach, the second and fourth compartment are sutured back underneath the EPL without any tension, the distal part of tendon sheath is left intact so the tendon still lies in its anatomical position , if a plate has been applied with the EPL lying over it , the v- shaped retinacular flap should be drawn underneath the EPL tendon to prevent contact with plate, leaving the EPL tendon in a subcutaneous position is also acceptable and the skin is then closed. No drains have used (figure 7).

Figure (7): Wound closure; second and fourth compartments are sutured back underneath

the extension pollicis longus tendon (in dorsal approach)

III. Follow up:

Early follow up:

- Posterior resting slap had done for all patients for two weeks. Immediate post operative plain x-ray (anterio posterior and lateral views) had done.
- Fourteen day after surgery sutures are removed.

Late follow up:

- Serial plain x-ray was done for articular congruity, loss of reduction, and fixation, progress in union, and appearance or progression of arthritic changes.
- Wrist range of motion (ROM) score was recorded at 6 weeks, 3 months and 1 year and (Disability of Arm, Shoulder and Hand) score DASH. The items ask about the degree of difficulty in performing different physical activities because of the arm, shoulder, or hand problem (21 items), the severity of each of the symptoms of pain, activity-related pain, tingling, weakness and stiffness (5 items), as well as the problem's impact on social activities, work, sleep, and self-image (4 items). Each item has five response options. The scores for all items are then used to calculate a scale score ranging from 0 (no disability) to 100 (most severe disability).
- Follow up of complications included; loss of reduction, superficial skin infection, tendon rupture, plate removal from dorsal surface, superficial radial nerve injury and dystrophic changes (figure 8).

Figure (8): Primary tendon repair after removal of dorsal plate

Statistical analysis

Microsoft Excel was used to analyze the data. After that, the data was imported into the Statistical Package for the Social Sciences (SPSS version 22.0) software for analysis. The Shapiro Walk test was used to determine whether the data had a normal distribution. Frequencies and relative percentages were used to represent qualitative data. To calculate the difference between two or more groups of qualitative variables, the Chi square test was used. The quantitative data were presented as mean SD. To compare two independent groups of normally distributed variables, the independent samples t-test was used (parametric data). For differences between multiple quantitative independents, ANOVA or Kruskal Wallis was used. P value of ≤ 0.05 was deemed significant.

Results:

Demographic data and Fracture characters are shown in tables 1,2.

Table (1): Demographic data distribution among the studied group(N=32)

	Age		
Mean ± SD	40.5 ± 10.12		
Median (Range)	40.0 (22-59)		
		NO	**%**
Sex	**Male**	23	71.88
	Female	9	28.12
Dominant	**Left**	4	12.5
	Right	28	87.50
Co morbidities	**DM**	5	15.62
	HTN	4	12.50
	Smokers	16	50.0

Table (2): Fracture characters distribution among the studied group(N=32)

		NO	%
Mode of injury	Fell down	6	18.75
	Fell from height (FFH)	4	12.50
	Road traffic accident(RTA)	21	65.63
	Direct trauma	1	3.12
Side of fracture	Left	17	53.13
	Right	15	46.87
AO classification	B1	1	3.12
	B2	3	9.38
	B3	7	21.88
	C1	16	50.0
	C2	5	15.62

Number of plates among the studied group are shown in figure 9.

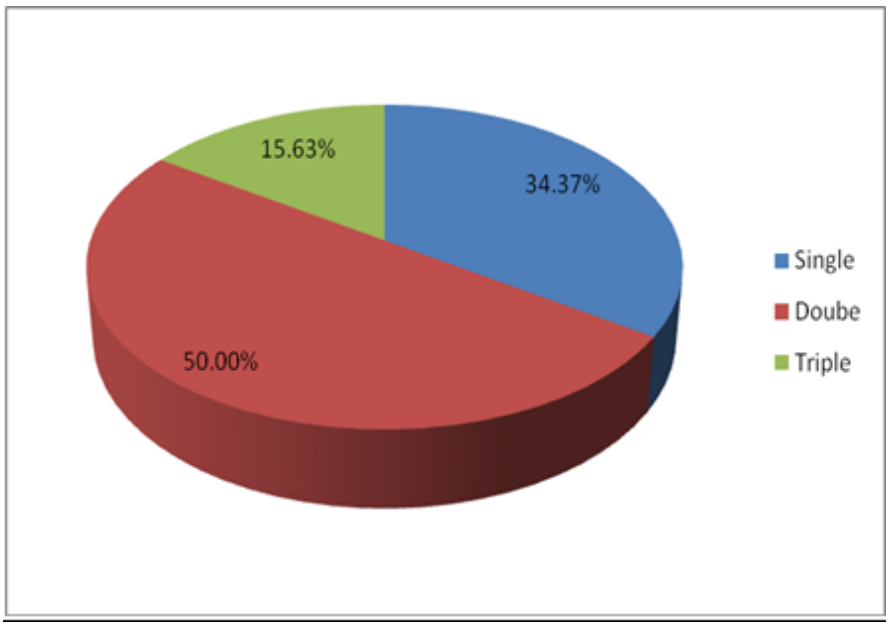

Figure (9): Number of plates among the study group patients

Type of approach among the studied group (N=32), the majority of patients were operated on using a volar approach (53.12%) as in figure 10

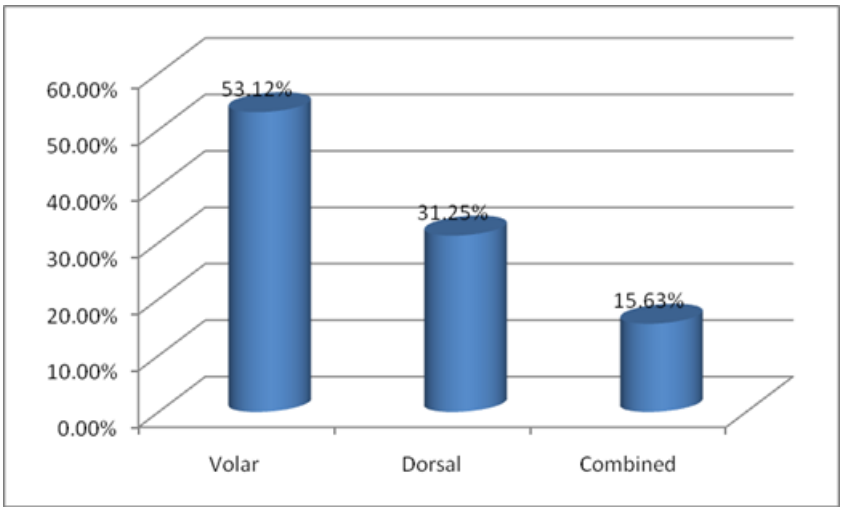

Figure (10): Type of approach among the studied group

Radiological outcome results are shown in table 3

Table (3): Radiological outcome results among the studied group(N=32)

	Radial length	Radial inclination	Volar tilt	Ulnar variance	Time of union
Mean ± SD	(10 ±1.9) mm	(19.4° ±2.8°)	(11° ± 3.4°)	(0.6 ± 1.2) mm	(6-12 weeks) (9.0)

Time of union among the studied group (N=32) as shown in figure 11

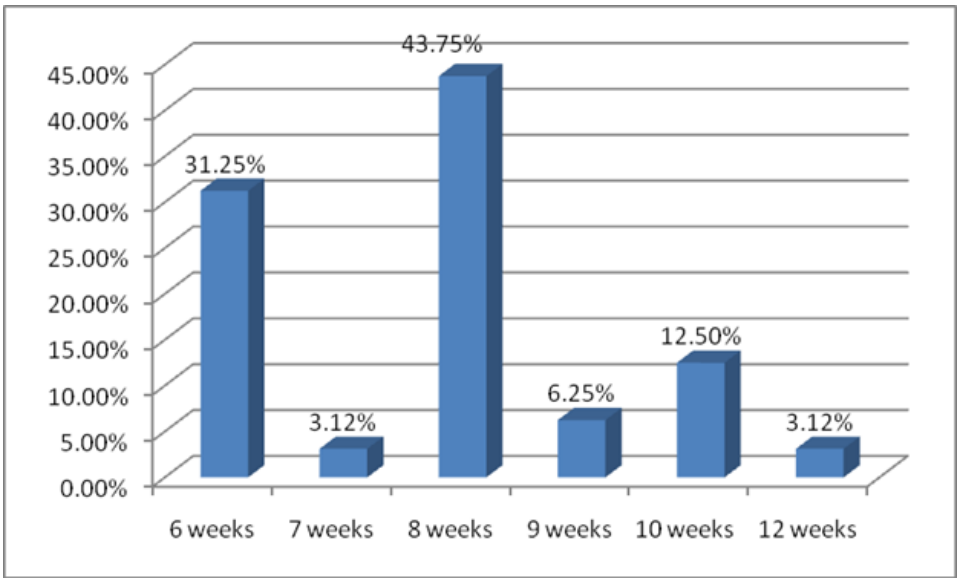

Figure (11): Time of union among the studied group

DASH score at final follow up among the studied group We found a median DASH score of 7.25 (Range: 3–11). AO classification of fractures and corresponding DASH as shown in table 4. ROM distribution at different follow up time is presented in

table 5.

Table (4): AO classification of fractures and corresponding DASHscore among the studied group (N=32)

AO classification	DASH
B1	3
B2	4-10 (6)
B3	3-11 (6.5)
C1	4-9 (7)
C2	4-9 (6.4)

Table (5): ROM distribution at different follow up time among thestudied group (N=32)

ROM	At 6 weeks	At 3 months	At 12 months
Flexion	60(49-72)	68(60-77)	78(66-90)
Extension	61(53-69)	68(60-76)	78(67-90)
Pronation	74(61-88)	75(65-86)	83(76-90)
Supination	71(60-83)	74(63-85)	78(68-88)
Ulnar deviation	25(20-31)	33(27-40)	34(29-40)
Radial deviation	13(10-17)	15(13-18)	17(14-20)

Complications were recorded in (5/32) (15.62 %) of patients as in figure 12

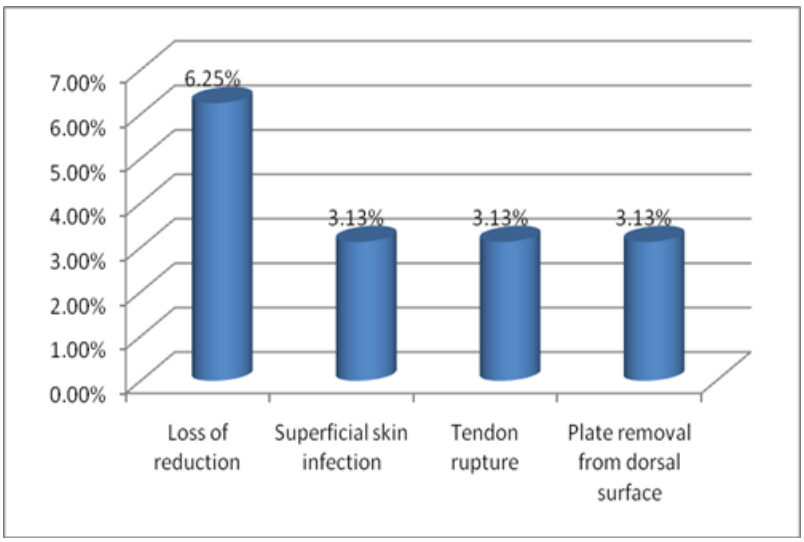

Figure (12): Complications distribution among the studied group

Discussion

The primary goal of treating intra-articular radius fractures is to restore anatomy through the use of a stable fixation mechanism. As part of this procedure, all step-off and gap distances must be minimized to the greatest extent possible. Conventionally, these fractures had been treated with closed reduction and casting. Even so, due to recent technological advances and emerging preferences for anatomic reduction and absolute stability, open reduction and plating are being

preferred as a treatment choice (4).

The current study aimed to evaluate the clinical outcome and radiological results of open reduction internal fixation of intra-articular distal radius fractures using fragment specific fixation principles which provides the surgeon a versatile and biomechanically stable system to successfully treat complex intra-articular distal radius fractures with availability to fix fractures which cannot be stabilized with the standard single plating and gives the mechanical advantage of multi-planer fixation.

In our study; the mean age of patients was (40.5 ± 10.12) with minimum 40 and maximum 59 years. Khalil et al.(2)study showed that age was distributed as (39.5 ± 9.17) with minimum 23 and maximum 56 years. The mean age was (70.9 ± 8.9) years in the study of Chung et al.(5).

Results of the present study showed that the majority of patients were males (71.88%) while females represented (28.12%) of patients. In the study of Khalil et al.(2)males were (61.1%) and females were (38.9%). While in the study of Chung et al.(5), [86.7%] was women. In the study of Phadnis et al.(6); (73%) were females and (27%) were males.

Results of the present study showed that (78.12 %) of patients had co-morbidity, 15.62% had DM, 12.5% had HTN and 50% were smoker. Khalil et al.(2) study showed that (16.7%) had DM, (5.6%) had HTN and (38.9%) were smokers.

Regarding the cause of injury in our study, (65.63%) of injuries was caused by RTA. Road traffic accident was the mode of injury in (66.7%) of patients while low energy fall was recorded for (33.3%) patients in Kumar et al.(4)study. Also, in the study of Khalil et al.(2); the majority of injuries were caused by RTA (66.7%).

Results of the present study showed that (46.87%) of injuries were right sided and (53.13%) were left sided. In the study of Kasapinova and Kamiloski(7); (42.2%) were right side injured and (57.8%) were left side injured. In the study of Kumar et al.(4); (63.3%) were left side injured.

In our study; right and left sides were distributed evenly as well as dominant affection. In the study of Khalil et al.(2); right and left sides were distributed evenly as well as dominant affection.

Results of the present study showed that AO classification were B1 (3.12%); B2 (9.38%); B3 (21.88%); C1 (50.0%) and C2 (15.62%). According to the AO classification of distal radius fractures in the study of Khalil et al.(2), 50% of patients had type B fractures, while 38.9% of patients had C1 fractures, and 11.1% of patients had type C2.. Based on AO classification, there were (33.1%) type A, (22.1%) type B and (44.9%) type C fractures in the study of Zhu et al.(8). All patients had type C fractures in the study of Jia et al.(9).

Results of the present study showed that (53.12%) were operated on using a volar approach; (31.25%) with dorsal approach and (15.63%) with combined approach).In total, 105 consecutive patients were enrolled in the study of Gavaskar et al.(10)the majority of patients were operated on using a volar approach (90, volar approach; 11, dorsal approach; 4, combined approach).

Radiological outcome results in our study showed that the mean radial length was (10 ±1.9) mm; radial inclination, (19.4° ±2.8°); volar tilt, (11° ± 3.4°); and ulnar variance, (0.6 ± 1.2) mm; the mean time of union was (9.0 weeks).Union was achieved in all patients in the study of Gavaskar et al.(10). In the immediate post-operative radiographs, the mean radial length was 10 (SD 1.9) mm; radial inclination, 19.4° (SD 2.8°); volar tilt, 7.4° (SD 3.4°); and ulnar variance, 0.6 (SD 1.2) mm.

At the end of the follow-up of patients in the study of Jia et al.(9)the mean radial height was 10.5 mm (ranging from 8.1 to 12.6 mm), mean volar tilt angle was 9.28° (ranging from 5.7° to 12.8°) and mean radial inclination angle was 23.02° (ranging from 19.5° to 29.3°).

The mean volar tilt was 8.6°±5.2° (range, 0 to 17°), mean radial inclination was 21.1°±4.7° (range, 12° to 29°), mean ulnar variance was 0.9±1.6 (range, -3 to 3) mm, mean radial height was 10.5±3.3 (7 to 18) mm, no reduction loss was observed after fixation in Kibar(11)study.

Results of the present study showed that complications were recorded in (15.62 %) of patients; loss of reduction was seen in (6.25%); ; (3.125%) had superficial skin infection managed by antibiotic and daily dressing; (3.125%) case of tendon rupture managed by plate removal and primary tendon repair ;(3.125%) case of plate removal from dorsal surface. In the study of Khalil et al.(2), the overall complicated cases were 6 cases with 16.7%.

Loss of reduction was seen in (5.1%) of patients in Gavaskar et al.(10) study. There were unaddressed dorsal comminution in four cases, and one patient had volar carpal subluxation. In the study of Phadnis et al.(6); 27 patients (15%) suffered a postoperative complication; 11 patients (6%) sustained a major complication, defined as deep infection, tendon rupture, acute carpal tunnel syndrome and chronic regional pain syndrome. Two patients developed persistent tingling in the median nerve distribution post operatively.

In Thorninger et al.(12); the overall complication rate was (14.6%); including carpal tunnel syndrome or change in sensibility in 5.2% and tendon complications in 4.7%. The complications recorded in the study of Zhu et al.(8)were wound infection (4.0%) was most common, followed in decreasing frequency by carpal tunnel syndrome (3.1%), tendon rupture/irritation (2.4%), complex regional pain syndrome (1.9%), and plate/screw-related complications (1.7%).

In our study; the mean DASH score at the last follow up was (7.25) ranged from (3-11). A score between 0 and 10 can be considered to be a very good result, and means a return to pre-fracture function (13).The median DASH score for all patients in the study of Phadnis et al.(6)was 2.3 (IQR 0- 6.4). The mean DASH score was 16.25 (ranging from 11 to 21) in Jia et al.(9)study. The mean DASH score was (10±9) in the study of Kibar(11).

Results of the present study showed that the mean flexion was 60° at 6 weeks ; 68° at 3 months and 78° at 12 months. The mean extension was 61° at 6 weeks; 68° at 3 months and 78° at 12 months. The mean pronation was 74° at 6 weeks; 75° at 3 months and 83° at 12 months. The mean supination was 71° at 6 weeks; 74° at 3 months and 78° at 12 months. The mean ulnar deviation was 25° at 6 weeks; 33° at 3 months and 34° at 12 months. The mean radial deviation was 13° at 6 weeks; 15° at 3 months and 17° at 12 months.

The mean dorsiflexion ROM was 77.1° (ranging from 59° to 83°), and the mean volar flexion ROM was 76.5° (ranging from 62° to 81°). The average ROM of ulnar deviation angle was 21.4° (ranging from 15° to 28°), the average ROM of radial deviation angle was 17.5° (ranging from 12° to 23°) in Jia et al.(9)study.

This study had some limitations. To begin, the small group of patients included those with intraarticular distal radius fractures. Secondly; the massive price of fragment-specific plates and their scarcity. Finally, some patients were uncooperative and did not understand the significance of fixation method, follow-up. The factor that reduced the total number of cases has been included.

Conclusion

In well-planned and chosen patient populations, fragment-specific fixation is a successful approach for intra-articular distal radius fractures with a high rate of union and a good functional outcome on follow-up.

Recommendations

Additional research should be conducted with bigger populations of patients, with longer post - operative follow-up times and more accessibility of fragment-specific plates, which are needed for long-term outcomes and to verify the findings from this research.

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