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A Comparative Study Showing Elbow Kinematics in Radial Head Replacement Versus Radial Head Excision Versus Radial Head Fixation

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Abstract

Background: Radial head fractures are quite common with incidence 1.5-4% of all adult fractures. The management of these fractures depends upon age and type of injury.

Aim: To compare the outcome in comminuted radial head fractures(Mason type III) based on mayo elbow scoring and handgrip strength test when managed with radial head excision, radial head fixation or radial head replacement.

Material and Methods: We did a prospective comparative study comprising 60 patients between age 20-60 years with Mason type III radial head fractures. The patients were randomised using the admission day of the week placing 20 patients each in arthroplasty , excision and in the fixation group. The patients were followed up for 18-24 months postoperatively. Results were evaluated by the Mayo's elbow performance and Handgrip strength score at 6 months and 18 months and were statistically evaluated by one-way ANOVA test.

Results: As per Mayo's score at 6 months follow up, mean and standard deviation (SD) of the scores in arthroplasty was 83.25 and 11.50, for excision it was 76.25 and 11.38 & for fixation, it was 68.75 and 17.83 respectively. At 18 months follow up, mean and standard deviation was 90 and 12.56 for arthroplasty, 83 and 9.92 for excision & 76.25 and 21.69 for fixation respectively. As per handgrip strength score at 6 months follow up, mean and standard deviation of the scores in arthroplasty was 31.1 and 4.37, for excision it was 28.75 and 4.27 & for fixation, it was 27.15 and 5.94 respectively. At 18 months follow up, mean and standard deviation was 32.95 and 4.006 for arthroplasty, 30.7 and 4.06 for excision & 28 and 6.75 for fixation respectively. The difference between the results according to both Mayo's score as well as Handgrip strength test was statistically significant ($p < 0.05$).

Conclusion: Our study shows that long and short-term results of radial head replacement are better than radial head excision and radial head fixation in comminuted radial head fractures based on mayo elbow scoring and hand grip strength score

Keywords: Radial head fracture, Radial head replacement, Mason classification

Introduction

Radial head fractures accounts for approximately 4% of all fractures,10% associated with elbow dislocation and 33% of elbow fractures [1]. Radial head act as secondary stabilizer in medial collateral ligament deficiency and provides around 30% resistance to valgus. Radial head fracture thus needs to be replaced, fixed or excised to maintain stability at the elbow joint. Fractures of the radial head are classified according to Modified Mason's classification [2, 3].

In 1926 Cutler recognised direct trauma as the commonest cause of injury to the radial head [4]. According to static loading studies around 60% of the force is transmitted across the radiocapitellar articulation [5, 6]. Radial head excision has been a popular choice of management for comminuted fractures throughout the years and stiffness in the elbow as the most common complication following the fracture even in the undisplaced ones. For fixation ideally the fracture should have 3 or fewer fragments and these fragments must be large enough to accept a screw. Implants for radial head replacement have evolved over time from monoblock design to modular prostheses, few of which even have bipolar features. With the advent of different implant materials the chances of capitellar wear has also decreased. Comminuted radial head fractures can be managed by excision, fixation or arthroplasty of the radial head. The aim of our study is to compare the results of excision, fixation and arthrolplasty, in comminuted fractures of the radial head.

Material and Methods

The study comprises of 60 patients between the age group of 20 - 60 years (37 male, 23 female) with an average age of 50 years and study was conducted at Grant Government Medical College.

The inclusion criteria were as follows:

(1) Type 3 radial head fractures according to Mason's classification
(2) Age of patient between 20 -60 years
(3) Presentation within 2 weeks from trauma
(4) No ligament injury

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Exclusion criteria were as follows:
(1) Compound radial head fractures
(2) Radial head fracture associated with other fractures of upper limb
(3) Associated ligament injury with radial head fracture
Written informed consent was taken. Clinical examination and radiological evaluation was done. Pre-operative routine work up was done for the patients. Following randomisation, 20 patients each were included in the excision group , fixation group and the arthroplasty group.

The technique of Radial Head Excision (Figure 1)
Patient is supine with arm across the chest and affected elbow up. Incision is initiated superiorly to lateral condyle and extended 6 cm distally across the joint. Interval between extensor carpi ulnaris and anconeus is created and used to expose lateral capsule. Annular ligament is incised transversely. The fractured radial head was excised. Reconstruction of radial head is done on the operation table to avoid leaving any fragments behind. The wound was closed in layers.

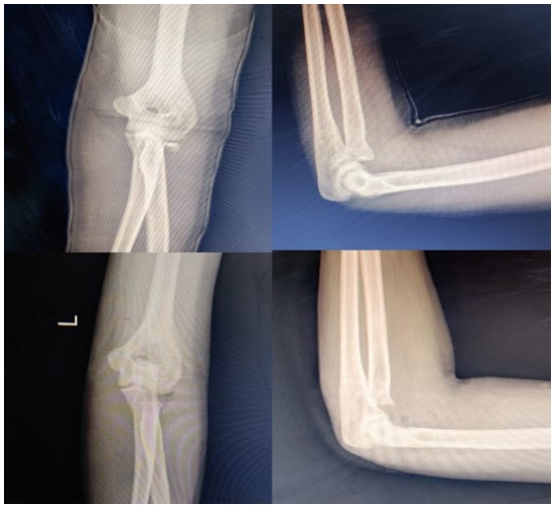

Figure 1 : Preop and Postop anteroposterior and lateral radiographs showing Radial Head Excision.

The technique of Radial Head Fixation (Figure 2)
Patient is supine with arm across the chest and affected elbow up. Incision is initiated superiorly to lateral condyle and extended 6 cm distally across the joint. Interval between extensor carpi ulnaris and anconeus is created and used to expose lateral capsule. Annular ligament is incised transversely. Fracture site exposed and cleaned. Primary reduction is fixed using k wires. Small plate is fixed on the lateral surface of proximal radius while keeping the wrist in neutral position. Annular ligament and lateral capsule repaired. The wound was closed in layers.

The technique of Radial Head Arthroplasty (Figure 3)
Patient is supine with arm across the chest and affected elbow up. Incision is initiated superiorly to lateral condyle and extended 6 cm distally across the joint. Interval between extensor carpi ulnaris and anconeus is created and used to expose lateral capsule. Annular ligament is incised transversely and radial neck is cut just proximal to fracture site. Head sizes with diameters of 14, 16, 18, and 20 mm with a

Figure 2 : Preop and Postop anteroposterior and lateral radiographs showing Radial Head Fixation.

Figure 3 : Preop and Postop anteroposterior and lateral radiographs showing Radial Head Replacement.

stem size of 5 mm were available. Reaming initiated with 3 mm size with 1 mm increment until size 5 mm. Trial prosthesis is used first and after satisfactory result and range of motion final implant is inserted. Lateral capsule and annular ligament repair done. The wound was closed in layers.

Follow Up
Immediately after the surgery active range-of-motion exercises of the elbow were started. Suture removal was done between 10^{th} to 12^{th} postoperative day. The cases were followed up after 2 weeks till 1 month, after that till the acceptable range of motion was regained. After that, the patient was followed up every 3 months. The results were analysed by the Mayo elbow performance score and Handgrip scoring system using dynamometer. One-way ANOVA test was done for statistical analysis . According to biomechanical studies activities of daily living can be performed without discomfort within a functional arc of motion of elbow flexion extension of 100°, and forearm rotation of about 100° (pronation 50° to supination 50°). Patients were evaluated at 6 and 18 months based on the Mayo Elbow Performance Score and Handgrip strength score.

Results

60 patients between the age group of 20 - 60 years were a part of the study, with average an age being 50 years. Study group had 37 male and 23 females. At 6 months, radial head arthroplasty gave excellent results in 10 patients, good in 7 patients and fair in 3 patients. In excision, there were 4 patients with excellent results at 6 months, 9 with good results and 7 with fair results. In fixation, there were 4 patients with excellent results at 6 months, 7 with good results and 9 with fair results. At 18 months, of the 20 patients who had undergone arthroplasty, 12 had excellent results, 5 patients had good results and 3 had fair results. Of the 20 patients who had undergone head excision, 8 had excellent results, 8 patients had good results and 4 patients had fair results. 6 of the 20 cases who had undergone radial head fixation had excellent results, good results were obtained in 5 cases and 8 patients showed poor results at 18 months. As per Mayo's score at 6 months follow up, mean and standard deviation (SD) of the scores in arthroplasty was 83.25 and 11.50, for excision it was 76.25 and 11.38 and for fixation, it was 68.75 and 17.83 respectively. At 18 months follow up, mean and standard deviation was 90 and 12.56 for arthroplasty, 83 and 9.92 for excision & 76.25 and 21.69 for fixation respectively. As per handgrip strength score at 6 months follow up, mean and standard deviation of the scores in arthroplasty was 31.1 and 4.37, for excision it was 28.75 and 4.27 & for fixation, it was 27.15 and 5.94 respectively. At 18 months follow up, mean and standard deviation was 32.95 and 4.006 for arthroplasty, 30.7 and 4.06 for excision & 28 and 6.75 for fixation respectively. The difference between the results according to both Mayo's score as well as Handgrip strength test was statistically significant ($p < 0.05$) as per the One-way ANOVA test.

.	Excellent	Good	Fair
Radial head arthroplasty(T1)	10	7	3
Excision(T2)	4	9	7
Fixation(T3)	4	7	9

Pairwise Comparisons using Hand Grip Score at 6 Months	p-value
T1:T2	0.294
T1:T3	0.036
T2:T3	0.563

Results at 6 months follow up

Using the One-way ANOVA test, for comparison between the three modalities of treatment as per the Hand Grip score at 6 months, the p-value is 0.046. The result is statistically significant ($p < 0.05$).

Pairwise Comparisons using Mayo's Score at 6 Months	p-value
T1:T2	0.211
T1:T3	0.004
T2:T3	0.257

Pairwise Comparisons using Mayo's Score at 6 Months

Using the One-way ANOVA test, for comparison between the three modalities of treatment as per the Mayo's Score at 6 months, the p-value is 0.006. The result is statistically significant ($p < 0.05$).

Results at 18 months follow up

.	Excellent	Good	Fair
Radial head arthroplasty	12	5	3
Excision	8	8	4
Fixation	6	5	9

Pairwise Comparisons using Hand Grip Score at 18 Months	p-value
T1:T2	0.351
T1:T3	0.009
T2:T3	0.224

Results at 18 months follow up

Using the One-way ANOVA test, for comparison between the three modalities of treatment as per the Hand Grip score at 18 months, the p-value is 0.012. The result is statistically significant ($p < 0.05$).

Pairwise Comparisons using Mayo's Score at 18 Months	p-value
T1:T2	0.336
T1:T3	0.191
T2:T3	0.362

Pairwise Comparisons using Mayo's Score at 18 Months

Using the One-way ANOVA test, for comparison between the three modalities of treatment as per the Mayo's Score at 18 months, the p-value is 0.025. The result is statistically significant ($p < 0.05$).

At 6 months	Arthroplasty	Excision	Fixation
Mayo score	83.25±11.50	76.25±11.38	68.75±17.83
Hand grip strength score	31.1±4.37	28.75±4.27	27.15±5.94

Mayo score and hand grip strength score at 6 months

At 18 months	Arthroplasty	Excision	Fixation
Mayo score	90±12.56	83±9.92	76.25±21.69
Hand grip strength score	32.95± 4.006	30.7±4.06	28±6.75

Mayo score and hand grip strength score at 18 months

Pain, which was moderate to severe, was present in 1 out of 20 cases of radial head Arthroplasty, 2 out of 20 cases of excision and 3 out of 20 cases of fixation. Pre-operatively no neurological defecit was present in any of the patients. Posterior interosseous nerve palsy occurred in one patient who had undergone a radial head excision which recovered after 7 months of follow-up. One out of 60 operated patients had a postoperative infection of the wound which was kept on daily dressing and under higher antibiotic coverage, which resolved uneventfully in 2 weeks.

Discussion

With various surgical options(ORIF,excision and arthroplasty) available for the management of Mason type III radial, the treatment protocol to be preferred still remains a grey area in the filed of orthopaedics. Proximal radial epiphysis has a scanty blood supply. It is supplied by small intraarticular vessels and a few intraosseous vessels [7]. Yamaguchi et al concluded in their study that intraosseous vessels are the primary blood supplier to radial head [8]. For fixation ideally the fracture should have 3 or fewer fragments and these fragments must be large enough to accept a screw for fixation and should have minimal metaphysial bone loss, thus making fixation a difficult entity. Fixation leads to complications like osteonecrosis, nonunion, or displaced fragments [9].

Author	Year of publication	No. of patients	Type of treatment
Daphne et al	2004	8 cadaveric upper extremities	Effect of elbow excision and arthroplasty on elbow kinematics and stability
Ikeda et al	2005	28 patients	15 patients – Radial head resection 13 patients - Fixation
Hao Sun et al	2016	319 patients	181 patients – Arthroplasty 138 patients - Fixation
Sinha et al	2020	23 patients	6 patients – Excision 10 patients – Arthroplasty 7 - Fixation
Heim	1998	120 patients	92 patients – Fixation 28 patients - Excision
Ring et al	2002	56 patients	Radial head fixation
Herbertsson et al	2004	61 patients	Radial head excision
Shetty et al	2017	40 patients	20 patients – fixation 20 patients - excision

According to a study conducted by Daphne et al on the effect of radial head excision and arthroplasty on elbow kinematics and stability, radial head excision alters the kinematics and varus-valgus laxity of the elbow which can be improved after radial head arthroplasty [10]. The prosthetic replacement of fractured radial head helps in maintaining longitudinal radioulnar stability and radicapitellar relationship. Ikeda et al in their study concluded that fixation of comminuted radial head fracture gave better outcome in comparison to excision [11]. Swensen et al, in their study about maximising outcomes in treatment of radial head fractures, concluded that current evidence supports open reduction and internal fixation of simple Mason type II fractures whereas good to excellent results have been seen with radial head replacement in patients with Mason type III fractures [12]. Hao Sun et al, revealed that radial head arthroplasty has better outcome than ORIF in patients with modified Mason type III and IV radial head fractures [13]. According to Sinha et al, radial head fractures with ligamentous and other bony injuries like coronoid/olecranon fractures, radial head osteosynthesis has better outcomes than radial head arthroplasty, although it is not statistically significant [14]. Radial head excision though has acceptable outcomes but there is a statistically significant restriction of movements especially flexion–extension [14]. Management of comminuted radial head fracture by open reduction and internal fixation is difficult and can lead to poor functional outcome. Non-united radial head fractures may be accompanied by articular injury to the capitellum and radial notch of the ulna and lead to elbow arthrosis.

Heim described avascular necrosis and non-union of 6 of 10 complex whole-head fractures after open reduction and internal fixation [15].

Ring et al,[17] noted that 4 of 15 comminuted type II fractures recovered less than 100° forearm rotation, and 10 patients with type III fractures had failure of fixation or non-union. Specifically, among the 14 patients with Mason type III fractures with more than 3 articular fragments, 3 had failure of fixation, 6 had non-union, and 4 recovered less than 100° forearm rotation. Result was satisfactory in only 1 patient.

According to Herbertsson et al, radial head excision leads to a good or fair result [17]. Shetty et al concluded that patients who were managed with open reduction and internal fixation had better functional outcome than those managed with radial head excision [18]. But, replacement of the unsalvageable radial head with a metallic prosthesis and acute repair of the torn collateral ligaments optimizes joint stability and allows early safe active motion in these patients [19]. Excision of the radial head might lead to stiffness, weakness and pain [17]. Our study indicated that radial head arthroplasty has better outcomes in modified mason type III fractures.

Limitations

This study has certain limitations, which have implications for its interpretation. The small sample size of patients and follow up till only 18 months makes it difficult to make long term conclusion regarding the best management for such fractures. To rule out ligament injury clinical assessment and intra operative assessment was done as magnetic resonance imaging could not be done for all the patients.

Conclusion

In this study, we found that radial head arthroplasty is preferred method in comparison to radial head excision and fixation, for modified Mason type III radial head fractures due to the better long term functional outcomes as evident from Mayo Elbow Performance Score and Handgrip strength test.

Declaration of patient consent : The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his/her consent for his/her images and other clinical information to be reported in the Journal. The patient understands that his/her name and initials will not be published, and due efforts will be made to conceal his/her identity, but anonymity cannot be guaranteed.

Conflict of Interest: None, **Source of Support:** None

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