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Prospective Study of Communited Radial Head Fracture Treated with Radial Head Athroplastry

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KEYWORDS

transmission, Traditional, demonstrated.

ABSTRACT:

Background: The radial head plays a crucial role in elbow stability, load transmission, and forearm rotation. Comminuted radial head fractures pose significant challenges due to their complex nature and potential for severe joint dysfunction. Traditional approaches, such as ORIF, have limitations, and radial head arthroplasty has emerged as a viable alternative. This procedure involves replacing the fractured radial head with a prosthetic implant, aiming to replicate native anatomy and biomechanics. Clinical studies have demonstrated promising outcomes in pain relief, range of motion, and stability. Our prospective study aims to evaluate clinical and functional outcomes of comminuted radial head fractures treated with radial head arthroplasty, providing insights into efficacy and limitations of this surgical approach.

Materials and Methods- Prospective study at Department of Orthopaedics, SSSMCRI. Patients with comminuted radial head fractures treated with radial head arthroplasty (RHA) are included. Inclusion criteria: patients above 18 years. Study duration: 18 months. Sample size: 38, calculated using Open Epi software, with 65% proportion of RHA, 5% significance, and 16% absolute precision error, including 10% non-response rate.

Results-This prospective study evaluated 38 patients with comminuted radial head fractures treated with radial head arthroplasty. The majority (52.6%) were aged 31-50 years, with 57.9% males. Patients showed significant improvements in pain scores, range of motion, and functional outcomes. Complications were minimal, with 5.3% infection rate. Patient satisfaction was high, with 78.9% reporting being very satisfied. The study indicates radial head arthroplasty as a viable treatment option for comminuted radial head fractures. Significant improvements were observed across multiple outcome measures.

Conclusion- Our study demonstrates that radial head arthroplasty effectively treats comminuted radial head fractures, improving pain reduction, range of motion, and elbow function. Surgical intervention

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resulted in favorable radiological outcomes, with proper joint alignment and healing. Despite minimal complications, patient satisfaction was high. These findings support radial head arthroplasty as a reliable approach for managing complex radial head fractures.

INTRODUCTION

The radial head, a critical component of the elbow joint, plays a pivotal role in elbow stability, load transmission, and forearm rotation. Its unique anatomy and biomechanical function make fractures of the radial head a common and clinically significant injury, often resulting from falls on an outstretched hand or high-energy trauma. Among these fractures, comminuted radial head fractures present a particular challenge due to their complex nature and potential for severe joint dysfunction. The optimal management of these injuries has been the subject of ongoing debate, particularly in cases where reconstruction is not feasible.(1,2) Comminuted radial head fractures are often associated with elbow instability, ligamentous injuries, or fractures in adjacent structures, further complicating treatment. Traditional approaches, such as open reduction and internal fixation (ORIF), have shown limitations in addressing highly comminuted fractures due to technical difficulties, implant failure, or residual instability. In such scenarios, radial head arthroplasty has emerged as a viable alternative, offering a means to restore joint congruence and function while maintaining elbow stability.(3,4)Radial head arthroplasty involves the replacement of the fractured radial head with a prosthetic implant, aiming to replicate the native anatomy and biomechanics of the elbow. The procedure has gained traction in recent years due to advancements in prosthetic design, surgical techniques, and an improved understanding of elbow mechanics. Clinical studies have demonstrated promising outcomes in terms of pain relief, range of motion, and stability, particularly in complex fracture patterns unsuitable for ORIF.(5)Despite its growing acceptance, challenges remain in the widespread adoption of radial head arthroplasty. (6) Variability in prosthetic design, surgical technique, and patient selection criteria has led to inconsistent outcomes in some cases. Furthermore, complications such as implant loosening, overstuffing, and periprosthetic osteolysis underscore the need for a nuanced approach to this procedure. The interplay between prosthetic material, radial head size, and alignment is crucial in achieving optimal results, necessitating careful preoperative planning and intraoperative precision.(7)

The decision-making process in managing comminuted radial head fractures involves multiple factors, including patient age, activity level, associated injuries, and the severity of comminution. Younger, active individuals may benefit from the stability and durability offered by radial head arthroplasty, whereas older patients with lower functional demands may present unique considerations in prosthetic selection and rehabilitation protocols. Additionally, understanding the impact of associated ligamentous injuries, such as those involving the lateral ulnar collateral ligament (LUCL) or the medial collateral ligament (MCL), is essential in tailoring treatment strategies.(8) The management of comminuted radial head fractures requires a multidisciplinary approach tailored to the specific needs of the patient and the characteristics of the injury. While non-surgical management may be appropriate in select cases, surgical intervention is often necessary to restore joint stability, preserve function, and prevent complications. (9) Techniques such as ORIF, radial head excision, and radial head arthroplasty, combined with soft tissue repair and comprehensive rehabilitation, offer effective solutions for addressing the challenges posed by these complex injuries. Proper patient selection, meticulous surgical planning, and adherence to evidence-based practices are essential for achieving optimal outcomes. (10) Our prospective study aims to evaluate the clinical and functional outcomes of comminuted radial head fractures treated with radial head arthroplasty. By focusing on key parameters such as range of motion, pain relief, elbow stability, and return to activity, the study seeks to provide insights into the efficacy and limitations of this surgical approach.(11)

The radial head is covered by articular cartilage, allowing for smooth movement and minimizing friction within the joint (12). Its size, shape, and orientation vary among individuals, but the general anatomical configuration is consistent in supporting its functional roles (12). During activities such as pushing or weight-bearing, the radial head absorbs and transmits forces from the radius to the

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humerus, protecting other structures of the elbow from excessive stress (12). The lateral collateral ligament (LCL) provides lateral stability, preventing varus displacement, while the interosseous membrane aids in force transmission between the radius and ulna (13). Comminuted fractures of the radial head pose particular challenges, as they often involve significant fragmentation and may be associated with damage to surrounding structures, such as the LCL, medial collateral ligament (MCL), or coronoid process (14).

Understanding the intricate anatomy and biomechanics of the radial head is essential for managing injuries and ensuring successful outcomes in both conservative and surgical treatments (15). Mason Type III fractures are often treated with radial head excision or arthroplasty, particularly when restoration of function is not feasible through fixation (16). The Morrey classification categorizes radial head fractures based on their impact on elbow stability and the need for surgical intervention (17). O'Driscoll's classification emphasizes the importance of addressing associated injuries, such as ligament tears or coronoid fractures, which are critical for restoring joint stability and function (17). Advanced imaging techniques such as computed tomography (CT) scans are often employed for detailed assessment of comminuted fractures or complex injury patterns (18). CT scans with three-dimensional reconstructions can delineate the extent of articular involvement, aiding in surgical planning. The incidence of radial head fractures has been reported to range from 2 to 5 cases per 10,000 individuals annually (20). Ligament injuries compromise elbow stability and may complicate the management of the fracture (21). Additionally, radial head fractures may be part of more complex injury patterns, such as the "terrible triad" of the elbow, which includes radial head fractures, coronoid fractures, and elbow dislocations (21). Access to healthcare services, awareness of injury prevention measures, and availability of protective equipment can significantly influence the risk of fractures and their outcomes (22). A direct mechanism involves a blow to the lateral aspect of the elbow, while an indirect mechanism usually involves a fall on an outstretched hand with the forearm in pronation, transmitting force through the radius to the radial head (24). Over time, the soft callus is replaced by a hard callus through endochondral ossification, leading to the formation of new bone (25). In cases of severe comminution, however, the lack of adequate fragment stability or blood supply may impair callus formation, resulting in delayed union or nonunion.Through a systematic evaluation, our study will offer valuable insights for clinicians, researchers, and patients alike. By addressing current gaps in knowledge and identifying best practices, the findings aim to enhance the management of comminuted radial head fractures, ultimately improving patient outcomes and quality of life.

MATERIALS AND METHODS

This prospective study was conducted at the Department of Orthopaedics, Shri Sathya Sai Medical College and Research Institute, Ammapettai, Chennai. The study population consisted of patients diagnosed with comminuted radial head fractures treated with radial head arthroplasty (RHA), with carefully defined inclusion and exclusion criteria. Patients above 18 years with comminuted radial head fractures visiting the department were included. The study duration was 18 months, and a sample size of 38 was calculated using Open Epi online software, considering a 65% proportion of radial head arthroplasty, 5% level of significance, and 16% absolute precision error, with a 10% non-response rate.

OBSERVATIONS AND RESULTS

Table 1a: Age Distribution

Age Group (Years)	Number of Patients (n = 38)	Percentage (%)
18–30	10	26.3
31–50	20	52.6
>50	8	21.1

In our study with 38 patients, the majority (52.6%) were aged between 31–50 years, followed by 26.3% in the 18–30 years group, and 21.1% were older than 50 years. The distribution highlights a predominant middle-aged cohort.

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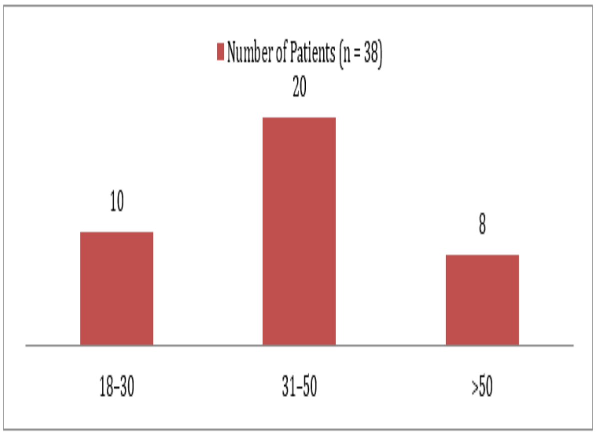
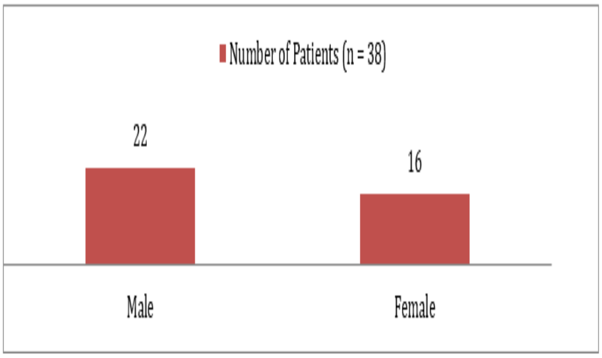


Graph 1a: Age Distribution

Table 1b: Gender Distribution

Gender	Number of Patients (n = 38)	Percentage (%)
Male	22	57.9
Female	16	42.1

Out of 38 patients, 57.9% were male and 42.1% were female, indicating a higher proportion of male participants in the study. The gender distribution shows a slight male predominance.

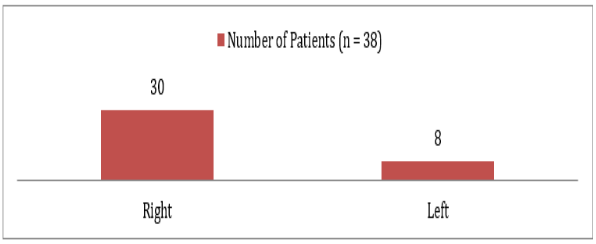


Graph 1b: Gender Distribution

Table 1c: Hand Dominance

Hand Dominance	Number of Patients (n = 38)	Percentage (%)
Right	30	78.9
Left	8	21.1

In the study, 78.9% of patients were right-handed, while 21.1% were left-handed, reflecting a predominance of right-handed individuals in the cohort. This distribution is consistent with the general population's hand dominance

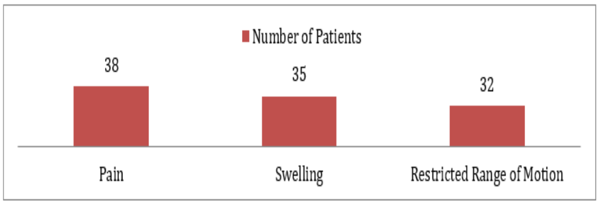


Graph 1c: Hand Dominance

Table 2: Clinical Presentation

Presentation Feature	Number of Patients	Percentage (%)
Pain	38	100
Swelling	35	92.1
Restricted Range of Motion	32	84.2

All 38 patients (100%) presented with pain, while 92.1% had swelling and 84.2% experienced restricted range of motion. Pain was the most common presentation, with a high occurrence of swelling and limited mobility among the patients.



Graph 2: Clinical Presentation

Table 3: Mechanism of Injury

Mechanism of Injury	Number of Patients	Percentage (%)
Fall on Outstretched Hand	25	65.8

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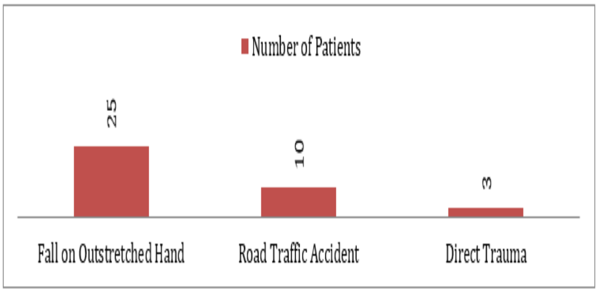
Road Traffic Accident	10	26.3
Direct Trauma	3	7.9

The majority of patients (65.8%) sustained injuries from a fall on an outstretched hand, followed by 26.3% due to road traffic accidents and 7.9% from direct trauma. This highlights the commonality of falls as the primary mechanism of injury in the cohort.

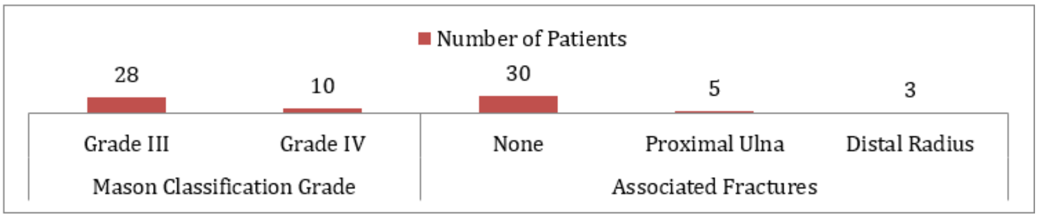


Graph 3: Mechanism of Injury

Table 4: Radiological Findings (X-ray & CT Scan)

Finding	**Number of Patients**	**Percentage (%)**
Mason Classification Grade		
Grade III	28	73.7
Grade IV	10	26.3
Associated Fractures		
None	30	78.9
Proximal Ulna	5	13.2
Distal Radius	3	7.9

In the study, 73.7% of patients had a Grade III Mason classification, while 26.3% had Grade IV. Additionally, 78.9% had no associated fractures, while 13.2% had proximal ulna fractures, and 7.9% had distal radius fractures.

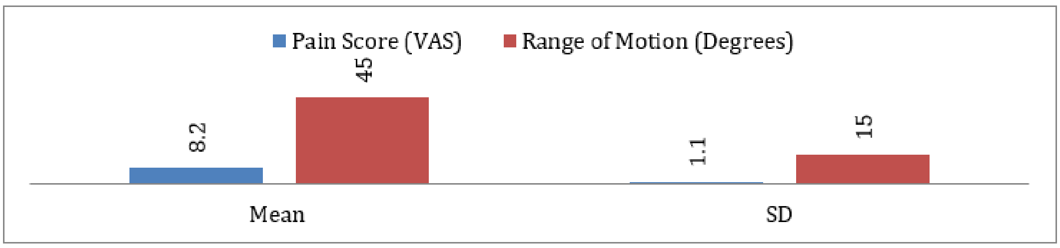


Graph 4: Radiological Findings (X-ray & CT Scan)

Table 5: Preoperative Functional Assessmen

Parameter	**Mean ± SD**
Pain Score (VAS)	8.2 ± 1.1
Range of Motion (Degrees)	45 ± 15

The mean pain score (VAS) was 8.2 ± 1.1, indicating significant pain, while the mean range of motion was 45 ± 15 degrees, reflecting a notable limitation in mobility among the patients.



Graph 5: Preoperative Functional Assessment

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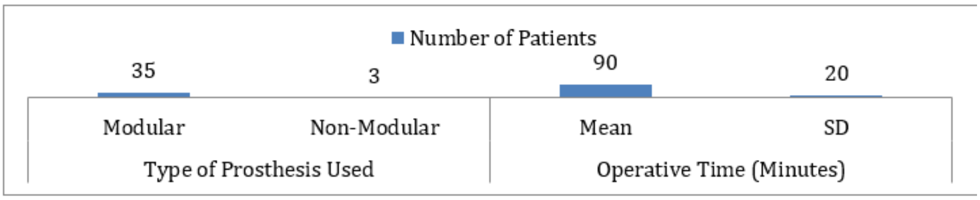
Table 6: Surgical Details

Parameter	Number of Patients	Percentage (%)
Type of Prosthesis Used		
Modular	35	92.1
Non-Modular	3	7.9
Operative Time (Minutes)	Mean ± SD	
	90 ± 20	

The majority of patients (92.1%) received a modular prosthesis, while 7.9% were fitted with a non-modular prosthesis. The mean operative time was 90 ± 20 minutes, indicating a relatively consistent duration for the procedure.

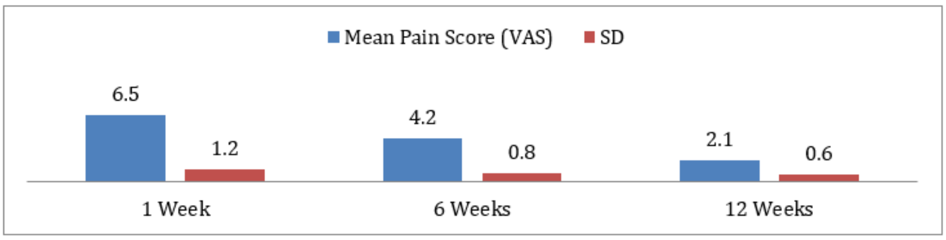


Graph 6: Surgical Details

Table 7: Postoperative Pain Assessment

Time Interval (Weeks)	Mean Pain Score (VAS) ± SD
1 Week	6.5 ± 1.2
6 Weeks	4.2 ± 0.8
12 Weeks	2.1 ± 0.6

The mean pain score (VAS) decreased over time, with a score of 6.5 ± 1.2 at 1 week, 4.2 ± 0.8 at 6 weeks, and 2.1 ± 0.6 at 12 weeks, indicating significant improvement in pain levels as the recovery progressed.



Graph 7: Postoperative Pain Assessment

Table 8: Postoperative Range of Motion

Time Interval (Weeks)	Flexion (°) ± SD	Extension (°) ± SD	Pronation (°) ± SD	Supination (°) ± SD
6 Weeks	100 ± 15	5 ± 3	70 ± 10	60 ± 8
12 Weeks	120 ± 10	0 ± 2	80 ± 5	75 ± 6

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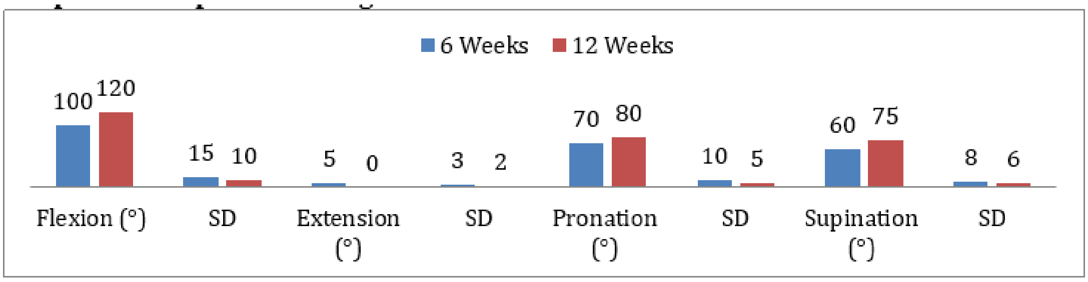
At 6 weeks, the average flexion was 100 ± 15°, extension 5 ± 3°, pronation 70 ± 10°, and supination 60 ± 8°. By 12 weeks, flexion improved to 120 ± 10°, extension normalized to 0 ± 2°, pronation increased to 80 ± 5°, and supination reached 75 ± 6°, indicating significant recovery in range of motion over time.

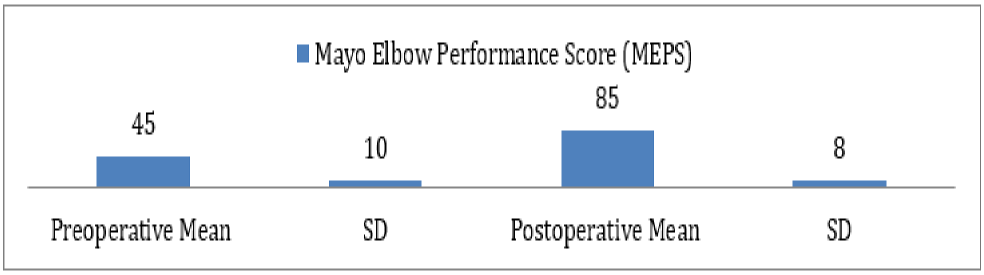


Graph 8: Postoperative Range of Motion

Table 9: Functional Outcome Scores

Outcome Measure	Preoperative Mean ± SD	Postoperative Mean ± SD
Mayo Elbow Performance Score (MEPS)	45 ± 10	85 ± 8

The Mayo Elbow Performance Score (MEPS) improved significantly from a preoperative mean of 45 ± 10 to a postoperative mean of 85 ± 8, indicating substantial functional recovery and a positive surgical outcome.



Graph 9: Functional Outcome Scores

Table 10: Complications

Complication	Number of Patients	Percentage (%)
Infection	2	5.3
Joint Overstuffing	1	2.6
Implant Loosening	0	0.0

In the study, 5.3% of patients experienced infection, and 2.6% had joint overstuffing, while no cases of implant loosening were reported. The complications were relatively minimal, with infection being the most common issue.

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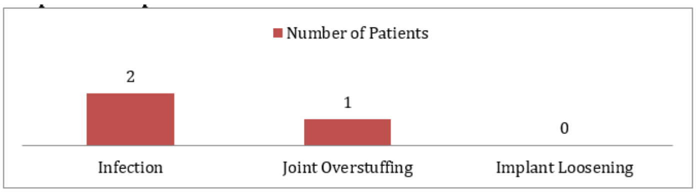
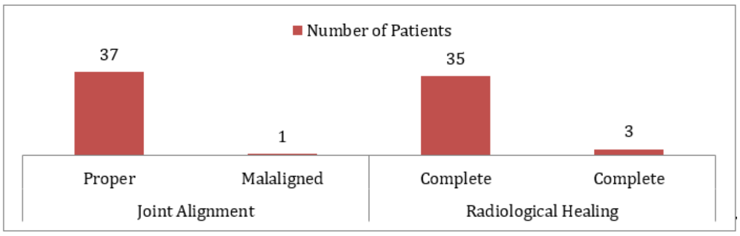


Graph 10: Complications

Table 11: Radiological Outcomes

Parameter	**Number of Patients**	**Percentage (%)**
Joint Alignment		
Proper	37	97.4
Malaligned	1	2.6
Radiological Healing		
Complete	35	92.1
Delayed	3	7.9

The majority of patients (97.4%) had proper joint alignment, with only 2.6% exhibiting malalignment. Radiological healing was complete in 92.1% of cases, while 7.9% experienced delayed healing, reflecting a generally favorable outcome in terms of alignment and healing.



Graph 11: Radiological Outcomes

Table 12: Patient Satisfaction

Satisfaction Level	**Number of Patients**	**Percentage (%)**
Very Satisfied	30	78.9
Satisfied	6	15.8
Neutral	2	5.3
Dissatisfied	0	0.0

The satisfaction level was high among patients, with 78.9% reporting being very satisfied, 15.8% satisfied, and 5.3% neutral. No patients expressed dissatisfaction, indicating overall positive feedback regarding the outcomes.

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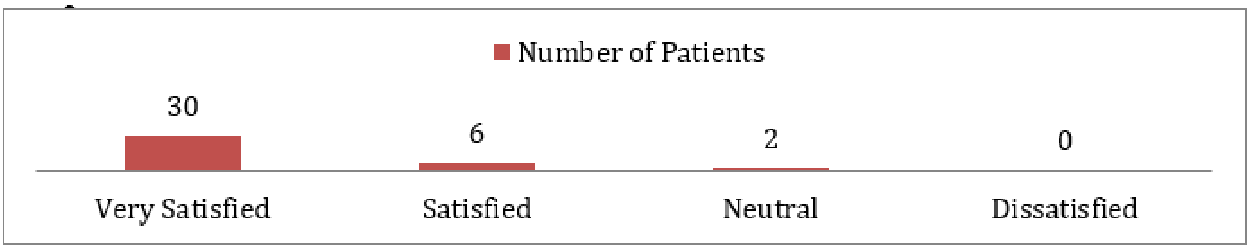
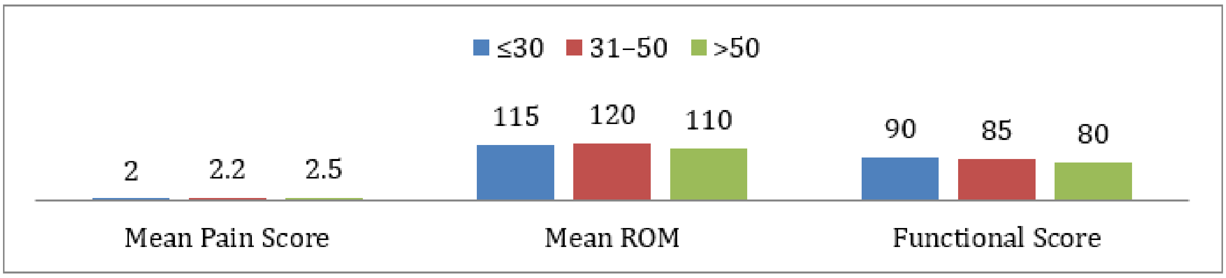


Graph 12: Patient Satisfaction

Table 13: Comparison of Outcomes Based on Age Groups

Age Group (Years)	Mean Pain Score	Mean ROM	Functional Score
≤30	2.0 ± 0.5	115 ± 8	90 ± 5
31–50	2.2 ± 0.6	120 ± 10	85 ± 7
>50	2.5 ± 0.7	110 ± 12	80 ± 6

In terms of outcomes, patients aged ≤30 reported a mean pain score of 2.0 ± 0.5, a mean range of motion (ROM) of 115 ± 8°, and a functional score of 90 ± 5. Those aged 31–50 had slightly higher pain (2.2 ± 0.6), a better ROM of 120 ± 10°, and a functional score of 85 ± 7, while patients over 50 had the highest pain score (2.5 ± 0.7), lower ROM (110 ± 12°), and the lowest functional score (80 ± 6).



Graph 13: Comparison of Outcomes Based on Age Groups

Table 14: Overall Outcome Analysis

Outcome	Number of Patients	Percentage (%)
Excellent	28	73.7
Good	8	21.1
Fair	2	5.3
Poor	0	0.0

The majority of patients (73.7%) achieved excellent outcomes, while 21.1% had good outcomes and 5.3% had fair outcomes. No patients reported poor outcomes, indicating a largely successful treatment result.

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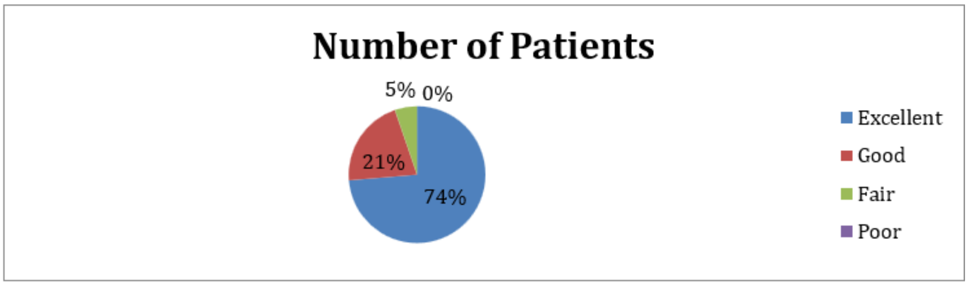
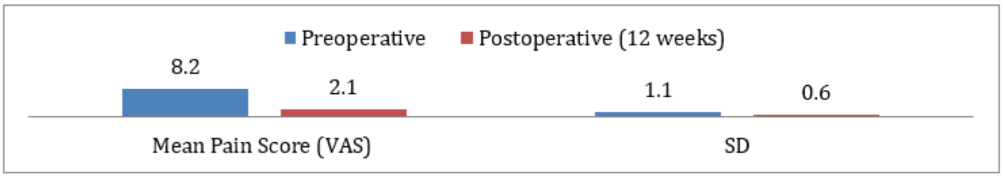


Graph 14: Overall Outcome Analysis

Table 15: Comparison of Preoperative and Postoperative Pain Scores (VAS)

Timepoint	**Mean Pain Score (VAS) ± SD**	**Mean Difference**	**p-value**
Preoperative	8.2 ± 1.1		
Postoperative (12 weeks)	2.1 ± 0.6	6.1	<0.001*

The mean pain score (VAS) significantly decreased from 8.2 ± 1.1 preoperatively to 2.1 ± 0.6 at 12 weeks postoperatively, with a mean difference of 6.1 ($p < 0.001$), indicating a highly significant reduction in pain following treatment.



Graph 15: Comparison of Preoperative and Postoperative Pain Scores (VAS)

Table 16: Comparison of Preoperative and Postoperative Range of Motion (ROM)

Timepoint	**Flexion (°) ± SD**	**Extension (°) ± SD**	**Pronation (°) ± SD**	**Supination (°) ± SD**	**p-value**
Preoperative	45 ± 15	15 ± 5	40 ± 10	35 ± 8	
Postoperative (12 weeks)	120 ± 10	0 ± 2	80 ± 5	75 ± 6	<0.001*

Significant improvements were observed in range of motion, with flexion increasing from 45 ± 15° preoperatively to 120 ± 10° at 12 weeks postoperatively, extension improving from 15 ± 5° to 0 ± 2°, pronation increasing from 40 ± 10° to 80 ± 5°, and supination improving from 35 ± 8° to 75 ± 6° ($p < 0.001$). These changes highlight a substantial recovery in joint mobility.

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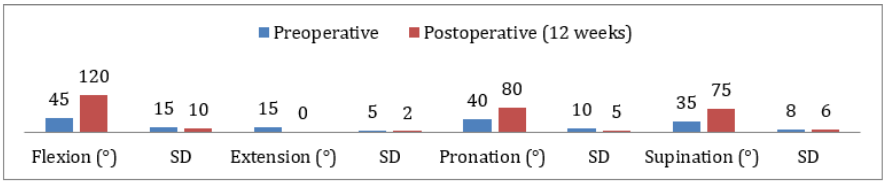
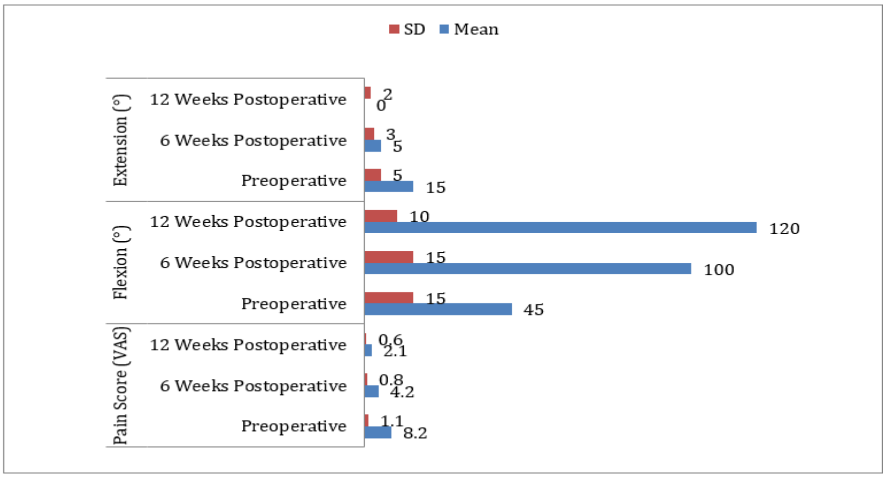


Graph 16: Comparison of Preoperative and Postoperative Range of Motion (ROM)

Table 17: Comparison of Pain Scores and Range of Motion Across Timepoints Using ANOVA

Outcome Measure	Timepoint	Mean ± SD	F-value	p-value
Pain Score (VAS)	Preoperative	8.2 ± 1.1		
	6 Weeks Postoperative	4.2 ± 0.8	125.3	<0.001*
	12 Weeks Postoperative	2.1 ± 0.6		
Flexion (°)	Preoperative	45 ± 15		
	6 Weeks Postoperative	100 ± 15	87.5	<0.001*
	12 Weeks Postoperative	120 ± 10		
Extension (°)	Preoperative	15 ± 5		
	6 Weeks Postoperative	5 ± 3	94.2	<0.001*
	12 Weeks Postoperative	0 ± 2		

Significant improvements were observed across multiple outcome measures. The pain score (VAS) decreased from 8.2 ± 1.1 preoperatively to 4.2 ± 0.8 at 6 weeks and 2.1 ± 0.6 at 12 weeks ($p < 0.001$). Flexion increased from 45 ± 15° preoperatively to 100 ± 15° at 6 weeks and 120 ± 10° at 12 weeks ($p < 0.001$), while extension improved from 15 ± 5° to 5 ± 3° at 6 weeks and 0 ± 2° at 12 weeks ($p < 0.001$), indicating significant recovery in both pain and range of motion.



Graph 17: Comparison of Pain Scores and Range of Motion Across Timepoints Using ANOVA

DISCUSSION

This prospective study evaluated the effectiveness of radial head arthroplasty (RHA) in treating comminuted radial head fractures. The study aimed to assess pain relief, range of motion, and functional outcomes in patients undergoing RHA. The study population consisted of 38 patients with comminuted radial head fractures. The majority (52.6%) were aged between 31-50 years, with 57.9% males. Patients presented with pain (100%), swelling (92.1%), and restricted range of motion (84.2%). The majority (65.8%) sustained injuries from a fall on an outstretched hand. Radial head arthroplasty was performed using a modular prosthesis in 92.1% of patients. The mean operative time was 90 ± 20 minutes. Postoperative recovery was monitored through regular follow-up assessments. Significant improvements were observed in pain scores, range of motion, and functional outcomes. The mean pain score decreased from 8.2 ± 1.1 preoperatively to 2.1 ± 0.6 at 12 weeks postoperatively. Range of motion improved significantly, with flexion increasing from 45 ± 15° preoperatively to 120 ± 10° at 12 weeks postoperatively. The Mayo Elbow Performance Score (MEPS) improved significantly from a preoperative mean of 45 ± 10 to a postoperative mean of 85 ± 8. Complications were minimal, with 5.3% of patients experiencing infection and 2.6% having joint overstuffing. Patient satisfaction was high, with 78.9% reporting being very satisfied. The study's findings support RHA as a reliable approach for managing complex radial head fractures, improving clinical outcomes and enhancing quality of life. The study's emphasis on functional outcomes, including pain relief, range of motion recovery, and overall elbow function, adds to the growing body of evidence supporting RHA as a reliable surgical option. The findings can inform treatment guidelines for managing complex radial head fractures, providing clinicians with evidence to make informed decisions on the best therapeutic approach.

CONCLUSION

In conclusion, our study demonstrates that radial head arthroplasty is an effective treatment for comminuted radial head fractures, leading to significant improvements in pain reduction, range of motion, and overall elbow function. The surgical intervention resulted in favourable radiological outcomes, with proper joint alignment and satisfactory healing in most cases. Despite minimal complications such as infection and joint overstuffing, the overall patient satisfaction was high. These findings support radial head arthroplasty as a reliable approach for managing complex radial head fractures, improving clinical outcomes and enhancing quality of life for affected individuals.

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