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Functional Outcomes And Restoration Of Radial Bow In Lateral Plate Fixation Of Radius Fractures

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Abstract

Introduction: Plate fixation is a standard method of treatment for adult displaced both bone forearm fractures. Conventionally radius fractures are plated either on the volar or dorsal surface depending on the approach. An alternative lateral side plating is used in this study. Pre bent Lateral plating" allows placement on the tension side of the fracture, restores radial bow and hence the interosseous space, additionally achieves compression, facilitates bi-cortical screws in medio lateral plane and avoid plate eccentricity. In this retrospective observational study of 8 patients with a mean age of 35.6 years indications were both bone fractures with nonunion-1, malunion -2, acute both bone fractures-2, Isolated radius shaft fracture-2 and Galeazzi fracture dislocation-1. All these patients had the standard volar Henry's approach for exposure and after reduction fixation was done using pre contoured 3.5 DCP or locking compression plate to lateral side of radius. Primary outcome is to assess the fracture healing and the secondary comes are to assess the restoration of radial bow and the post- operative adjacent joint range of movements. Radiological measures were used for assessment of fracture healing and restoration of radial bow including the bow percentage and bow ratio. Functional measures of adjacent joint range of movements were assessed based on Anderson's criteria and Eversmann's criteria. Fracture Union was achieved in a mean of 4.2 months. The mean bow ratio was 13.05 with a range 11.2 -17.3. The mean bow percentage was 60.98% and the range was 52.4% - 66.5% Functional results were excellent in all our cases. In conclusion lateral radial plating is biomechanically a viable alternative to dorsal or volar plating with lesser operative complexity and complications.

Keywords: Lateral radius plating, Radial bow restoration, Radial bow ratio, Bow percentage. Postoperative radial bow

Introduction

Forearm injures with bimodal distribution has an incidence of 1-10 per 10,000 population per year. In displaced fractures it is difficult to have rotational and axial control with nonoperative options. Perren's strain theory explains the excessive fracture site movements and associated nonunion with resulting forearm dysfunction. Displaced forearm fractures compromise the interosseous space in addition to loss of axial length with or without disrupted radio ulnar syndesmotic harmony. Hence these are essential fractures for surgical fixation. The methodology of fixation and the approaches can vary but the

definitive methods of fixation aim for anatomical reduction, restoration of radial length, radial bow and interosseous space where the effective muscle forces play a major role in the complex kinematics of forearm rotations. Volar and dorsal plate fixation for radius are considered the gold standard after the World War II. Lateral plating of radius has many biomechanical advantages and in specially restoring the radial bow.

Aim & Objective:

To study the feasibility of plate placement on the lateral side of radius in shaft fracture fixation. To assess and correlate fracture healing as primary outcome the post operative adjacent joint mobility with radiological restoration of radial bow as secondary outcome.

Materials and methods:

Retrospective study of 8 patients with mean age of 35.6 years. Indications for fixation include isolated shaft of radius or both bone fracture including established nonunion and malunited both bone forearm fractures.

Method of fixation and technique of fixation:

All our cases were done under general anesthesia with nerve block using tourniquet control. Standard volar Henry's approach was used for all radius fractures. Reducibility of both bones were checked in cases of nonunion and malunion both bone fractures where fixation of radius was preceded by ulna. Standard 3.5 narrow DCP or Locking compressing plate with combo holes were used. Pre bending of the plate to match the radial bow allowed placement on the tension side and were able to achieve reduction and compression in all our cases. DRUJ was assessed in Galeazzi type injuries and addressed accordingly. Additional open osteoclasis was needed in the malunited cases and bone grafting in nonunion case from the ipsilateral iliac crest.

Post-operatively, a plaster splint was used in only patients with DRUJ disruption. Active Hand, wrist and elbow exercises were encouraged from the 1st post-op day. Activity was gradually increased depending on patient comfort and were followed up periodically until minimum of 6 months. Radiological union was assessed with gradual disappearance of the fracture line in serial X rays. Functional outcomes were determined by Anderson's criteria and Grace-Eversmann criteria. (fore-arm rotations and adjacent joint ROM).

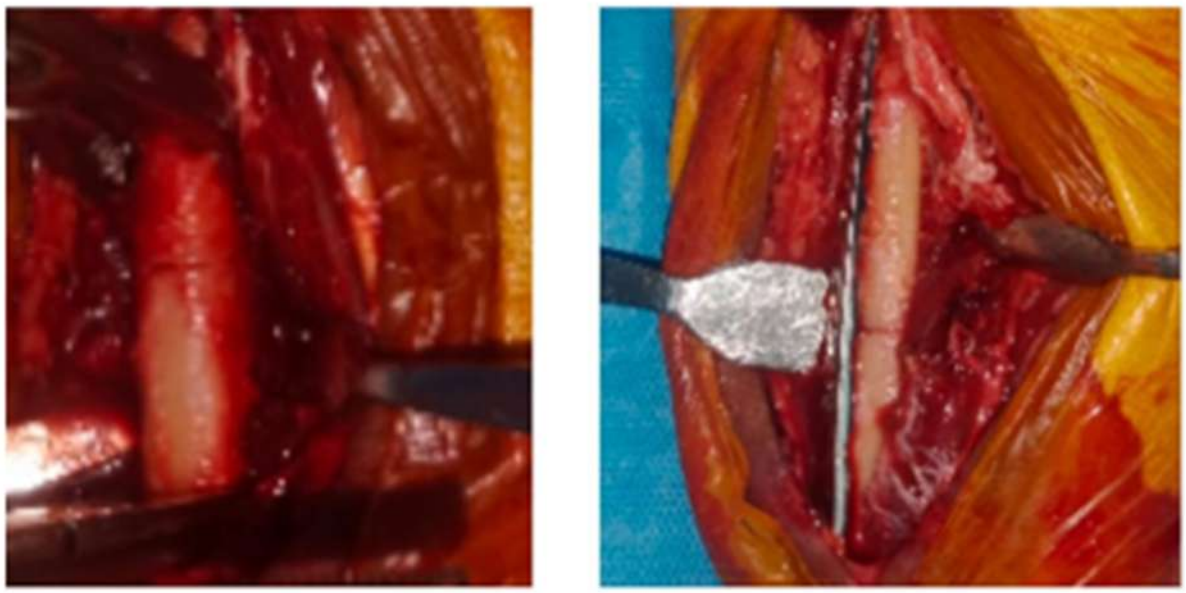

Figure 1: Intraop. – Pre bent lateral plating of Radius

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Radiographic Bow assessment:

Maximum bow magnitude varies between 10 – 15mm (3, 4). In view of the post traumatic reconstructed bow assessment, we do not have access to the pre operative values. Xray magnification errors can bias on the bow height measurements. Cohort in the study are mixed cases of non-union, malunion, both bone forearm fractures and single bone radius fracture with DRUJ disruption with varying morphometry. Hence we emphasis on Bow ratio and Bow percentage.

We used the modified Schemitsch and Richard's method (1) for the measurement of radial bow in the coronal view of the forearm radiographs exposing elbow and wrist joint.

Bow percentage: (location of the maximum radial bow) is a ratio of length (X)of segment from the midpoint of bicipital tuberosity to location of maximal radial bow and the length of radius(Y) from the midpoint of bicipital tuberosity to the most distal and ulnar point of distal radius, multiplied by 100. The bow percentage were consistently seen at 59 - 61% (3, 4,12).

Bow magnitude or Bow height: (r) was calculated by the point of radius with maximum curve at which the medial border of radius shaft is farther from the radial line. Normal Radial height is being 10- 15mm (3,4) where the magnification factor has to be considered.

Bow ratio: The ratio of reconstructed bow magnitude (r) to its radial length (y).

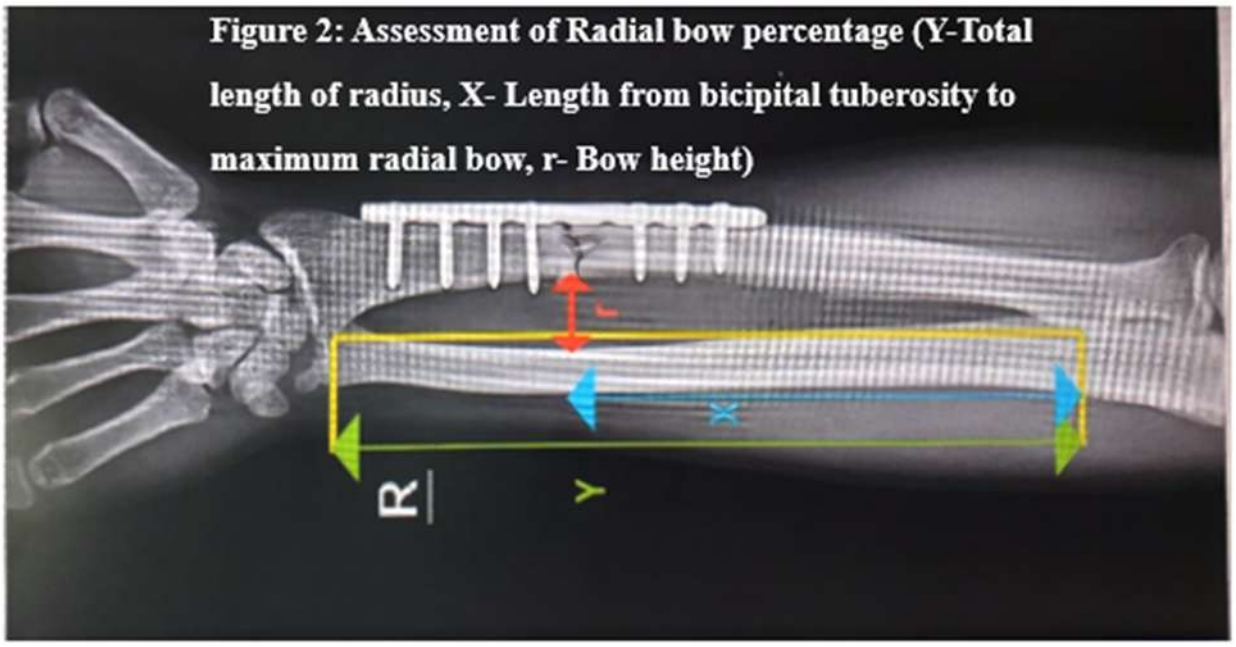

Figure 2: Assessment of Radial bow percentage (Y-Total length of radius, X- Length from bicipital tuberosity to maximum radial bow, r- Bow height)

Functional assessment:

Grace and Eversmann Criteria :- (Normal range of rotation arc= 130-150°)

Outcome:	Arc of forearm rotation	Fracture union:
Excellent.	120-135° arc	Fracture United
Good	105- 120° arc	Fracture United
Acceptable	75 - 90° arc	Fracture United
Unacceptable	Less than 75° arc	Fracture Non union

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Anderson's criteria:

Outcome:	Wrist ROM	Forearm rotations:	Fracture union:
Excellent	<10° loss of flexion/extension	<25% loss of supination/pronation	United
Satisfactory	<20° loss of flexion/extension	<50% loss of supination/pronation	United
Unsatisfactory	<30° loss of flexion/extension	<50% loss of supination/pronation	United
Failure	With or without loss	With or without loss	Non union

Results:

In all the cases the fracture healed completely and all these patients returned back to pre-injury status. Functional outcome based on Anderson criteria scored excellent in all but one of the malunion case scored satisfactory. Based on Grace and Eversman's criteria all scored excellent except one showed good results. Radiological restoration of radial bow was assessed. The mean bow ratio was 13.05 with a range of 11.2 -17.3. The mean bow percentage was 60.98% and the range was 52.4% - 66.5%. The radiological restoration of radial bow corelated with the clinical range of forearm supination and pronation.

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Figure 3: A Case of Galleazi fracture (a- preoperative x ray, b- immediate post op x ray, c- 6 months post op follow up x ray, d- functional outcomes at 6 months follow up

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Figure 4: A Case of both bone fracture nonunion (a- preoperative x ray, b- immediate post op x ray, c-6 months post op follow up x ray, d- functional outcomes at 6 months follow up

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Figure 5: A Case of both bone fracture mal union (a- preoperative x ray, b- immediate post op x ray, c-6 months post op follow up x ray, d- functional outcomes at 6 months follow up

Discussion:

Normal anatomy of Radius and Radial bow:

The Radius and Ulna maintain a parallel balance that is essential for the energy efficient forearm rotations. Volar surface of Radius is convex proximally and concave distally, vice versa for Dorsal radial surface. The dorsal and volar surface have significant muscle cover and are slightly curved mediolaterally due to the dorso- lateral radial bow. Hence this can create potential for error and mal reduction when straight

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plate is placed on the curved surface as some part of the plate has to remain off the bone (12). Furthermore the assessment of radial bow and the interosseous space is frequently obscured by the plate in the post-op AP X-ray,(3) and in practice also while using intra operative C arm screening.

Fixation methods and its Influence and importance on Radial bow:

Functions of the forearm depends on the combination of stability (both proximal and distal DRUJ) and rotational mobility of Radius on the Ulna (4) Non-surgical options are notorious for malunion and non-union. In the Fractures of the forearm, functional results depends on fracture union, forearm rotations in addition to mobility of the adjacent joints. Open reduction and plate fixation of the fractures of both bones forearm aims to achieve union and restore good function. Fracture reduction and rotational stabilisation are mandatory in addition to the restoration of anatomical radial bow which has positive correlation to its rotational movements (5). The maximum radial bow was present at 60 % of the radial length and the bow should be less than 10 percent of the radial length. The length of radius and bow alters with age but the site of maximum bow remains constant among different age groups (9) Loss of radial bow secondary to IM nailing impacts on the outcome of forearm rotations (1) especially when associated with malunion. Compression plating gives high rates of union and low rates of complications. Rigid fixation and early active mobilization are the keys to good functional outcome.

Nail versus plate fixation if forearm fractures:

The Displaced both bone forearm fractures or the Isolated radius fractures are unstable not only in the long axis but also rotationally. Intramedullary elastic nail is an inferior technique of fixation in terms of the rigidity. The advantages are being minimal incision, shorter operating time but will need increased radiation exposure. They restore the axial length but, they offer relative stability and are rotationally unstable. (11). Some of the newer generation interlocking intra medullary square nails may allow early mobilization (13).

The elastic titanium nails need additional period of splinting and delays the effective elbow and wrist mobilization. Although the studies on square nails claims negative relation to the DASH score, they found a significant positive correlation with the forearm rotations. (2). Lesser Angular deformity won't have much influence on forearm rotations but angulation of 20 degrees or more than that has significant rotational movements limitation(10). Studies that favour nail although claims to have restoration of rotations they fail to assess the precision, power and energy efficiency on repetitive rotational movements. Plate fixation of both bones or in the hybrid fixation (Plate for Radius and Elastic nail for ulna) restore bow ratio between than Intra medullary elastic nail fixation technique. (11). Although loss of upto 2 mm of magnitude of radial bow did not affect the functional outcome (6) When the bow magnitude differs from the contra lateral side, the effective muscle forces and the efficiency and the precision of the forearm pronation differs in the biomechanical studies (14). The clinical studies in favour of intra medullary nails for forearm fails to report on the precision, energy efficiency with forearm rotations and specifically the comparison of pronator teres functions.

Biomechanical advantages of Lateral Plate Fixation:

The lateral radial surface is uniformly curved representing lateral bow. The cross- section of the radius is triangular in most of its length, except in the proximal most part. Hence the screws placed through a lateral plate get far cortex purchase (bicortical purchase) in the interosseus border which is thick and strong. The biomechanical studies claim tension side plate fixation than its compression side in the presence of a bow surface. The straight plate on a bowed surface when placed volar or dorsal side cause plate eccentricity which can be avoided. The screw orientation also avoids potential irritation of extensor tendons which can happen with volar plate. A high volar plate may cause Biceps tendon impingement (8). It maintains the interosseus space and hence the biomechanical kinematics of pronation/supination of the forearm.

Limitations of study:-

1. Our study sample size is inadequate to draw a statistical significance.
2. We did not compare the radial bow with the opposite non-operated extremity.

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3. Not a comparative study with volar plating to claim the Biomechanical strength

Conclusion:

The lateral plating of radius is a viable alternative to the conventional dorsal and volar plating technique. It has the biomechanical advantage, ensures restoration of radial bow and thus achieves excellent functional outcome.

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