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Dr. Ampolu Atchuta Rao
Associate Professor, Department of Orthopaedics, Andhra Medical College, Visakhapatnam, Andhra Pradesh, India

Dr. Namballa Srinivasa Rao
Junior Resident, Department of Orthopaedics, Andhra Medical College, Visakhapatnam, Andhra Pradesh, India

Corresponding Author:
Dr. Ampolu Atchuta Rao
Associate Professor, Department of Orthopaedics, Andhra Medical College, Visakhapatnam, Andhra Pradesh, India

Evaluation of functional outcome of prosthetic replacement of comminuted radial head and neck fractures in young adults

Dr. Ampolu Atchuta Rao and Dr. Namballa Srinivasa Rao

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Abstract
Introduction: The radial head fracture is the most common type of elbow fracture, occurring in between 2.5% and 2.9% of the general population per every 10,000 people.
Women are more likely than men to suffer from radial head fractures, which most usually happen between the 20 years and 60 years.
"Mildly displaced and un-displaced fracture radial head typically occur independently of the capitellum, coronoid, or proximal ulna, while highly comminuted and displaced fractures frequently injure the collateral ligaments".
Dislocations of elbow joint also happen in high energy trauma. The Essex-Lopresti lesion, which is characterized by interosseous membrane damage and distal radial ulnar joint ligament, may cause forearm axial instability.
The radial neck or head fractures are usually non-displaced or minimally displaced injuries. Conservative treatment of these fractures typically yields a satisfactory functional outcome.
Aim of The Study: To assess functional results of replacing the broken radial neck and head fractures with a radial head prosthesis
Materials and Methods: The study was provisionally approved by the institutional ethics committee, Andhra medical College, visakhapatnam.
This prospective study of comminuted radial head fractures treated by radial head prosthesis was done at the Department of Orthopedics, King George Hospital, Andhra Medical College, Visakhapatnam, from September 2020 to september 2022 Over a period of 2 years with in my academic years from May 2020 to May 2022.
Conclusion: The elbow, radioulnar joint, or wrist joint won't be impacted by excision of radial head in a comminuted fracture of radial head, contrary to earlier expectations.
And yet, multiple studies have shown that for the elbow joint to remain stable and for the DRUJ complex to be intact, the proximal radioulnar joint must be intact.
A non-repairable radial head fracture can be replaced with a prosthetic to give the damaged limb a reliable basis for long-term use.
Therefore, we draw the observation that the radial head arthroplasty is technically superior than excision or osteosynthesis in the extremely demanding world of today. It offers a far better functional result than the other two operations.
This study has several restrictions. Despite being a prospective research, subjects were only followed for a brief time. As a result, a study with sophisticated methodology and a long follow-up period is required to properly evaluate the efficacy of the prosthesis used in radial head arthroplasty.

Keywords: Intraarticular fractures, plating, internal fixation

Introduction

The radial head fracture is the most common type of elbow fracture, occurring in between 2.5% and 2.9% of the general population per every 10,000 people. Women are more likely than men to suffer from radial head fractures, which most usually happen between the 20 years and 60 years.
"Mildly displaced and undisplaced fracture radial head typically occur independently of the capitellum, coronoid, or proximal ulna, while highly comminuted and displaced fractures frequently injure the collateral ligaments".

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Inclusion criteria
1. "Mason type 2,3,4 radial head fracture
2. Radial neck fracture
3. Age greater than 18 years
4. patients who do not have any major comorbid conditions"

Exclusion Criteria
- "Mason type I radial head fracture
- Ageless than18 years
- Age more than 45 years
- Concurrent neurovascular injuries
- Complex fractures
- Congenital malformation".

Surgical Technique
Preoperative planning
- Prior to surgery, the patient or a relative provided informed written consent.
- A single dose of tetanus toxoid and antibiotic was administered 1 hour prior surgery.
- "The elbow and axilla were prepared the day before surgery.
- Throughout the preoperative period, the injured elbow was kept in a rigid, above-elbow slab, and all of the surgical tools and implants were checked and sterile.
- On an operating table, supine, with the injured arm pronated over the chest".
- The limp can be exsanguinated by raising it for three to five minutes, using a soft rubber bandage, or by employing an exsanguinator.

Operative Procedure
- Anesthesia type: supraclavicular block
- In all cases, a pneumatic tourniquet was used.
- A curved incision is made over the lateral humeral epicondyle's posterior side and continues medially and downward to a position over the ulna's posterior border, about 6 cm from the olecranon's tip.
- "The extensor carpi ulnaris muscle is split, and the top of the anconeus muscle is cut off from the lateral epicondyle of the humerus or interval between ECRB and EDC.
- To move the posterior interosseous nerve out of the path of the operating field during deep surgical dissection, the forearm is totally pronated.
- A cut down the middle of the elbow, which shows the radial head, capitulum, and annular ligament

Surgical Technique
"After thorough dissection, severing the annular ligament is required to radial head and neck exposure for prosthesis insertion. After removing any loose pieces, the neck of radius can be cut with an oscillating saw at the head/neck joint or at the fracture site. The majority of radial head prosthesis are fixed bearing monoblock with dimensions equivalent to a true radial neck and head. The diameter and thickness of the radial head prosthesis can be optimised by reassembling the removed sections on the back table after removing them from the elbow. This verifies that the entire radial head has been removed. While the diameter of an artificial radial head should be comparable to that of a real radial head, the articular dish should be smaller. The minor diameter of the elliptical native head of radius is utilised to calculate the implant diameter, which is usually two millimetres smaller than the maximum diameter". An implant with a too wide diameter could result in residual instability, poor annular ligament closure and the lateral trochlea erosion. A smaller prosthesis is chosen in both thickness and diameter when choosing between sizes.
Apply pressure on the rear of the ulna by wrapping a Homan retractor around the radial neck. Radial neck preparation done with serial rasping, In order to allow the stem of prosthesis to move slightly in the neck and track optimally with the capitellum, choose a stem that is one mm smaller than the largest diameter neck rasp. The radial head should articulate at the proximal radial ulnar joint, which is typically two mm distal to the coronoid tip, following the implantation of the trial implants. For consistent monitoring of the radial head implant on the capitellum, a thorough visual and fluoroscopic examination is needed. Radial head over lengthening cannot be detected using radiographic criteria. After confirmation, cemented is mixed in manual method and wraped around stem of radial head prosthesis of desired size and kept inside the radial canal and reduced. To ensure elbow stability after the placement of the final radial head prosthesis, the annular ligament and any associated osseous and ligament damage must be meticulously treated.

Postoperative Protocol
Patients were instructed to move their fingers and shoulders, as well as raise the affected limb. When the two days were up, the suction drain was taken out. The cut was checked after three days. The first three postoperative days were spent receiving IV antibiotics and pain medication. Sutures were removed on day 10 or 12, and X-rays were collected in both the frontal and lateral planes. After patients were given arm pouches and instructions on how to move their elbows, shoulders, fingers, and wrists, they were released from the hospital. There should be no strain placed on the injured upper limb, thus patients shouldn't try to carry anything heavy or use it for any other purpose.
Patients were told to return to the ortho OPD for follow-up appointments at six weeks, twelve weeks, and every three months after they were discharged. The post-op progress was checked in on every three months. Patients were subjectively assessed for symptoms such pain, edoema, and restricted joint motion during each follow-up clinical examination. By employing CPM, we were able to instruct patients in active flexion extension and pronation supination physiotherapy

Outcome Assessment

MAYO ELBOW PERFORMANCE SCORE

Adapted from: Gill DR, JBJS 1998;80A:1327

Criteria	Points	Patient Score
Pain (45 points)		= 45
None	45	
Mild	30	
Moderate	15	
Severe	0	
ROM		
>100 degrees	20	= 20
50-100 degrees	15	
<50 degree	5	
Stability (10 points)		= 10
Stable	10	
Moderate instability	5	
Gross instability	0	
Daily function (25 points)		= 25
Combing hair	5	
Feeding oneself	5	
Hygiene	5	
Putting on shirt	5	
Putting on shoes	5	
	Patient Score=	100

> 90 points = excellent, 75 to 89 points = good, 60 to 74 points = fair, and less than 60 points = poor

Stable = no apparent varus-valgus laxity clinically, moderate instability = less than 10 degrees of varus-valgus laxity, and gross instability = at least 10 degrees of varus-valgus laxity.

Fig 1: Mayo Elbow Performance Score

The Functional outcome was assessed by using the MAYO Elbow Performance Score

Case

Fig 2: Pre-Op X-ray

Fig 3: Post op X-ray

Fig 4: Intraoperative Radial Head Prosthesis

Fig 5: Post Op Supination

Fig 6: Neutral Position with Scar

Fig 7: Post-Operative Pronation

Observation and Results

1. During our study, we made the following observations.
2. "From SEPTEMBER 2020 to SEPTEMBER 2022, 11 patients with radial head fractures were treated in our hospital with radial head replacement.
3. Every one of the 11 cases met the inclusion criteria. No one refused to participate in the study.
4. 11 patients with radial head fractures were treated surgically with radial head replacement and were followed for an average of 12 months.
5. The cases' average age was 33 years (range 18 – 45 years). Half of the patients were between the ages of 30 and 40".
6. There were eight males and three females. Males dominated our research.
7. 9 fractures on the right side and 2 on the left side • RTA was responsible for 63.6% of the fractures 36.4% were caused by an unintentional fall.
8. The MASON radial head fracture classification system was used to categorise the fractures, which were all simple (closed) fractures.
9. "Mason type II fractures accounted for 18.2% of all fractures, Mason type III for 54.5%, and Mason type IV for 27.3%".
10. None of the patients had any concomitant injuries, and none had nerve damage due to fractures before surgery. None of them had ever had elbow problems before.
11. Within 7 days, 9 patients (81.8%) underwent surgery. Surgery was performed on 2 patients (18.2%) between eight and fourteen days.
12. All of the patients had bone cement-assisted radial head replacement surgery. There were no difficulties throughout the operation.
13. "Seven patients experienced elbow stiffness, which was managed with routine physiotherapy sessions and CPM. The average surgical time was 1 hour, with a range of 45 to 90 minutes".
14. Most of the patients later made progress.
15. One patient experienced transient PIN palsy after surgery, which resolved spontaneously after three weeks.
16. There had been no cases of heterotopic calcification.
17. "During the one-year follow-up period, none of them developed implant loosening or capitio humeral arthritis.
18. No patients were missed for follow-up
19. After three months, eight patients had FAIR MEPS scores, three had GOOD MEPS scores, and none had EXCELLENT MEPS scores.
20. At 6 months, two patients had FAIR MEPS scores and three patients had GOOD MEPS scores. Six patients received an EXCELLENT MEPS score.
21. At the 12-month follow-up, 1 patient had a FAIR and GOOD MEPS score, while 9 patients had an EXCELLENT MEPS score".

Statiscal Analysis

Table 1: Age Incidence in this study, 54% of the 11 patients are between the ages of 31 and 40".

Age in years	Frequency	Percentage
20 TO 30	3	27.3%
31 TO 40	6	54.5%
41 TO 45	2	18.2%
Total	11	100%

Table 2: Sex Incidence there are 72.7% male patients and 27.3% female patients in this study.

Sex	Frequency	Percentage
Male	8	72.7%
Female	3	27.3%
Total	11	100%

Table 3: Side of Injury In 81.8% of cases, the right side was involved, while the left side was involved in 18.2% of cases

Side	Frequency	Percentage
Right	9	81.8%
Left	2	18.2
Total	11	100%

Table 4: Mode of Injury The majority of patients (65%) had a history of an unintentional fall

Mode of Injury	Frequency	Percentage
Accidental fall	4	36.4%
RTA	7	63.6%
Total	11	100%

Table 5: Fracture Distribution Type

Fracture type	Frequency	Percentage
Mason type 2	2	18.2%
Mason type 3	6	54.5%
Mason type 4	3	27.3%
Total	11	100%

Table 6: Interval between injury and surgery most of the patients operated with in 7days after injury

Time of interval	No. of cases	Percentage
0 to 7 Days	9	81.8%
8 to 14 Days	2	18.2%
Total	11	100%

Table 7: Complications Seven patients developed elbow stiffness, and one developed pin palsy

Complications	Frequency	Percentage
Pin Palsy	1	0.90%
Elbow Stiffness	7	63.6%
Heterotopic calcification	0	0
Capitohumeral Arthritis	0	0
Implant Loosening	0	0

Table 8: Functional Outcome

Follow up	Case with fair mayo score	Case with excellent mayo score	Cases with excellent mayo score
3 Months	8	3	0
6 Months	2	3	6
12 Months	1	1	9

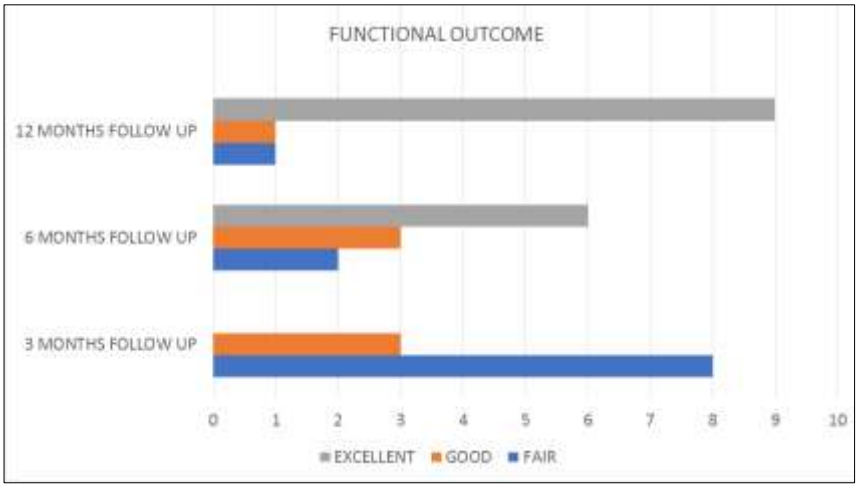

Fig 8: Functional Outcome

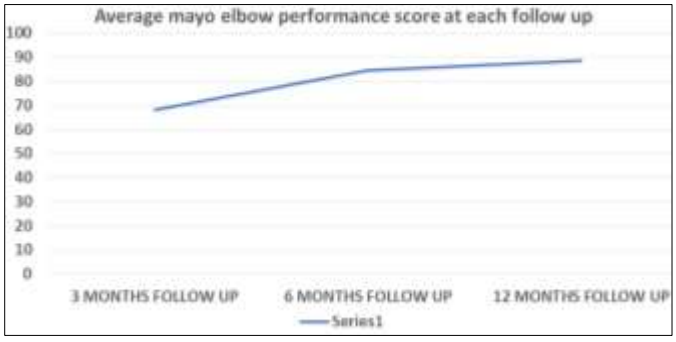

Fig 9: Average mayo elbow performance score at each follow up

At the outset, the vast majority of patients scored moderately well on the MAYO elbow. After 6 months and 12 months of follow-up, the majority of patients showed improvement, with good and excellent MAYO elbow performance scores.

Standard Deviation

Standard deviation is calculated by using below formula

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2},$$

Count, N:
Sum, Σx:
Mean, $\bar{x}$:
Variance, s^2

Standard error of mean calculated by using below formula

$$s_{\bar{x}} = \frac{S}{\sqrt{N}} = 2.2452889154961$$

Based on standard error of mean
Mean mayo elbow performance score at 1 year is 86.6+/-4.4 with 95% confidence interval

Discussion

Fractures of the radial head can be treated in a different variety of ways, which including open-reduction and internal-fixation (ORIF), radial head resection (RHR), and prostheses (P), but the commonest of all treatments are [25] osteosynthesis and replacement. This is because these procedures can reconstruct both the radial-head and the radio-humeral contact, both of which are necessary following most traumas and fractures.

The head of radius of an adult is supplied by intraosseous arteries that go vertically from the radius neck to the head of the radius. This is because the radial epiphysis is completely confined inside the articular capsule.

Yamaguchi showed that the head of the radius is directly supplied by a vessel that enters through the non-articular anterolateral side of the neck. Because of this, the epiphysis may become avascular after a neck fracture.

Successful osteosynthesis does not always prevent stiffness, instability, and pain of the elbow after a fracture, especially when the fracture fragments are comminuted or the dislocation is significant, as seen in Mason's type-III and IV fractures.

In these situations, prosthetization or head of the radius excision are the surgical options.

The surgical alternatives in these circumstances include [26, 27] prosthetization or head of the radius removal.

The stem's stability,
The head's dimensions,
The head's height and the humeroradial joint's stability.

The success of the intervention depends on accuracy in following these procedures.

It is crucial to achieve a good fit of the stem during implantation because this will lower the risk of mobilisation.

The [28, 29] stem should also be as large and stable as possible, and measure the diameter of the removed radial head, and be positioned well that it's equal to the existing capitulum.

The [30, 31] height of the prosthesis should be kept below the coronoid in the antero-posterior and lateral projections to ensure a proper fit between the head and the sigmoid-notch of the ulna [32].

Examine the radial ligamentous complex for damage and repair it as needed to keep the implant and joint stable.Resection [33] is frequently indicated because it may be beneficial in some patients with acute comminution of the head of the radius fractures. Clinical results were found to be good or excellent after 15-17 years of follow-up, however post-traumatic alterations like the elbow and wrist arthrosis, proximal radial migration, and a valgus carrying angle were seen [34].

The head of the radius functions as a secondary stabiliser to reduce the effects of valgus stress.The head of the radius fractures are best treated by amputation because of the extensive damage to the lateral-collateral-ligament complex.

Early 1980s saw the introduction of silicone [35] (Silastic) implants, with initially encouraging results noted; however, longer-term follow-up data indicated issues with failure of the prosthesis and silicone-synovitis.

Most of head of radius prostheses currently in use are made of metal [36] because it is durable and helps to maintain the elbow's valgus stability after the replacement of radial head, which are issues with silicone radial head replacements.

When an elbow dislocation is involved, head of the radius fractures are usually amputated right away because they eventually break up and can't be fixed. Damage to the lateral-ulnar-collateral ligament, which is mostly a tear, can cause an unstable elbow.

Both a low coronoid fracture and a ruptured medial collateral ligament are examples of more complicated related injury patterns.

Putting in a radial-head implant is advised for joint stabilization.

If the head of the radius has been broken and the [37] distal radio-ulnar joint is displaced, a prosthetic replacement of radial head may prevent upward migration of the radius after a simple excision of head of radius.

Any of these conditions could call for the prosthetic radial head placement to help stabilise elbow, get the patient back to DOIng exercises that increase their ROM as soon as possible.

To avoid elbow dislocation, migration of the proximal radius, and excessive instability after certain elbow injuries and forearm axis, prosthetic radial heads were developed [38].

When an injury or sickness has considerably damaged the joint of elbow, radial forearm axis, and distal radioulnar joint, it is permissible to contemplate excision of head and prosthetic head of radius replacement.

Arthroplasty of head of radius was found to be been more efficient than ORIF for comminuted radial head fractures, at least in the short term.

Now a days, we can select from a great variety of radial head implants, including both monoblock and modular prostheses. The inclusion of bipolar characteristics and alternative materials in some of these implants may reduce the likelihood of capitellar wear.

21 subjects that were initially participated in our investigation were evaluated at their recent most visit, and basing on the data collected, 17 received excellent, three received acceptable, and one received fair (between 6 - 30 years).

"There were nil instability cases, degeneration of wrist cases, or restricted elbow flexion. 11 patients were found with mild elbow degeneration; eight had lost elbow extension, one had restricted pronation, and two had restricted supination".

Pain persisted for four of the patients. The investigators suggest Mason type-lII fractures be treated with resecting and mobilisation to avoid permanent functional impairment.

Outcomes of thirty-six fractures of head of radius were analysed retrospectively; of these, 16 subjects had Mason type-III fractures managed by excision of head of radius.

31 out of 36 subjects (31%) reported feeling satisfied with how good their elbows functioned. Nine out of the 36 participants said they were in different levels of pain. Of the 36 participants, 19 reported having arm weakness.

Eleven patients with Mason type III fractures had their radial heads replaced with a bipolar prosthesis, and their functioning and rates of complications were studied by Popovic and co [39]. 4 patients had excellent outcomes, 4 had good outcomes, 2 had acceptable outcomes, and one had poor outcomes, as determined by a modified Morrey scoring system at average follow-up of 32 months.

One patient with several injuries to the involved upper limb experienced a terrible prognosis.

The outcomes for eight patients were great, five were good, three were acceptable, and none were poor. Patients who postponed surgery experienced all three positive outcomes.

For Mason type 3 fractures, the authors reached a positive conclusion, and they stressed the need of early mobilisation in preserving elbow ROM and function.

In the current study, 11 patients with radial head fractures between the ages of 18 and 45 had radial head underwent replacement surgery, and the results of their functional recovery were assessed.

At one year after receiving titanium radial head arthoplasty, 11 patients in our study (8 men and 3 women) with comminuted fractures of radial head had exceptional MEPS scores, 9.1% (1) had good MEPS scores, and 9.1% had fair MEPS scores.

Seven patients had stiff elbows, which were treated with routine PT and CPM. Most of the patients later made progress. After surgery, 1 patient suffered brief PIN palsy, which disappeared on its own three weeks later.

According Broberg and Morrey Score, in fresh fractures, there were two exceptional results and three good results, while in older fractures, there were one excellent result, four good results, and two fair results.

The results of a multicenter trial involving a bipolar radial head prosthesis were published by Smets *et al*. after a mean follow-up of 25.2 months.

Thirteen cases of Mason type III fractures were examined, all of which were treated with radial head prostheses. The median age was 46.

According to Smets *et al*., average active flexion was 135.5°, average active pronation was 79.3°, and average active supination was 83°.

MEPI Score indicated that 7 were excellent, 3 were good, 1 was fair, and 2 were poor". One patient had to have their prosthesis removed because of a poor outcome

Conclusion

Elbow, radioulnar joint, or wrist joint won't be impacted by excision of radial head in a comminuted fracture of radial head, contrary to earlier expectations.

And yet, multiple studies have shown that for the elbow joint to remain stable and for the DRUJ complex to be intact, the proximal radioulnar joint must be intact.

A non-repairable radial head fracture can be replaced with a prosthetic to give the damaged limb a reliable basis for long-term use.

Therefore, we draw the observation that the radial head arthroplasty is technically superior to excision or osteosynthesis in the extremely demanding world of today. It offers a far better functional result than the other two operations.

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