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A short term prospective study of the functional outcome of comminuted displaced intra-articular fracture of the distal radius treated with volar locking compression plate

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Abstract
Distal radius fracture accounts for approximately 17% of all fractures. More than half of these fractures are intra-articular and associated with Distal Radio Ulnar Joint (DRUJ) injuries. Several treatment modalities have been described like plaster cast, external fixation and open reduction and internal fixation with plate osteosynthesis. Superiority of open reduction and internal fixation with plate osteosynthesis has been established well, as it provide angular stability and allow for early mobilization, thereby achieving early functional recovery. In this prospective study, done over a period of 36 months and with a minimal follow-up of at least 12 months, we were able to recruit 56 patients conforming to our inclusion criteria. We had followed the Melone Classification and had operated all cases using the Ellis approach with distal radius volar side specific locking compression plates. We had evaluated the functional outcome of wrist function using the Demerit point system of Gartland and Werley at the end of 12 months of follow-up. Our study concluded that ORIF is an effective surgical management protocol for unstable intra-articular distal radius fracture. In our short term study the overall complication rate was 17.86%. The functional outcome excellent to good in 75% of cases, it was fair in 17.9% of cases and poor in only 7.1% of cases.

Keywords: Intra-articular distal radius fracture, volar locking compression plate, ORIF

1. Introduction
Distal radius fractures are a common orthopedic injury with a bi-modal age distribution pattern. They account for approximately 17% of all fractures [1]. In the younger age group it is as a result of high energy injury but in the elderly it's a result of low energy falls. Of these injuries about half are intra-articular. It is very important to evaluate in these instances the Distal Radio Ulnar Joint (DRUJ) injuries. Accompaniment of a radial styloid injury is indicative of an additional soft tissue injury and it is seen in about 70% of the cases; for example TFCC injury in 40% of cases, Scapho-Lunate ligament injury in 30% of cases and Luno-Triquetral injury in about 15% cases [2]. In the elderly, especially in women with osteoporosis is a direct cause and also predictive of subsequent fractures. Based on the involvement of the Radio-Carpal and Radio-Ulnar joint they can be named as Colle's fracture, Smith fracture and Barton fracture. Some fractures are severely comminuted with varying degree of fracture pattern which cannot be grouped into the above named fractures.
Distal end of radius fractures most often seen in old osteoporotic patients due to trivial trauma, like fall from the standing height. Owing to the increase in the number of road traffic accidents, these injuries are being seen with increasing frequency, in the younger people as well. Several treatment modalities have been described which includes closed reduction and application of plaster cast, bridging external fixation and open reduction and internal fixation (ORIF) by dorsal or volar conventional or locked plates. The drawbacks of cast immobilization are loss of reduction, mal-union, deformity, incongruent articular surface that leads to post-traumatic arthritis and stiffness due to prolonged immobilization. In order to avert these problems, open anatomical reduction and absolute stability by volar locking plates have come into vogue and has become the treatment modality of choice in the last few years.

Advantages of open reduction and internal fixation with volar locking plates are that it provides for angular stability and allows for early mobilization [3]. They are on the principles of internal fixators and prevent late displacement of the fracture fragments. This stability and early mobility helps in achieving rapid functional recovery.

2. Materials and Methods

This prospective study was conducted at the Department of Orthopaedics, Sree Balaji Medical College and Hospital, Chromepet, Chennai, between June 2015 and May 2018. The recruitment was for a period of 36 months, with a minimum follow-up of 12 months (Range: 12 to 35 months).

2.1 Inclusion Criteria

- Both males and females in the age group of 46 to 75 years alone were included.
- Intra-articular distal radius fracture of Melone classification Type 3 to Type 5 was included.

2.2 Exclusion Criteria

- Extra-articular distal radius fracture and intra-articular Type 1 and 2 of Melone classification were excluded.
- Open fractures were excluded.
- Poly-trauma, pathological fractures and medically unfit cases were excluded.

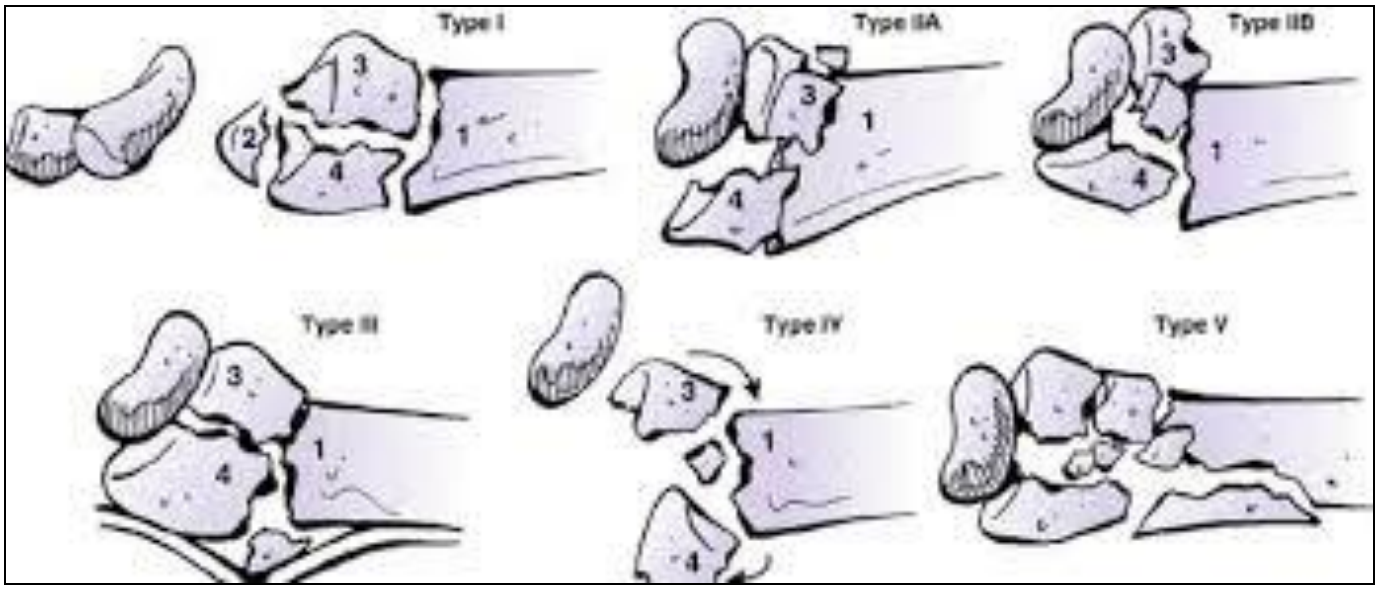

Fig 1: Melone Classification [4].

2.3 Pre-op protocol

All the patients were evaluated for co-morbid conditions like diabetes mellitus, systemic hypertension, heart disease etc; and anesthetic fitness obtained. Cases categorized under Type 3 to type 5 of Melone classification were not attempted for any closed reduction. For pain relief initially a dorsal slab was applied, until work-up for surgery was completed. Drip stand forearm elevation was executed by bed side. Anti-edema drugs were initiated. Preoperative radiographic evaluation was done for the intra-articular incongruity based on Knirk and Jupiter criteria. All the patient having a grading of 2 or more (i.e; an intra-articular step of above 2mm) were considered for open reduction and internal fixation.

Table 1: Articular incongruity as per Knirk and Jupiter Criteria [5].

Grade	Intra-articular Step-off (mm)
0	0-1
I	1-2
II	2-3
III	>3

2.4 Intra-op

All cases were done under general anesthesia or regional anesthesia with tourniquet control and were taken up for surgery within a week of admission. Using the Ellis approach open reduction internal fixation was done. Reduction and screw position were checked with C-arm. Any step-off of two millimeters or more was considered incongruent. For patients who had multiple small fragments, intra-operative external fixation initially facilitated reduction of the fracture components to achieve a reasonably acceptable anatomical reduction prior to plate osteosynthesis. Kirschner wires were generally used to stabilize smaller fragments and were particularly helpful in holding the articular fragments that had little or no metaphyseal support. Cancellous bone-grafting was used in ten patients to support the articular surface when it was found that when the depressed articular fragment, when raised to congruity created gaps in the sub-articular zone. All the fractures were fixed with volar locking plate. Intra-operative parentral third generation cephalosporin was administered intra-venously. Wound was closed in layer over DT. Only softly padded, crepe compression was given post-operatinely.

2.5 Post-op protocol

Post-operatively broad spectrum antibiotics were given for 48 hours. DT if kept was removed on POD 2.Suture removal was done on POD 12.Active finger movements elbow and shoulder joint mobilization was started as tolerated by the patient. Active and assisted passive wrist mobilization was initiated by POD 14. Patients were followed up at 2 weekly intervals for the first 6 weeks and thereafter at monthly intervals for the next 3 months. At the end of 12 months clinical and radiological evaluation was done using the "Demerit point system of Gartland and Werley" (Table 3, 5).

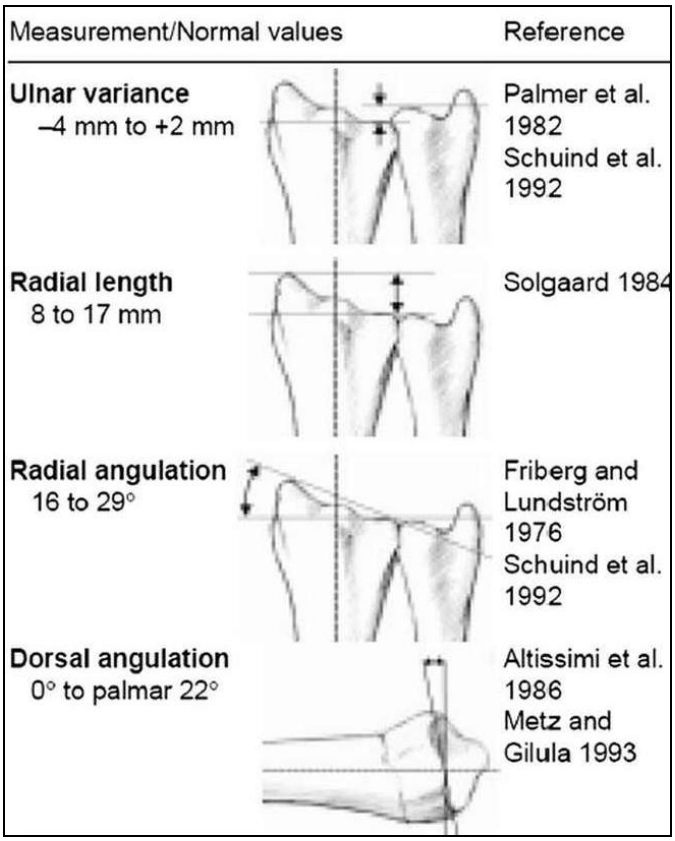

Fig 2: Radiological criteria for acceptable reduction per-operatively.

Postero-anterior and lateral radiographs of the involved wrist were taken for all patients at the end of 3, 6 and 12 months. These radiographs were evaluated for any arthritic changes as graded by Knirk and Jupiter (Table 5), radial and dorsal-volar tilt of the distal radial surface, and non-union of the ulnar styloid process.

Table 2: Demerit point system of Gartland and Werley.

Result	Points
Residual deformity	
Prominent ulnar styloid	1
Residual dorsal tilt	2
Radial deviation of hand	2–3
Point range	0–3
Subjective evaluation	
Excellent – no pain, disability, or limitation of motion	0
Good – occasional pain, slight limitation of motion, no disability	2
Fair – occasional pain, some limitation of motion, feeling of weakness in wrist, no particular disability if careful, activities slightly restricted	4
Poor – pain, limitation of motion, disability, activities more or less markedly restricted	6
Point range	0–6
Objective evaluation*	
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
Loss of pronation	2
Pain in distal radioulnar joint	1
Grip strength - 60% or less of opposite side (Using dynamometer)	1
Point range	0–5
Complications	
Arthritic change	
Minimum	1
Minimum with pain	3
Moderate	2
Moderate with pain	4
Severe	3
Severe with pain	5
Nerve complications (Median)	1–3
Poor finger functions due to cast	1–2
Point range	0–5

* The objective evaluation is based on the following ranges of motion as. being the minimum for normal function: dorsiflexion, 45 degrees; palmar flexion, 30 degrees; radial deviation, 15 degrees; ulnar deviation, 15 degree, pronation, 50 degrees; and supination, 50 degrees. Patients were assessed for wrist pain both at rest and with movement, active range of movement of wrist, any deformity and grip strength, were also recorded.

Table 3: Results interpretation in Demerit point system of Gartland and Werley.

Excellent	*0 – 2*
Good	3 – 8
Fair	9 – 20
Poor	>21

Table 4: Grading of wrist arthritis by Knirk and Jupiter [5].

Grade.	Radiological characteristics.
0	None.
I	Slight joint-space narrowing.
II	Marked joint-space narrowing formation of osteophytes.
III	Bone on bone, formation of osteophytes and cysts.

3. Results

Table 5: Age and Sex distribution chart:

Age (in years)	Male 'n'	Female 'n'	'n'	% age
46-55	6	8	14	25
56-65	6	12	18	32.14
66-75	8	16	24	42.86
Total	20	36	56	100
	35.71%	64.29%		

Table 6: Mechanism of injury.

Mechanism of injury	Male	Female	Total	% age
Slip and fall	10	26	36	64.3
Road traffic accident	10	10	20	35.7
Total	20	36	56	100

Table 7: Fracture Classification type.

Melone	Male	Female	Total	% age
Type 3	6	8	14	25
Type 4	10	16	26	46.4
Type 5	4	12	16	28.6
Total	20	36	56	100

Table 8: Complications.

Nature	No of cases	% age
Flexor tendon attrition	0	0
Carpal tunnel syndrome	1	1.79
Reflex sympathetic dystrophy	5	8.93
Arthritis	4	7.14
Total	10	17.86

Table 9: Demerit point system of Gartland and Werley score.

Grade	No of cases 'n'	% age
Excellent	20	35.7`
Good	22	39.3
Fair	10	17.9
Poor	4	7.1
Total	56	100

56 patients were enrolled in this study, which conformed to our inclusion criteria. These included 20 patients with Melone type 3, 24 patients with Melone type 4 and 12 patients with

the Melone type 5 variants. Of these 35.7% (n=20) were males and 64.3% (n=36) were females (M: F ratio 5:9). The patients distribution was dissimilar in all age distribution groups with the majority 42.9% (n=24) in the 66 to 75 age group, followed next at 32.1% (n=18) in the age group 56 to 65 years and least 25% (n=14) in the age group 46 to 55 years. With regard to the mechanism of injury; trivial fall from standing height constituted 64.3% (n=36) patients and in the remaining 35.7% (n=20) RTA was the cause. In 71.43% (n=40) the injury was on the right wrist and left wrist constituted 28.5% (n=16). The majority of cases 46.4% (n=26) were of Melone Type 4 followed by 28.6% (n=16) of Type 5 and the least 25% (n=14) of Type 3 Melone fractures. The average time lag between injury and surgery was 2.3 days (range: 1 to 7 days). The average duration of surgery was 50 minutes (range 42 to 65 minutes), mean duration of hospital stay was 7 days (range 3 to 10 days). All cases were followed up for a minimum period of 12 months (mean 16.8 months; range 12 to 35 months).

In our study we had 75% (n=42) cases with excellent to good outcomes, 17.9% (n=10) of fair outcome and 7.1% (n=4) of poor outcomes as evaluated by the Demerit point system of Gartland and Werley scoring system.

3. Case Illustration

Case 1

Fig 3a: Pre- op X-ray

Fig 3b: 12 months follow up X-Ray

Fig 4a: Pre-OP X- Ray

Fig 4b: 12 months follow- up X-Ray

4. Discussion

Volar locking plate has become the treatment of choice in the last decade for the treatment of intra-articular distal radius fractures. An anatomical reduction of the joint surface with rigid fixation is the main goal in the treatment of intra-articular fractures. It has been shown that residual intra-articular incongruity leads to post-traumatic arthritis in the intermediate to long term. Comminuted, displaced intra-articular fracture of the distal end of radius fracture requires open reduction and internal fixation to restore the articular congruity thereby preventing the post-traumatic arthritis, achieving early recovery and a good functional outcome. Distal radius fracture being common in the elderly osteoporotic women, achieving a satisfactory functional outcome is a challenging task. This can be achieved by following the surgical principles like using external fixator to restore the length of distal radius, fixing small intra-articular fragments with 'K' wire, stabilizing the fracture with volar locking compression plate and bone grafting of osteoporotic cases or in those with juxta articular gaps.

In our study 10 patients who had severely comminuted fracture following high energy fracture had fair results, and 4

patients, conforming to Melone Type 5, had poor result with residual arthritic changes at 30 month follow-up. As presented by Knirk and Jupiter study [5], the fractures that healed with an intra-articular step off of 2 mm or more had led to post-traumatic degenerative arthritis.

Ten patients over 70 years of age with severe osteoporotic bone had fair results in our study and four patients over 70 years had poor results indicating age and quality of bone does affects the final functional outcome, as also reported by Bradway *et al*.

In this series we did encounter one case of carpal tunnel syndrome as a complication at 32 months follow-up. We had six patients with reflex sympathetic dystrophy (RSD), these patients were all above 70 years of age probably the fracture severity and osteoporosis would have been the causative factors. Studies have shown that the nature of RSD after distal radius fracture is not affected by the operative procedure. There were four cases of wrist arthritis, who had Type 5 Melone fracture and were aged above 70 years.

Bassett et al; suggested that displaced intra-articular fractures of the distal end of the radius needs anatomical reduction and fixation, and that open treatment can lead to an excellent result if the reduction is near anatomical [6]. Melone et al; reported on fifteen patients who had a severely displaced intra-articular fracture of the distal end of the radius that were treated by open reduction and internal fixation and had a similarly good functional outcome of approximately 80% cases which is comparable to ours of 75% [7].

Knirk and Jupiter also had reported that intra-articular fractures of the distal end of the radius that were treated with open reduction and internal fixation, had a good result as per the criteria of Gartlandand Werley [5].

We are in concurrence with the findings of Knirkand Jupiter that patients who have a fracture of the dista lend of the radius, that have an intra-articular incongruity of two millimeters or more, are rightfully managed surgically by ORIF in order to get a good functional outcome. Xavier et al; have also shown that restoration of the radial length is an important determinant of the difference in extension and grip strength between the fractured and non-fractured limbs [8]. Trumble et al; in a study of management of distal radius fractures by K-wires have also shown that the radial length restoration was by far the most important factor in determining the functional outcome [9]. Similarly Walenkamp et al; had also shown that distal radius fractures treated with a volar locking plate had a better functional outcome than (augmented) external fixation at 12 months of follow-up [10].

Instability of the DRUJ is to be recognized as a poor prognostic factor in the management of distal radius fractures [11]. However, recent studies have shown that if the distal radius fractures are anatomically reduced and rigidly fixed with locking plates, no significant difference is noted in the final outcome between patients with and without ulnar styloid fractures, despite the location of the fractures and the degree of displacement, Even if the ulnar styloid fracture does not progress to union, no significant clinical difference has been noted when compared with patients with united ulnar styloid fractures.

5. Conclusion

Open reduction and internal fixation has been shown to be effective in the treatment of unstable intra-articular distal radius fracturs. When a dorsal approach is used extensor tendons tend to be irritated and also at times due to attrition can get ruptured. Carpal tunnel syndrome, flexor tendon irritation and RSD are known complication of the volar approach. In our instance the overall complication rate was 17.9%. But the overwhelming fact that we could get a functional outcome of excellent to good approaching 75% of the cases, makes us to affirm positively in favour of considering the volar dynamic compression plating system in treating Melone Type 3 to Type 5 intra-articular distal radius fractures.

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