

A COMPARATIVE STUDY OF FUNCTIONAL OUTCOME OF DIFFERENT MODALITIES OF TREATMENTS FOR FRACTURES OF DISTAL END OF RADIUS

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ABSTRACT

BACKGROUND

Fractures of the distal end of radius are the most frequently occurring upper skeletal injuries managed by orthopaedic surgeons. Despite continuous refinement in treatment modalities, there is no consensus regarding the same.

MATERIALS AND METHODS

This prospective study was conducted on 80 patients with distal radial fractures after taking informed consent of the patients. Based on the fracture anatomy, different treatment protocols were assigned- a) Closed reduction and plaster cast application; b) Percutaneous K-wire fixation; c) External fixator application; and d) Open reduction and internal fixation with volar plate application. The fractures were classified with Frykman's classification. During the follow-up, functional parameters were assessed by the demerit point system of Gartland and Werley with Sarmiento et al modification and Mayo's wrist scoring.

RESULTS

Excellent to good results were obtained in most fractures treated by open reduction and internal fixation with volar plate and external fixation. Reduction was well-maintained, complications were less and functional parameters showed a significant improvement during the follow-up period.

CONCLUSION

External fixation and volar plating produce almost equivalent functional results in distal radial articular fractures with volar plating having better anatomical results than external fixation in the present study. Volar plate fixation of unstable distal radius fractures provides a stable construct that helps in early mobilisation, thereby achieving better functional outcomes and minimises chances of delayed/malunion. External fixator used for ligamentotaxis is an effective method of treating unstable extra-articular and complex intra-articular fractures of distal radius. Complication such as irregular articular surface, wrist pain, finger stiffness, malunion and K-wire loosening were observed. Thus, based on this study, we conclude that volar plating and external fixation have relatively better outcome for distal end radius fractures with minimum chance of implant failure and complications even in highly comminuted cases and cases having osteoporosis and should be preferred over the conventional treatment methods of percutaneous K-wire fixation and closed reduction with casting.

KEYWORDS

Distal Radial Fracture, Percutaneous Pinning, External Fixation, Volar Plating.

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BACKGROUND

The fracture of distal end radius is the most common fracture of upper extremity encountered in practice and constitutes 17% of all the fractures and 75% of all forearm fractures.¹ There are three main age groups of distal radial fracture occurrence. The first is between ages 5 to 14, the second in males under 50 years of age and the third is in females over the age of 40 years.²⁻⁴ Fractures of the distal radius usually occur as a result of high energy trauma in

younger individuals with good bone density and are associated with substantial articular and periarticular tissue injury.⁵ There is a growing incidence of these fractures in all the three groups with a significant increase in elderly females and young adult males. Distal radius fractures are the third most common fractures in osteoporotic fractures following vertebral and hip fractures.

In 1814, Abraham Colles first described the distal end radius fracture with characteristic deformities well before the advent of radiographs. Varying patterns of extra-articular and intra-articular radius fractures are common in adults. They are commonly referred to as Colles, Barton's or Smith's depending upon the pattern of involvement of the distal radioulnar and radiocarpal joint surface and displacement. Treatment of such injuries is often difficult and demanding, particularly when the fracture is severely comminuted or displaced as there is still a debate over the classification of

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the unstable distal radius fracture and there is no consensus regarding management of the same. Without proper assessment and timely treatment, collapse, loss of palmar tilt, radial shortening and articular incongruity are frequent and can often result in permanent deformity, pain and loss of function. The degree of residual deformity correlates with the degree of disability.

Management protocols for these fractures have undergone significant advancement over the preceding years. These can be treated conservatively using closed reduction and immobilisation in a plaster cast, which may lead to early displacement, hence skeletal fixation to maintain the reduction has been recommended. Other methods such as external fixation used for ligamentotaxis, percutaneous fixation with K-wires or plate osteosynthesis or combination of all the above have been advocated to achieve adequate reduction and stable fixation.

The present study was aimed at comparing the different modalities of treatment and measuring their effectiveness in treating the distal end of radius fractures with respect to functional outcome, complications, ease of application and cost effectiveness.

Objectives- The study was done to compare the functional outcome, complications, ease of application and cost effectiveness of different treatment modalities.

MATERIALS AND METHODS

This prospective study was conducted over a period from September 2015 to December 2016 and the detailed analysis of different modalities of treatment of fractures of the distal end radius was carried out. A total of 80 patients who presented to the emergency and outpatient departments of the Karnataka Institute of Medical Sciences, Hubli, Karnataka, with distal end radius fractures and fulfilling the inclusion/exclusion criteria were included.

Patients were included in the study, if they (1) had an undisplaced fracture of the distal radius; (2) had a displaced unstable comminuted fracture of the distal radius, which was defined as any distal radial fracture with more than 20 degree of dorsal angulation, metaphyseal comminution with or without intra-articular extension and more than 10 mm loss of radial height; (3) reported within 7 days of injury (fresh fracture); (4) had an age >20 years and <65 years; and (5) gave informed consent for operative care. The subjects were excluded, if they had (1) an open/severely comminuted fracture with bone loss; (2) a pathological fracture; (3) an Injury Severity Score (ISS) of >17; (4) an ipsilateral upper limb fracture; (5) a fracture of the scaphoid or scapholunate dissociation of the same wrist; (6) a pre-existing inflammatory or degenerative arthritis of the injured wrist, ipsilateral elbow or shoulder (which would affect the functional outcome); (7) associated arterial and neural injuries; and (8) patients noncompliant for postoperative physiotherapy and follow-up. Fractures of the ulna were noted separately.

Fractures were preoperatively managed by initial reduction to reduce pain and swelling and application of

dorsal slab. Fracture anatomy was studied by plain posteroanterior and lateral radiographs of the affected wrist joints. All the necessary clinical data was recorded using a proforma prepared for the study. Fractures were classified by the Frykman's classification.⁶

| Fracture | Distal Ulnar Fracture | |
|---|-----------------------|---------|
| | Absent | Present |
| Extra-articular | I | II |
| Intra-articular involving radiocarpal joint | III | IV |
| Intra-articular involving distal RU joint | V | VI |
| Intra-articular involving both radiocarpal and distal radioulnar joints | VII | VIII |
| Frykman's Classification | | |

Having concluded the diagnosis, preanaesthetic checkup was done and once the patient was declared fit, operative intervention was contemplated after explaining the details of surgery and written informed consent with cast for undisplaced extra-articular fractures, percutaneous fixation with K-wires for minimally displaced extra-articular and undisplaced stable intra-articular fractures, external fixation used for ligamentotaxis for unstable grossly comminuted intra-articular fractures and volar plating for displaced noncomminuted intra-articular fractures.

| Categories | Score | Findings |
|-----------------------------|--------|--|
| Pain (25 points) | 25 | No pain |
| | 20 | Mild pain with vigorous activities |
| | 20 | Pain only with weather changes |
| | 15 | Moderate pain with vigorous activities |
| | 10 | Mild pain with daily activities |
| | 5 | Moderate pain with daily activities |
| Satisfaction (25 points) | 0 | Pain at rest |
| | 25 | Very satisfied |
| | 20 | Moderately satisfied |
| | 10 | No satisfied, but working |
| Range of motion (25 points) | 0 | No satisfied, unable to work |
| | 25 | 100% percentage of normal |
| | 15 | 75-99% percentage of normal |
| | 10 | 50-74% percentage of normal |
| | 5 | 25-49% percentage of normal |
| | 0 | 0-24% percentage of normal |
| Grip strength (25 points) | 15 | 75-99% percentage of normal |
| | 10 | 50-74% percentage of normal |
| | 5 | 25-49% percentage of normal |
| | 0 | 0-24% percentage of normal |
| Final result (total points) | 90-100 | Excellent |
| | 80-89 | Good |
| | 65-79 | Fair |
| | <65 | Poor |

Table 1. Clinical and Functional Assessment by the Mayo's Wrist Score⁸

After operative treatment, patients were discharged and followed up in our outpatient department at specific intervals and were subjected to clinical examination and on the last follow-up were assessed according to the demerit point system of Gartland and Werley with Sarmiento et al modification⁷ and Mayo Wrist Scoring.⁸

| | 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 | 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 |
| End result point ranges | |
| Excellent | 0-2 |
| Good | 3-8 |
| Fair | 9-20 |
| Poor | 21 and above |

Table 2. Clinical and Functional Assessment by the Demerit Point System of Gartland and Werley with Sarmiento et al Modification⁷

RESULTS

The present study comprised of 80 patients of distal radius fractures, in which 25% patients were treated by plating, 37.5% by cast application, 25% by percutaneous K-wire application and 12.5% by external fixator. The minimum followup was for 12 weeks and the maximum was 36 weeks. Male patients (60%) outnumbered female patients (40%) and the average age of patients was 44.1 years with the range being 20-65 years. Fractures were more common in the dominant hand (65%). Road traffic accident was the commonest cause of the trauma (63.75%) followed by fall (22.5%) with fall on the outstretched hand being the commonest modality. 20% of our cases were with complex intra-articular fractures, i.e. Frykman type VII and VIII. Using the demerit point score system of Gartland and Werley with Sarmiento et al modification,⁷ we had 15 (75%) excellent results in volar plating, 7 (23.3%) in cast, 5 (25%) in K-wire fixation, 4 (40%) in external fixator, 3 (15%) good results in volar plating, 12 (40%) in cast, 9 (45%) in K-wire fixation, 4 (40%) in external fixator, 2 (10%) fair results by plating, 9 (30%) in cast, 5 (25%) in K-wire fixation and 1 (10%) in external fixator. There were 2 (6.6%) patients with poor result treated by cast application and 1 (10%) patient

each with poor result treated by external fixation and percutaneous K-wires.

| Demerit Score | Plate (%) | Cast (%) | K-Wire (%) | External Fixator (%) |
|---------------|-----------------|-----------------|-----------------|----------------------|
| Excellent | 15 (75) | 7 (23.3) | 5 (25) | 4 (40) |
| Good | 3 (15) | 12 (40) | 9 (45) | 4 (40) |
| Fair | 2 (10) | 9 (30) | 5 (25) | 1 (10) |
| Poor | 0 (0) | 2 (6.6) | 1 (5) | 1 (10) |
| Total | 20 (100) | 30 (100) | 20 (100) | 10 (100) |

Table 3. Distribution of Study Subjects on the Basis of the Demerit Point Score System of Gartland and Werley⁷

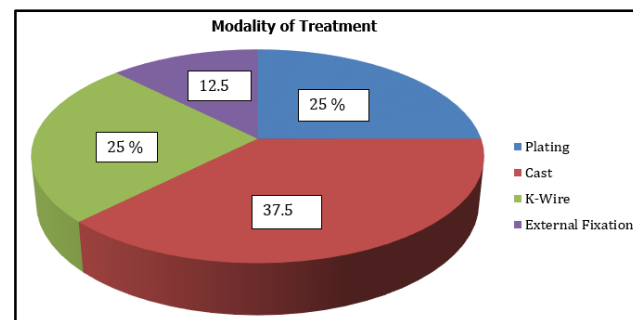


Figure 1. Percentage Distribution of Study Subjects on the Basis of Treatment Modality

| Results | Pain Intensity (%) | Functional Status | ROM (% of normal) | Grip Strength (% of normal) |
|--------------|--------------------|-------------------|-------------------|-----------------------------|
| Excellent | 51 (63.75) | 53 (66.25) | 50 (62.5) | 49 (61.25) |
| Good | 21 (26.25) | 20 (25) | 22 (27.5) | 22 (27.5) |
| Fair | 5 (6.25) | 4 (5) | 4 (5) | 5 (6.25) |
| Poor | 3 (3.75) | 3 (3.75) | 4 (5) | 4 (5) |
| Total | 80 (100) | 80 (100) | 80 (100) | 80 (100) |

Table 4. Distribution of Study Subjects on the Basis of the Mayo's Wrist Score⁸

Functional scoring by the Mayo's wrist score⁸ showed excellent to good results in almost 90% of the patients.

Complication such as irregular articular surface, wrist pain, finger stiffness, malunion and K-wire loosening was observed. Overall results with plating were better as compared to other groups followed by K-wire fixation and cast application. Restoration of radial length, radial inclination and volar angle was best achieved in volar plating group.

DISCUSSION

The fractures of the distal end of radius despite being the commonest upper extremity fractures continue to pose a therapeutic challenge. The aim is to regain the normal range of movements and anatomical integrity without pain. Treatment modalities have undergone significant advancements due to improved imaging techniques, which have provided a better understanding of fractures and explained the effects of the different injury types on fracture formation and factors that lead to instability. Conventional treatment methods like closed reduction and cast immobilisation and percutaneous K-wire fixation are associated with loss of reduction, K-wire loosening and

malunion, but give mixed results, if used for undisplaced extra-articular and minimally-displaced extra-articular and undisplaced stable intra-articular fractures, respectively. On the other hand, external fixation used for ligamentotaxis for unstable grossly comminuted intra-articular fractures and volar plating for displaced noncomminuted intra-articular fractures give excellent to good results.⁹

Distal end radius fractures are often treated nonoperatively with the use of rigid immobilisation with the acceptance of some degree of displacement and then the emphasis is placed on function.¹⁰ This remains the accepted treatment method for 75% to 80% of distal radius fractures that are minimally displaced and judged inherently stable. For adequate immobilisation, a snugly fitted cast with three point fixation is must. Cast application avoids surgical intervention and other related complications, but has been associated with deficient fixation and slackening of the reduction. Maintenance of distraction to correct the length or control the angular rotation of distal fragment in case of comminution is not adequate with cast. Other studies have observed a high incidence of displacement deformity in plaster cast treatment.¹¹

Percutaneous K-wire fixation is a simple and accepted treatment for both unstable intra-articular and extra-articular fractures. Techniques of percutaneous K-wire fixation have been divided into extrafocal and intrafocal types. Literature has described various named intrafocal techniques such as Kapandji¹² modified Kapandji, Lambotte's, DePalma's, Rayhack's, Stein's¹³ and Uhl's technique, etc. The use of these different techniques has not shown any difference in long-term clinical outcome. Biomechanical study on distal radius fractures showed that crossed K-wire fixation gives stable biomechanical construct. Injury to superficial nerve and extensor tendon is a known rare complication of percutaneous K-wire fixation.

External fixator provides a simple and a reliable means of treating unstable grossly comminuted intra-articular fractures according to the concept of ligamentotaxis that was proposed by Vidal et al.¹⁴ The aim is to maintain the distraction of intact ligaments in a complex comminuted fracture to restore the fragments in place and keep them in position till union is achieved.

External fixator was found to maintain the radial length best due to the sustained counter traction utilising the principle of ligamentotaxis. Thus, external fixation is considered as one of the better treatment option. Cooney et al⁸ had stressed the importance of anatomical correction and choose various methods of external fixation to achieve it. Pronation and supination was best restored with the use of an external fixator. Hence, a better range of motion is observed with the fixator. The better grip strength in the wrist treated by external fixation is probably due to a combination of decreased pain and better joint and muscle mechanics. Aro and Koivenum¹⁵ in a study on axial shortening of radius had reported similar findings and suggested that external fixation should always be considered if there are any signs of persistent axial shortening. External fixator maintains rigid fixation, but over distraction can lead

to- 1) Triangular fibrocartilage complex related problems; 2) Severe stiffness of wrist and hand; and 3) Collapse of fragments once fixator is removed.

In recent times, open reduction and plate fixation with either a volar or a dorsal incision has gained popularity. Depending on the extent of displacement and comminution of fracture, a combined volar and dorsal approach has also been described.¹⁶

Open reduction and internal fixation with locking and non-locking radius volar T-plate in adults is shown to restore articular congruity and restore excellent wrist function. It is often considered as the treatment of choice for fracture of distal radius especially in noncomminuted or mildly comminuted intra-articular fractures and is often required when closed manipulation has failed to restore articular congruity. Postoperative fracture alignment, articular congruity and radial length were significantly improved following surgery. The advantage of plating includes decreased rate of complication when compared with other treatment modality due to its strength and stability of construct that allows early wrist motion and enhances hand and finger functions, but they are expensive. Intra-articular penetration of distal screws is a worrisome complication leading to severe restriction of joint motion and secondary osteoarthritis over a period of time. Extensor tendon attrition due to long screws can lead to rupture of extensor tendon of wrist and abductor pollicis longus.

Over last decade, there have been numerous clinical trials that have tried to find the best method of management for displaced unstable comminuted distal radial fractures. A Cochrane review of the subject concluded that there is still no robust evidence to support any specific modality of treatment. Treatment is based on fracture type, patient's demand and characteristics, financial status and on treating surgeon's experience and preference. Each method has its own advantages and disadvantages. The modality of treatment has shifted from conservative to surgical management and especially plate osteosynthesis with time. There may be multiple reasons behind this increase mainly due to patient awareness and increased demand for anatomical fracture reduction, early mobilisation and rehabilitation and final important issue, affordability of patient, which has improved overall.

Our study has a few limitations. Most of our patients were active males below 60 years of age and had good bone stock. Hence, it may not be possible to extrapolate our results to an older age group or postmenopausal female patients with poor bone quality. The sample was not homogenous regarding the stages of classification system for comparison by different method of treatment, and therefore, the findings are inconclusive. The sample size of our study is limited to one centre and is very small to conclude very effectively. Many patients who were planned for plate osteosynthesis were managed by cast or K-wire due to financial constraints. Frykman's⁶ classification does not have any prognostic value. The major strength of our study is the 100% follow-up rate.

CONCLUSION

Thus, based on this study, we conclude that volar plating and ligamentotaxis have a relatively better functional outcome for fractures of the distal end of radius as compared to percutaneous k-wire fixation and closed reduction with cast application, particularly in cases of intra-articular fractures. Volar plating has excellent functional results in volar barton fractures with less chance of loosening of implant. Use of volar locking plate resulted in a faster recovery of function, better anatomical reduction and grip strength, compared with external fixation. Better functional outcome with volar locked plating can be ascribed to anatomical reduction and rigid fixation, and early mobilization post-operatively and to the absence of pin-site infections and post-operative immobilizations. Similarly, external fixator application proved to be an easy, cost-effective and reliable treatment modality in treating unstable comminuted intra-articular distal end of radius fractures, specially cases having osteoporosis and its functions on the "principle of ligamentotaxis". Recovery of movements was faster in patients who were operated upon than in those managed conservatively with cast or k-wire fixation. Therefore we propose that in the coming future, the modality of treatment of distal radial fractures should shift from conservative to surgical management and especially plate osteosynthesis as evident from its benefits but the vast difference in treatment costs should be taken into consideration when deciding on the treatment option.

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