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Radiological and functional outcome of dorsal distraction plating of comminuted distal radius fractures

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Abstract

Comminuted intra articular fractures of the distal end of radius AO type C3 is a very gruesome injury considering the difficulty in treatment and the results. Treatment decisions are often difficult and they may end up in loss of range of movement and CRPS, if not properly addressed. Complete anatomical reduction is difficult in these types of fractures and the methods adopted are external fixation or internal dorsal distraction plating, the latter being a relatively newer method.

Aims: To study the functional and radiological outcome of dorsal distraction plating of comminuted distal end of radius fractures AO type C3.

Patients and Methods: A single cohort longitudinal study of 24 Patients who sustained AO C3 type fractures of distal end of radius and have undergone dorsal distraction plating were selected and followed up for a period of 1year. Functional assessment was done using Green O'Brien score and radiological assessment was done using Sarmiento score.

Results: One year follow-up of 24 patients showed average palmar flexion of 56⁰, dorsiflexion 60⁰, radial length of 10mm, radial inclination of 15⁰, volar tilt of 3⁰ and ulnar variance of 0.5mm. Functional scoring using Green O'Brien score showed more than 80% good to excellent result and radiological assessment by Sarmiento scoring showed 95% good results.

Conclusion: Internal dorsal distraction plating in AO type C3 fractures yield better result compared to external fixation or volar locking plates. Functional and radiological outcomes are better in this type of fractures after dorsal distraction plating.

Keywords: Comminuted distal radius fracture, dorsal distraction plating, internal distraction plating, AO type C3 fracture

Introduction

Distal radius fractures are the commonest fracture incurred in the upper extremity. It occurs most commonly by a fall on outstretched hand. The treatment of distal radius fractures rely on attainment of acceptable anatomy defined in terms of volar tilt, radial length, radial inclination and articular step-off. The goal of treatment for distal radius fractures is to obtain sufficient pain-free motion, allowing return to activities while minimizing the risk for future degenerative changes or disability. This goal is usually attained by recreating the acceptable anatomical reduction^[1]

However, in a comminuted intra articular distal end of radius (AO type C3) fracture it is usually not possible to attain anatomical reduction with the currently available treatment methods. At present the most popular method of treatment in such fractures is external fixation (spanning/non-spanning) with or without k-wires. But external fixation carries its own problems in the treatment of comminuted distal end of radius fracture^[2], like poor patient acceptability, pin tract infection, pin loosening, increased chance of complex regional pain syndrome, cosmetic problems and functional disability during treatment period.

Recently another alternative, internal distraction plating^[3-6] has been developed that excludes some of the undesirable outcomes of external fixation. Distraction Plating involves "bridging" the fracture with the use of a standard 3.5mm plate applied dorsally; in distraction, from shaft of the radius, proximal to the fracture, to the second or third finger metacarpal distally, bypassing the comminuted segment.

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The proposed advantages of internal distraction plating^[5] include better patient acceptability, use of the limb during treatment period, avoids problem of pin tract infection and proximity of the distracting force which gets evenly distributed across the width of radius.

Aim and Objective

To study the functional and radiological outcome of internal dorsal distraction plating in AO type C3 fractures of distal end of radius.

Materials and Methods

Patients attending orthopaedic casualty and out-patient department at govt. medical college, kozhikode with comminuted distal radius fracture (AO C3 fracture) who were offered this modality of treatment between 1/2/2017 to 31/7/2018 are the study population. All patients were followed prospectively for a minimum period of 1 year.

Inclusion criteria: Any adult patient between 18 and 60 years with a closed type C3 distal radius fractures

Exclusion Criteria

Those associated with other fractures of ipsilateral upper limb, open fractures, fractures with associated vascular injury are excluded. Similarly paediatric and old age fractures

outside the age group 18 to 60 are also excluded.

All the required data were obtained from the patients during their stay in the hospital and during follow-up and recorded in the proforma. These patients were preoperatively evaluated with appropriate x-rays and blood investigations. Informed consent was taken.

Surgical Technique

The patient was positioned supine with the affected extremity on a radiolucent arm board. A tourniquet placed at the upper arm will be used for haemostasis. The extremity should be prepared up past the elbow to allow for easy pronation and supination of the wrist. An initial reduction will be performed to determine the effect of distraction plating and to establish the length of the plate needed for fixation. Typically, a 10-14 holes 3.5-mm limited contact dynamic compression plate is required. The plate will be selected to span from the second or third metacarpal to 4 cm proximal to the fracture in the radius. Currently there are commercially available dedicated low profile locking bridge plates. A 3-cm dorsal incision will be made at the level of the third metacarpal centred over the shaft. The incision should be midline to avoid the cutaneous branches of the radial and ulnar dorsal nerves. The dorsal aponeurosis should be incised at the 4th compartment and the common extensor tendon will be exposed. Alternatively, the second metacarpal may be used for distal fixation.

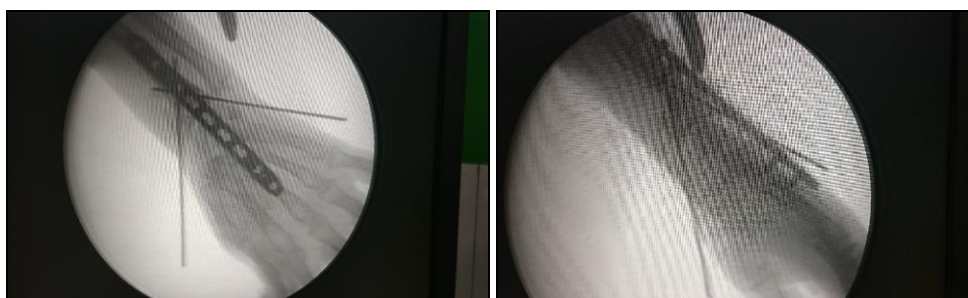


Fig 1: Intraoperative C-arm image

Next a 3-cm incision will be made approximately 4 cm proximal to the meta-diaphyseal extent of the fracture along the radial shaft. Tis can be identified under an image intensifier. The dorsal aponeurosis of the antibrachial fascia will be incised. The superficial radial nerve can be identified between the extensor carpi radialis longus and Brachioradialis and protected. Dissection will be performed down to the intact radial shaft. A third incision will typically be made over the distal radius to facilitate plate passing and assist in reduction or grafting of the fracture site or both. Lister's tubercle will be identified and marked. A 3-cm incision will be made at the level of the radiocarpal joint centered over Lister's tubercle. The third and fourth dorsal wrist compartments will be identified. Extensor pollicis longus will be released from the third compartment and retracted radially. The fourth dorsal compartment can be visualized and its radial border is mobilized from the periosteum and the joint capsule to create a plane for the plate. Having now prepared the fracture site and the surfaces of the radius and metacarpal, the plate can be inserted. It will be passed in a retrograde fashion starting at the most distal incision at the metacarpal deep to the extensor tendon and advanced proximally until seen in the second incision at the wrist. Care will be taken to ensure that the extensor pollicis longus and extensor digitorum communis tendons are not entrapped by the plate as it courses over the distal radius along the floor of the fourth compartment. If the

second metacarpal is to be used for distal fixation, then the plate will be passed through the second compartment, deep to the radial extensors of the wrist. It will then be advanced until seen in the most proximal incision, where it can be centered over the radial shaft.



Fig 2: Intra-operative clinical photographs

Once the plate has been successfully passed, the image intensifier is used to ensure that the plate is centered well over the metacarpal shaft and the proposed screw holes are distal to the metacarpophalangeal joint. The plate will then be fixed

distally with a single 3.5-mm cortical screw. Manual traction will be reapplied under fluoroscopy to restore radial length, height, and inclination. The plate will be provisionally fixed to the radial shaft with a reduction forceps or a Verbrugge clamp. Satisfactory positioning of the plate will be confirmed, with radial of ulnar adjustment performed as necessary. At this point, meticulous care will be taken to ensure that the radiocarpal distance is less than 5 mm, as over distraction predisposes to wrist and digit stiffness, as well as complex regional pain syndrome. Once satisfied with the reduction under anteroposterior and lateral views of the wrist, a single proximal bicortical screw will be placed. The fingers will be taken through a range of motion (ROM) to ensure that there is no tendon entrapment or extrinsic extensor tightness. Full passive forearm supination and pronation must also be confirmed. With the appropriate degree of distraction confirmed, 3.5-mm cortical screws will be placed in the remaining distal and proximal screw holes to complete the construct.

On completion of the distraction plating, radial length, height, and inclination should be re-established. Intraarticular reduction and dorsal bone grafting as needed, may be done at

this time. Radial styloid and dorsal ulnar fragments may be addressed with additional Kirschner wires. Any impacted fragments will be elevated and supported with bone graft if needed. Bone grafting was not done in any of the patients in this study.

Post-Operative Management and Follow UP

Postoperatively the patients were initially placed in a volar short arm splint with the fingers free to provide soft tissue rest. The splints are typically removed 2 weeks after the operation and patients were allowed finger movements and elbow movements. Patients were allowed to carry out their routine daily activities.

Plate removal had been planned 12-16 weeks postoperatively, after radiographic evidence of bone healing. Extensor tenolysis may be performed if needed during the plate removal.

Thereafter, patients were followed up in every 6-week interval with AP and lateral x-ray views of wrist for one year. At that time functional assessment was done using Green and O'Brien score. Radiological assessment was done using Sarmiento radiological score.

Table 1: Green and O'brien Score (Cooney Modification)

Pain (25 points)	Wrist Range of motion (25 points)		Grip strength (25 points) %		Activities (25 points)	
	flexion + extension	% of normal side	of normal side			
None 25	100%	25	100%	25	Returned to regular employment	25
Occasional 20	75-99%	15	75-99%	15	Restricted Employment	20
Tolerable 15	50-74%	10	50-74%	10	Able to work but unemployed	15
Intolerable 0	25-49%	5	25-49%	5	Unable to work because of pain	0
	0-24	0	0-24	0		
	Excellent 90-100		Good 80- 89		Fair <79	

Table 2: Sarmiento Radiological Scoring

	Dorsal Angulation	Shortening	Loss of Radial Deviation
Excellent	<0	< 3mm	<4
Good	1-10	3-6	5-9
Fair	11-14	7-11	10-14
Poor	>15	>12	>15

Results

The following observations were made after following up 24 patients with AO type C3 fractures who attended casualty and OPD. All the cases were treated with dorsal distraction plating in a week following the injury.

Out of the 24 patients majority had high velocity injury sustaining AO type C3 fracture of the distal end of radius. Out of 19 male patients and 5 female patients 11 of them sustained injury after road traffic accident, 9 due to fall from height and 4 due to trivial fall on out stretched hand.

Table 3: Age and Sex distribution pattern

Age Groups	Frequency	Percentage
20-30	8	33.3
31-40	7	29.2
41-50	6	25
51-60	3	12.5
Male	19	79.2
Female	5	20.8

All the cases were treated with internal dorsal distraction plating using 3.5 LCP within a week of the injury. All radiological parameters were taken care of intraoperatively under C-arm guidance and post-operative radiographs showed

satisfactory values compared to the opposite limb. After implant removal 12 weeks later, there appears to be no significant collapse and change in values of radial length, volar tilt, radial inclination and ulnar variance.

After one year follow-up 16 patients had radial length shortening less than 3mm, 6 patients had shortening between 3-6 mm and 2 patients had shortening more than 6 mm. The maximum value obtained was 13 mm and minimum value was 4mm with mean value of 10mm. Radial length is well maintained by the distraction plating due to uniform distribution of the distracting force along the width of the radius.

Table 4: Final Radiological Values

Radial Shortening	Radial Inclination	Volar Tilt
<3 mm 16 (64%)	5-10° 2 (8.3%)	-10 to 0° 7 (29.2%)
3-6 mm 6 (24%)	11-15° 9(37.5)	1-10° 16 (66.4%)
>6 mm 2 (8%)	16-20° 13(54.2%)	11-20° 1(4.2%)

13 patients had radial inclination between 16-20 degrees and 9 had radial inclination between 11 -15 degrees. 2 patients had inclination less than 10 degrees, who also had significant shortening of radial length. The mean value was 15 degrees.

Volar tilt showed negative values (i.e., dorsal tilt) ranging from -10degrees to 0 degree in 7 patients. Majority of the patients were in the middle range, 1-10 degrees of volar tilt, constituting 66 percent of the total. The mean value was around 3 degrees of volar tilt.

The mean ulnar variance was found to be +0.5mm with extreme values showing -2mm and +6.5mm.

Functional outcome had no correlation with radiological outcome in most of the patients. Patients with average

radiological values also had good outcome in one year of follow-up. Patients reported that they were able to use their hand for the activities of daily living without causing much functional limitation even with the implant insitu. There was no difficulty in using the fingers and some patients had difficulty in extension of the thumb due to EPL tendon being stretched over the locking plate. But EPL function became normal once implant removal was done after 3 months.

Average palmar flexion and dorsiflexion were 56 degrees and 60 degrees respectively with 2 patients reporting near normal flexion. The incidence of CRPS was lower than expected with only one patient having CRPS. Even though pain was reported in initial months of implant removal, with proper physiotherapy pain disappeared at one year follow-up with significant improvement in wrist movements. Grip strength was near normal in 23 patients and they resumed their normal job, except the one with CRPS.

Functional assessment using Green O'Brien score showed excellent result in 2 patients and good result in 20 patients which together covers almost 90 percent of the total sample. Two patients had fair result in which one had CRPS and other had significant stiffness with poor radiological values.

The radiological outcome was measured using Sarmiento scoring system. 23 patients had good result and one had fair result with no patients falling into the category of excellent or poor results.

Table 5: Functional and Radiological Outcome

Score	Green O'brien score	Sarmiento
Excellent	2 (8.3%)	0
Good	20 (83.3%)	23 (95.8%)
Fair	2 (8.3%)	1 (4.2%)
Poor		0



Fig 3: Preoperative Radiograph



Fig 4: Postoperative Radiograph



Fig 5: Radiograph after implant removal



Fig 6: Clinical Photograph at 1 year

Discussion

Comminuted distal end of radius fractures AO C3 types are difficult to treat considering the complexity of the anatomy and postoperative complications. Patients frequent the OPDs with CRPS, stiffness, decreased hand grip strength and arthritis following the treatment. A review of the previous published studies lack proper selection criteria and an inherent variation in fracture pattern makes it difficult for a comparative analysis. Large sample size case control studies or meta-analysis are lacking in this type of fractures.

After the introduction of ligament taxis using bridging external fixators, the scenario became better. But the external fixator system had many drawbacks like pin tract infection, pin loosening, inability to use the hand during treatment period, non-uniform distribution of distraction due to the cantilever mechanism and collapse after the external fixator removal. Due to non-uniform distribution of distraction force and collapse after implant removal results were often less than expected. Studies had shown increased chance of infection, non-union and malunion with external fixators [7, 8, 9, 10].

With the advent of internal distraction plating, which acts as an internally placed bridging external fixator, more uniform distribution of the distraction force could be given, which resulted in better outcomes. Previous studies (5, 6) show better functional and radiological results but a statistical analysis cannot be drawn as the study groups are different in various aspects. In general there are low incidences of infection, CRPS, stiffness with better patient compliance as it allows use of hand during treatment period. Patient's social life is better as internal distraction plating does not have a cosmetic disadvantage like external fixator.

In our study about 65% of the patients were between the age group 20-40 years (physically high demand) and 79% of them were males. The cause of the fracture were high velocity trauma with a very few proportion being low velocity injury. This indicates that AO type C3 fractures are more common in very active young males following high velocity injury, road traffic accidents and fall from height being the most common mode of injury.

Radiological outcome in this study are comparable with the published studies [5]. The radial length after 1 year follow-up averaged at 9.8mm (average shortening 2 mm), volar tilt of 3 degrees, and average ulnar variance of 0.5mm and radial inclination of 15 degrees. Functional outcome had no significant correlation with the radiological values after analysis of the results. Green O'Brien score showed good to excellent results in more than 85% of the patients with poor result in only one out of the 24 cases. Patients had undergone physiotherapy after implant removal. Grip strengths were more than 90 % restored, with no significant pain and they resumed their job within 3 months of implant removal. Palmar flexion averaged 56 degrees and dorsiflexion average 60 degrees. Superficial infection was present in 2 cases, but was cured uneventfully. No incidences of plate breakage, tendon rupture, non-union or mal-union were reported. One of the patients had severe CRPS and one had tendinitis. During the treatment course patients were able to use the limb and social life was better. Overall the results were comparable with previous studies

In the original study by Ruch DS [11] showed average radial shortening of 2mm, mean palmar tilt of 4.2 degree with only 1 patient with a dorsal tilt of 5 degree and average ulnar variance of 0mm. Ruch DS *et al.* had used bone grafting in 11 of 22 patients. In our study none of the cases underwent bone grafting to prevent post-surgical collapse. This resulted in 7 patients falling into the group with dorsal tilt in our study. We feel that radiological outcome could have been better with the use of bone grafting. The flexion and extension averaged 57 & 65 degree. According to the Gartland- Werley rating system they used, 14 patients had an excellent result, 6 had good result, and 2 had fair result.

In the study done by Richard M.J *et al.* [6] on internal distraction plating in elderly the radiographs demonstrated mean palmar tilt of 5° and mean positive ulnar variance of 0.6 mm. Mean radial inclination was 20°. Mean values for wrist flexion and extension were 46° and 50°, respectively. Hanel DP *et al.* [12] showed that in their study of 62 highly comminuted metadiaphyseal distal radial fractures treated with distraction plating, the average radial inclination was greater than 5° in all patients with neutral palmar tilt on average, compared to 3° palmar tilt and 15° radial inclination in our study. Although there were no reported values for average range of motion, the authors reported "functional range of motion" within a year of plate removal in their cohort.

In Lauder A, Agnew S *et al.* [3] study, all the fracture patterns were comminuted and intra-articular (AO 23.C3). There were significant decreases in wrist flexion (43° vs 58°), extension (46° vs 56°), and ulnar deviation (23° vs 29°) compared with the contralateral uninjured wrist. Flexion and extension were better in our study with values 56° and 60° respectively.

In the study by Wright *et al.* [13] comparing external fixation with ORIF using volar locking plates the mean passive wrist ROM at the final follow-up evaluation in EF patients was 59 degrees extension and 57 degrees flexion, compared with 63 degrees extension and 64 degrees flexion in patients treated with ORIF. Final radiographic measurements for the EF group averaged 5 degrees volar tilt and 25 degrees radial inclination, with 2.2-mm ulnar-positive variance. The ORIF with volar plating group averaged 10 degrees volar tilt and 22 degrees radial inclination, with .5-mm ulnar-negative variance. The results in both the groups are comparable with our study.

In John T Anderson, MD, George L Lucas *et al.* [8] in 2004,

retrospective study of 24 patients who were treated with external fixators, Sixteen of the 24 patients had complications: 5 with neuropathies of the median or superficial radial nerve, 9 with pin track infections, 2 with pin loosening, one with a nonunion, 2 with malunion, and 4 patients each with radial shortening, loss of radial tilt, collapse of ulnar border or volar intercalated segment instability (VISI) of the lunate and rotatory subluxation of the scaphoid. They concluded that postoperative complications following distal radius fractures treated with external fixation are common. In our study, there were no incidences of non-union or deep infection. 2 cases with superficial infections healed without any complications.

Limitations of study

Sample size of the study was insufficient to extrapolate the findings to the general population. Even though distal radius fractures are the most common fracture of the upper limb, AO typeC3 fractures are not very common unless a high velocity trauma occurred. Such high velocity injuries had associated fractures in the same limb or were open fractures, which were excluded from our study.

Conclusion

In this study we were able to highlight that the activities of daily living of the patients were not impaired during the course of treatment and functional and radiological results are at par or better compared with other modalities of treatment available for fracture of distal end of radius. Infection and CRPS are far less when compared to the historical data available for the external fixation.

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