

Fragment specific fixation of distal radius fracture

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Abstract-

Purpose:

To assess the clinical, radiographic and functional outcome of treating intraarticular distal radius fractures with fragment specific fixation and to study various complications associated with fragment specific approach.

Methodology: We conducted a prospective study from November 2018 to December 2020 on 15 patients. The radiographic goals to be achieved in the reconstruction of DRFs include radial shortening ,5 mm, radial inclination .15°, radiocarpal intra-articular step-off or gap ,2 mm, sigmoid notch incongruity ,2 mm, and less than 15° dorsal tilt.

Results:

6 patients were classified as 2R3C3 using AO/OTA classification, 5 patients were 2R3B3, 2 patients were 2R3B2, while 1 in each 2R3B1, and 2R3C1, while none of the patient fell down in 2R3C2.

However, mean volar tilt in the study comes down to 7.26 degrees when all the study subjects were included. In patients with volar rim, and radial column involvement, 8 patients were classified as excellent, while 1 had good score. Only 4 patients had residual dorsal tilt, none of the patients had prominence of ulnar styloid and radial deviation of hand.

Conclusion:

Encouraged by these advantages, we undertook this study to look for clear advantages and disadvantages of Fragment specific approach over the prevailing modalities of treatment for fracture distal end radius as described by Medoff and combined it with the concept of double-column fixation to achieve a stable result that would allow early wrist motion.

Keywords- Intra-articular, comminuted, bicolunar, LCP plates, osteoporotic bones.

INTRODUCTION

Distal radius fractures account for 15-20% of all fractures treated in the emergency room^{1,2} and are common in young adults, after 60 years, and postmenopausal women³. Displaced intra-articular fractures of the distal radius are a unique subset of these fractures and are usually a high-energy impaction injury resulting in a comminuted fracture pattern^{1,2}. The clinical objectives of treatment include restoration of distal radius configuration through anatomic stable reduction, restoration of articular congruity of radio-carpal and distal radio-ulnar joints, and reduction through stable fixation and early active rehabilitation. Surgery is mandatory in young, active, or high demand patients who have high expectations of regaining their normal activities. Open reduction and internal fixation by volar and dorsal plates have long been used to treat distal radius fractures, but their limitations have led to the development of newer surgical modalities^{4,5}.

Rikli and Reggazoni⁶ introduced the "3 column concept" for wrist in 1996, which proposes the bicolunar fixation of radial and intermediate column fractures by plating. Fragment specific fixation, introduced by Medoff and Kopyloff in 1998, helps in achieving anatomic reduction and biomechanical stability with easier and early rehabilitation. Fixation of these fragments is done using various low profile implants, including Fragment specific plates, T buttress plates, LCP plates and K-wires.

Fragment specific fixation allows for early mobilization, reduced soft tissue complications, and improved fixation strength in osteoporotic bones. This study looked for clear advantages and disadvantages of Fragment specific approach over the prevailing modalities of treatment for fracture distal end radius.

MATERIALS AND METHODS

This prospective study was carried out in the branch of Orthopaedics surgery, JNMCH, AMU, Aligarh. It protected the sufferers presenting to Orthopedics OPD & Emergency of JNMCH having Fracture Distal End Radius among November 2018 to December 2020.

Inclusion Criteria

AO/OTA type B & type C fractures fulfilling any of the following criteria and presenting within 3 week duration of injury:

1. Radial height <5mm
2. Radial inclination <15°
3. Dorsal tilt >10°
4. Intra articular step off distance >2mm.

Exclusion Criteria

Patients of fracture distal end radius

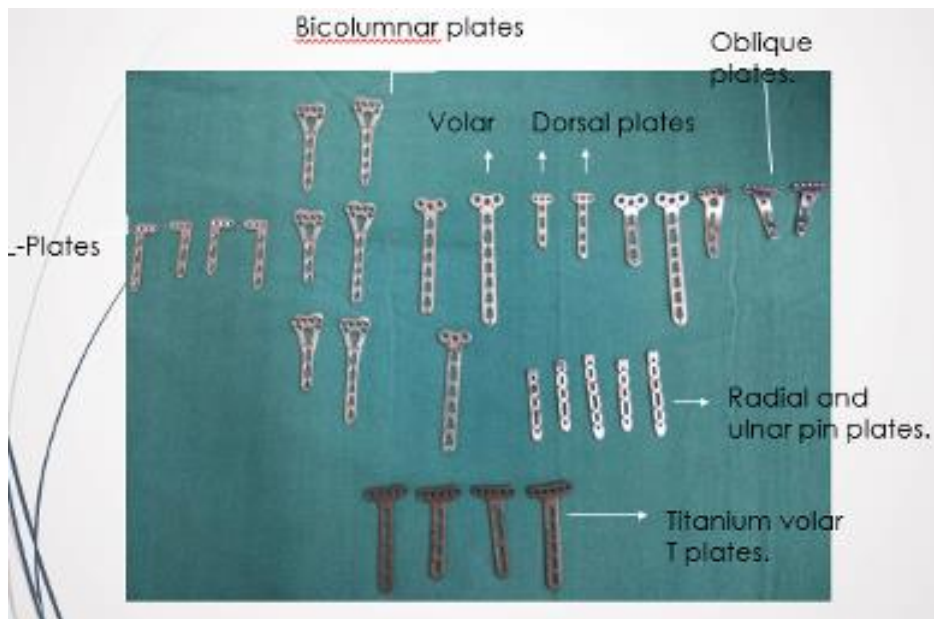
1. AO/OTA fractures type A
2. Pathological Fractures
3. Fractures not fulfilling the criteria.
4. Fractures >3 weeks duration.

PRE-OPERATIVE EVALUATION

- Standard antero-posterior and lateral radiographs of injured wrist
- Oblique radiographs of wrist.
- CT scan of wrist with 3 D reconstruction.

IMPLANTS

- Volar fragment was fixed using 2.4mm dual column variable angle plate/L-plate/Titanium T plate/simple volar LCP plate.
- Radial fragment was fixed using 2.0mm radial pin plate/K-wire.
- Dorso ulnar corner fragment was stabilized using 2.4mmDorsal –LCP



POST-OP RADIOGRAPHS SHOWING VARIOUS IMPLANT



Goals of Surgical Treatment

The radiographic goals to be achieved in the reconstruction of DRFs include radial shortening ,5 mm, radial inclination .15°, radiocarpal intra-articular step-off or gap ,2 mm, sigmoid notch incongruity ,2 mm, and less than 15° dorsal tilt.

Radial Column

Reconstructing the radial column requires restoring the radial height and inclination and obtaining articular congruity with the intermediate column.

Intermediate Column

Restoration of the volar tilt and articular congruity of the lunate facet and sigmoid notch is essential for satisfactory functional outcomes, as progressive dorsal collapse and an unstable DUC or dorsal wall fragment can lead to dorsal carpal translation and/or an incongruous DRUJ. Palmar instability of a displaced volar rim fragment can also lead to volar carpal translation.

Ulnar Column

The ulnar column serves as the rotational center of axial motion of the wrist⁷. Failure to address unstable concomitant injuries of the ulnar column may lead to loss of forearm supination, instability of the DRUJ, and persistent ulnar sided wrist pain.

Pedestal

Providing a stable foundation for the radial and intermediate columns is the primary goal in the reconstruction of the pedestal. Restoration of the length and alignment of the radial meta-diaphysis is essential, particularly in patients with an intact distal ulna, to prevent symptomatic ulnocarpal impaction or instability of the DRUJ.

Algorithm for Reconstruction of Multifragmentary Fractures

Sequence of Wrist Reconstruction

Reconstruction of a multifragmentary DRF consists of anatomic reduction and fixation of the intermediate column to the pedestal, followed by restoration of the radial column and, if necessary, management of any ulnar column injuries to restore stability of the DRUJ.

SURGICAL APPROACH

1. MODIFIED HENRY APPROACH



Skin incision is made along the Radial Border of Flexor carpi Radialis tendon.



The incision is deepened between flexor carpi radialis and the radial artery, exposing the pronator quadratus muscle.



The Pronator quadratus muscle is elevated using an L-shaped incision and the fracture is exposed.





The fracture is reduced under C-arm guidance and fixed with a plate.

DORSAL APPROACH

The third compartment of the extensor retinaculum is opened in line with the EPL tendon, the EPL tendon is mobilized and the fourth compartment is elevated subperiostally leaving the compartment itself intact, exposing the fracture.



POST-OP CARE

All patients were given Below elbow slabs/elbow pouch post operatively for 2 weeks. Strict limb elevation was maintained in all patients post operatively. In the immediate post-operative period, adequate pain relief was given.

Post op xray was done on post op day1.

Gradual active wrist motion were begun at 3rd week post operatively.

Follow UP

Follow up Interval:

At 4 weeks interval for the first 6 months.

At 6 weeks interval for the next 3 months.

At 3 months interval till final follow up.

At each follow up

- Clinical -radiological fracture healing was assessed
- Radiological morphometric parameters analysis namely volar tilt , Radial inclination, Radial height and intra articular step off were measured.
- Clinical parameters.... As defined in the scoring system
- Complications.

OUTCOME ASSESSMENT

Outcome was assessed using modified Gartland and werley scoring system.

Modified gartland and werley criteria	
Residual deformity(0-3)	
Prominent ulnar styloid	1
Residual dorsal tilt	2
Radial deviation of hand	2 or 3
Subjective evaluation(0-6)	
Excellent: no pain, disability, or limitation of motion	0
Good: occasional pain, slight limitation of motion, and no disability	2
Fair: occasional pain, some limitation of motion, feeling of weakness in wrist, no particular disability if careful and activities slightly restricted	4
Poor: pain, limitation of motions, disability, and activities more or less markedly restricted	6
Objective evaluation(0-5)	
Loss of dorsiflexion	5
Loss of ulnar deviation	3
Loss of supination	2
Loss of palmar flexion	1
Loss of radial deviation	1
Loss of circumduction	1
Pain in distal radio ulnar joint	1
Grip strength 60 % or less than the opposite site	1
Loss of pronation	1

Modified gartland and werley criteria	
Complications(0-5)	
Arthritic changes	
minimum	1
Minimum with pain	3
Moderate	2
Moderate with pain	4
Severe	3
Severe with pain	5
Nerve complication (median)	1-3
Poor finger function due to cast	1 or 2
Final results(Ranges of points)	
Excellent	0-2
Good	3-8
Fair	9-20
Poor	>=20

RESULTS AND OBSERVATIONS

This prospective study was carried out at J.N.Medical College & Hospital,AMU,Aligarh from November2018 to December 2020.There were 15 patients with AO Type B and Type C distal radius fractures who were treated operatively.

1. Age Distribution

In the present study, 40% of patients were in age group of 18-30 years, 40 % of patients were in age group 31-45 years, 13% patients were in 40-60 years age group, and 7% of patients fall in >60 years of age. Mean age was 38.1 ± 13.6 (18-62) years.

2. Gender Distribution

Table 1: Distribution of gender of study population

Gender	Frequency	Percentage
Male	14	93 %
Female	1	7 %

In the present study 93% of the patients were male and 7 % were females.

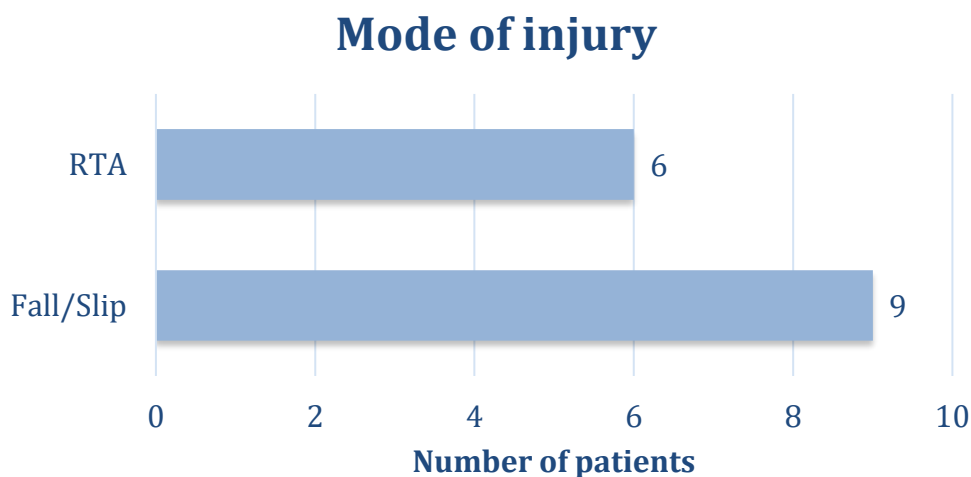
3. Side Distribution

Table 2 : Distribution of side of study population:

Side	Frequency	Percentage
Right	7	47 %
Left	8	53 %

In the present study, 53% patients were involved of left wrist, while 47% had involvement of right wrist. All the patients included in the study were right hand dominant.

3. Mode of Injury

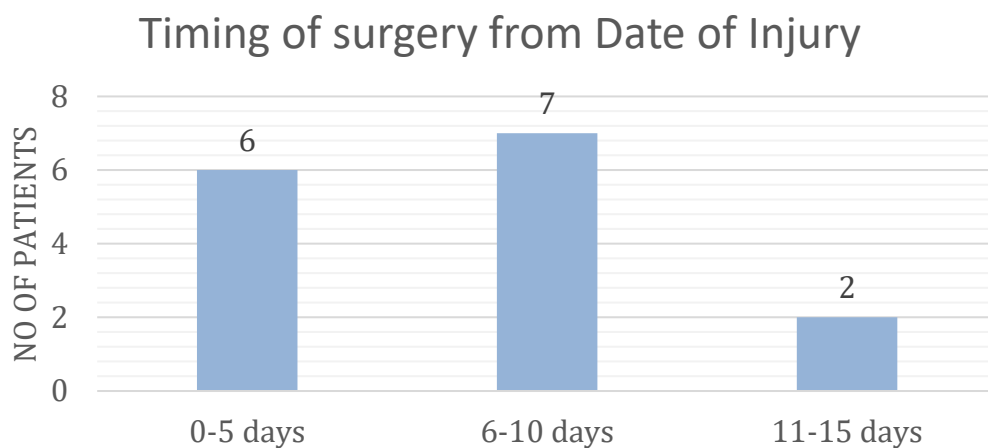


In the present study, 60% of the patients sustained injury due to RTA, while 40% of patient sustained injury due to fall/ slip.

4. Time to Surgery

Table 3: Time to Surgery:

Variable	Mean \pm SD	Min-Max (days)
Duration of injury (days)	7.6 \pm 3.0	3-14

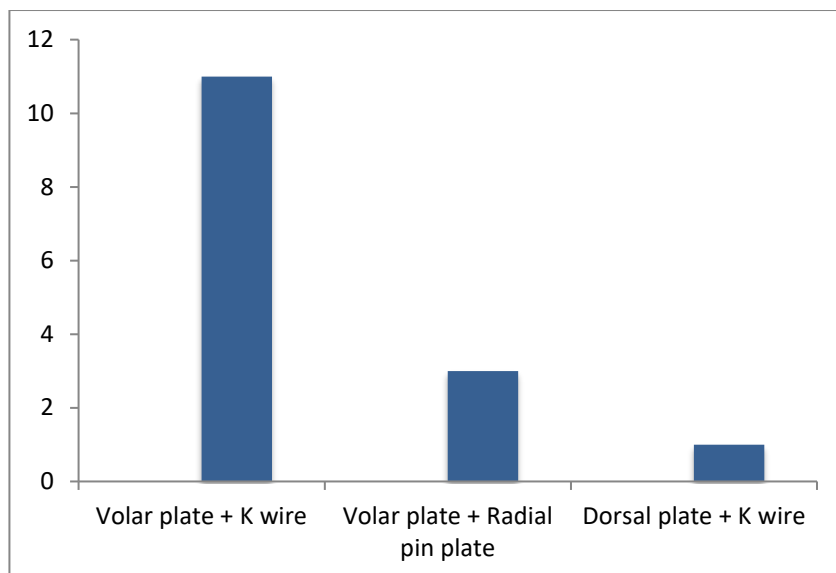


In the present study, 6 patients(40%) were operated within 5 days of injury, 7 patients (46.7%) were operated within 6 to 10 days, and 2 patients(13%) were operated after 10 days.

5. Implants used

Table 4: Implants used

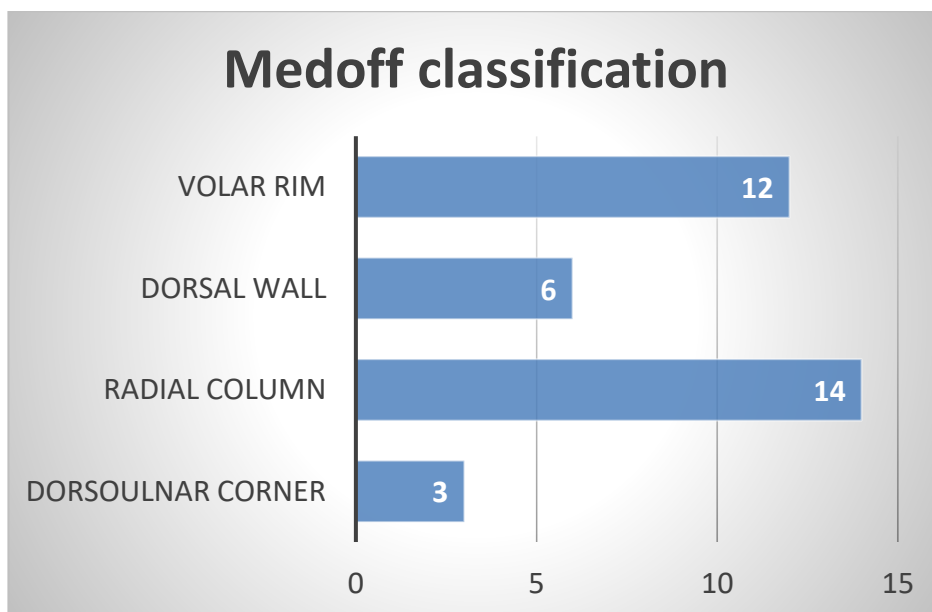
Type of implant	No. Of patients
1. Volar plate + k wires	11
2. Volar plate + Radial pin plate	3
3. Dorsal plate + k wires	1



Most common combination of implant in our study was ‘volar plate with k wire’ in 11 patients (73%) followed by ‘volar plate with radial pin plate’ in 3 patients(20%).Only 1 patient was operated by dorsal approach in our study and dorsal plate with k wire was done.

6. Medoff classification

Table 5: Distribution of subjects based on Medoff classification:



12 patients had involvement of volar rim, 6 patients had involvement of dorsal wall, 14 patients had involvement of radial column and only 3 patients had involvement of dorsoulnar corner. Most common fragment involved was radial column followed by volar rim.

3. AO/OTA Classification

Table 6: Distribution of study subjects based on AO/OTA classification system:

AO/OTA Classification		Number of Patients
2R3B	B1	1
	B2	2

	B3	5
2R3C	C1	1
	C2	0
	C3	6

6 patients were classified as 2R3C3 using AO/OTA classification, 5 patients were 2R3B3, 2 patients were 2R3B2, while 1 in each 2R3B1, and 2R3C1, while none of the patient fell down in 2R3C2.

Table 7: Outcome assessment in study subjects based on Medoff classification:

		RESULT		Total
		Excellent	Good	
Medoff Classification	1,2	8	1	9
	1,2,3	1		1
	1,2,3,4	2		2
	2,3	1	1	2
	3,4	1		1
Total		13	2	15

- 1- Volar Rim
- 3- Dorsal wall

- 2-Radial column
- 4- Dorsal ulnar corner

In patients with volar rim, and radial column involvement, 8 patients were classified as excellent, while 1 had good score. One patient who had involvement of volar rim, radial column, and dorsal wall had excellent score, 2 patients had involvement of volar rim, radial column, dorsal wall, and dorsoulnar column were classified as excellent, and in patients with radial column and dorsal wall involvement, 1 patient each had excellent and good results, 1 patient had involvement of dorsal wall and dorsoulnar corner involvement had excellent result.

Table 8: Outcome assessment based on AO/ OTA scores:

AO/OTA Classification	RESULT		Total
	Excellent	Good	

2R3B	B1	1	0	1
	B2	1	1	2
	B3	4	1	5
2R3C	C1	1	0	1
	C2			
	C3	6	0	6
Total		13	2	15

DISCUSSION

This study was a prospective study on 15 patients with AO type B and AO type C distal radius fracture, where we determined the clinico-radiological and functional outcomes and various complications associated with fragment specific fixation. All the patients were followed up for a mean period of 21 months (Ranging from 11-26.5 months).

In this study we applied the concept of fracture fragment identification as stipulated by Medoff and combined it with the concept of double column fixation using Kirschner wire and low profile fragment plates as implants to achieve stable fixation to allow early wrist motion.

1. Age incidence:

Table 9: Age Distribution in Various Studies

Study	No. of Patients	Mean age (in years)
1. Ejajahmed et al ⁸ (2018)	25	39 years (20-60 years)
2. Benson et al ¹⁰ (2006)	81	50 years (17-79 years)
3. Saw et al ¹¹ (2008)	21	32.3 years (18-58 years)
4. Chang et al ¹² (2007)	28	46 years (25-74 years)
5. Gavaskar et al ⁹ (2011)	105	43 years (22-68 years)
6. Our study	15	38.1 years (18-62 years)

In our study 80% of the patients were below the age of 45 years with mean age of 38.1 years ranging from 18 to 62 years. Similar findings were noted in the study done by Ejaj et al.,⁸ and Gavaskar et al.⁹ This age group is more vulnerable to road traffic accident.

Table 10: Mode of injury

Study	No. of Patients	Fall from height / slip	Road Traffic Accidents
1. Saw et al ¹¹ (2008)	21	9	12
2. Babikir et al ¹³ (2017)	25	13	12
3. Gavaskar et al ⁹ (2011)	105	82	23
4. Chang et al ¹² (2007)	28	21	8

5. Our study	15	6	9
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In our study 60% of the patients sustained injury due to fall from height, while rest due to road traffic accident. Similar findings were observed in studies done by Gavaskar et al.,⁹ Babikir et al.,¹³ and Chang et al¹².

Table 11: Time to surgery from injury (in days)

Study	No. of patients	Time of surgery from injury (in days)
1. Benson et al ⁹ (2006)	81	9 (3-15)
2. Saw et al ¹⁰ (2008)	24	14 (5-24)
3. Chang et al ¹¹ (2007)	28	5.78
4. Gavaskar et al ⁸ (2011)	105	7.2 (2-16)
5. Our study	15	7.6 (3-14)

Mean time from injury to surgery was 7.6 days ranging from 3 to 14 days. Similar findings were observed in the studies done by Benson et al.,¹⁰ Saw et al.,¹¹ Chang et al.,¹² Gavaskar et al.⁹ Delay in surgery can be attributed to long waiting list and limited operation theatre, especially during covid pandemic.

Table 12: Time to union (in weeks)

Study	No. of patients	Time for union (in weeks)
1. Jakob et al ¹⁴ (2000)	73	7.6 (6-8)
2. Gavaskar et al ⁹ (2011)	105	9.2
3. Chang et al ¹² (2007)	28	8.4
4. Saw et al ¹¹ (2008)	24	9
5. Our study	15	9.4 (8-12)

Union was achieved in all the patients at mean duration of 9.4 weeks (8-12 weeks). This duration is consistent with the observation of other studies conducted by Gavaskar et al.,⁹ Chang et al.,¹² Saw et al.,¹¹ and other studies.

Table13: Range of motion

Study	Palmar flexion	Dorsiflexion	Supination	Pronation	Radial deviation	Ulnar deviation
Martinez et al ¹⁵ (2004)	60	67	90	90	23	34
Ejaj Ahmad et al ⁸ (2018)	74.6	80.2	87	86.6	10.6	25
Chang et al ¹² (2007)	61	54	85	83	28	15
Our study	74.3	70.0	73.33	73.67	16	24.4

In our study, mean palmar flexion was 74.3 degrees (60⁰-80⁰). Mean dorsiflexion was 70.3 degrees (60⁰-84⁰). Mean radial deviation was 16 degrees (10⁰-18⁰). Mean ulnar deviation was 24.4 degrees (16⁰-32⁰). Mean pronation was 73.7 degrees (70⁰-80⁰). Mean supination was 73.3 degrees (70⁰-80⁰).

Our observation was similar to Ejaj ahmad et al.⁸ Good functional outcome in our study may be attributed to early initiation of physiotherapy under supervision. Meticulous technique in securing an anatomic reduction and stable fixation leads to good functional outcomes.

Complications:

None of the patients in our study developed superficial or deep infection following surgery.

1. Intra-articular screw penetration

One patient had intra articular screw penetration but the patient did not have any pain and limitation in range of motion.

2. Painful hardware

Prominent dorsal tip of cortical screws causing persistent discomfort and extensor tendon irritation was observed in our study. Although none of our patients sustained extensor tendon rupture, it is clear that the distal tip of the self tapping cortical screw can be a source of persistent discomfort and potentially cause a tendon rupture over a time, for the same reason one patient in our series required hardware removal.

This complication can likely be improved by attending to the details of screw length selection. The screws in the distal rows of the volar plates should be unicortical and the proximal screws should be sized correctly to prevent dorsal soft tissue irritation. Four patients required hardware removal for extensor tendinitis in the study conducted by Maurene et al.¹⁶ 5 cases of extensor tendinitis were reported by Saw et al and 8 cases of tendinitis(6 flexors and 2 extensors) were reported by Gavaskar et al.⁹

No incidence of flexor tendinitis is reported in our study.

3. Neurological complications; Superficial radial sensory nerve paresthesia in the skin overlying the thumb, radial styloid and Carpometacarpal region. None of these complaints required subsequent surgical exploration, the affected area was typically a few centimeters in diameter near the base of the thumb, we do however now routinely explained to the patients that swelling or intraoperative tractions may produce temporary numbness or discomfort in this area.

The incidence of radial sensory nerve paresthesia in open reduction of distal radius fracture has been reported to be as high as 28%, majority of which resolves within 3 months after the procedure.

Bensen et al reported sensory numbness in 10 patients. No incidence of complex regional pain syndrome, carpal tunnel syndrome was reported in our study.

Summary and conclusion:

Present study aimed to evaluate the outcome of AO type B and C distal radius fractures. This was a prospective study including 15 patients with the age of patients ranging from 18-62 years (mean age 39.1years) conducted from November 2018 to November 2020 with a mean follow up of 21 months (Range:11-26.5 months).Patients were evaluated using set proforma, clinic-radiological and functional outcome assessment was done using Modified Gartland and werley scoring system.

The incidence of distal radius fracture was more common in males (94%).Fall from height (60%) was the most common mode of injury followed by Road traffic accidents (40%), Dominant hand was involved in 47%patients. Mean duration from date of injury to surgery was 7.6 days. Type B fractures (53%) were more common than type C(47%) fractures.

Most common fragment involved in our study was Radial column followed by Volar rim. 14 patients were operated using modified henry's approach and 1 patient was operated using dorsal approach. Union was achieved in all patients at a mean duration of 9.47 weeks.

Radiological parameters were restored in all patients. According to modified gartland and werley score, excellent results were achieved in 13 patients and good results in 2 patients.

Complications observed in our study were intra articular penetration of screw in 1 patient, extensor tendon irritation in 1 patient, Radial sensory paraesthesia in 2 patients and residual dorsal tilt in 4(26.7%) patients.

Our experience with fragment specific fixation suggests that not only can precise articular relationships be restored and maintained but also early wrist motion can be pursued with little risk to the fracture reduction or soft tissue integrity.

EXHIBITS

CASE NO. 1

40 y / M with AO type C3 fracture left distal radius. (Fragments : volar rim and radial styloid)

PROCEDURE : ORIF with 2.4 mm bicolumnar variable angle plate for volar rim and 2.0 mm radial pin plate for radial styloid



Pre-op Radiograph



Pre-op CT scan



Post-op radiograph



Final follow-up

Outcome according to Gartland & Werley - EXCELLENT

CLINICAL PHOTOGRAPHS:



CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

As per international standard or university standard, written approval of Ethics committee has been collected and preserved by the author(s).

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