Original research article

Outcome Analysis of Radial Head Replacement in Comminuted Radial Head Fractures

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Abstract

Radial head fractures are the most common fractures around elbow in adults and occurs due to fall on the outstretched hand with the wrist extension and the forearm pronation. Comminuted radial head fractures can jeopardise the stability of the elbow and forearm. Radial head excision can lead to elbow instability in coronal plane . Radial head replacement restores the lateral column and ensures stability.

Aims: To assess the outcome of radial head replacement in comminuted Radial head fractures

Study Design: A prospective interventional study

Methods and Material: 28 patients of comminuted radial head fractures were managed with radial head replacement using mono bloc , cemented radial head prosthesis, at a tertiary institute of Bhopal, India from December 2019 to May 2021.

Statistical analysis used: paired t test

Results: After a mean follow up of 5.6 months Broberg and Morrey score is good to execellent in 89% patients with mean score of 86 and 90% patients had VAS score mild (<2).

Conclusions: Radial head arthroplasty gives good to excellent results in short term for most of the cases for treatment of Comminuted radial head fractures.

Key-words: Radial head replacement, comminuted radial head fractures, radial head prosthesis

Introduction

Radial head fractures are the most common fractures in elbow, which account for an estimated 33% of all elbow fractures and 1.7% to 5.4% of all fractures in adults , and frequently associated with ligamentous, cartilaginous, or other bony injuries, typically after a fall on the outstretched hand with the wrist extended and the forearm pronated[1,6].

Radial head fractures are more common in women than men and most frequently occur between the age of 20 & 60 years . Undisplaced and minimally displaced radial head fractures typically occur as isolated injuries while more displaced and comminuted fractures commonly have associated injuries to the collateral ligaments and may have associated fractures of the coronoid, capitellum, or proximal ulna. In high energy trauma, dislocations of the elbow and/or forearm can also occur. Disruption of the interosseous membrane and distal radio-ulnar joint ligaments may result in axial instability of the forearm, termed the Essex–Lopresti lesion.[3,6]

The majority of radial head and neck fractures are minimally displaced and are isolated injuries. These fractures typically have a good functional outcome with nonsurgical treatment. While comminuted radial head fractures can jeopardise the stability of the elbow and forearm. For isolated comminuted fractures excision can give good results. When there are associated ligament injuries, elbow instability in the coronal plane may become apparent after radial head excision alone. Radial head replacement restores the lateral column and ensures stability.[6]

The radial head is involved in secondary stability of the elbow. However, when the medial collateral ligament is injured in a ‘‘terrible triad’’ injury or when radial head fracture is associated with an Essex-Lopresti lesion, fixation or replacement of the radial head is mandatory.[3] Although conservation of the native radial head remains the ‘‘gold standard’’ for radial head fracture, a high number of complications occur after fixation of >3 fragments or when fixation is not stable.[3] Radial head resection results in variation of elbow joint kinematic with long-term radioulnar instability and ulnocarpal conflict. Moreover, determining whether radial head fracture is isolated in Mason type III fractures is difficult, and in those cases, radial head excision results in proximal migration of the radius, cubitus valgus deformation, and finally humeroulnar arthritis. Radial head replacement is then often recommended to avoid these complications. The radial head can be replaced as an initial procedure for acute unreconstructable fractures by itself or in association with other procedures for cases of terrible triad injury or Essex Lopresti lesions.[3]

In complex fractures of the radial head, conservative treatment is sometimes impossible and dictates resection. Elbow stability is therefore compromised due to the dual loss of the lateral bone capital and the frequently associated lesions of the medial collateral ligament. Over the long term, loss of the radial head causes the radial collateral ligament to get overstrained, a source of secondary instability and osteoarthritis. Therefore, preservation or reconstruction of the external side with a radial cup prosthetic implant is indispensable .

In general , Mason type I fractures are treated conservatively with early range of motion, Mason type II fractures are treated by open reduction and internal fixation or conservatively, and most Mason type III fractures are replaced.[11] In particular, the radial head should be replaced when the secondary stabilizing function of the radial head is required, as is the case with fracture of 25% to 50% of the coronoid process, disruption of the medial collateral ligament, disruption of the lateral collateral ligament, or acute longitudinal radioulnar dissociation. Radial head arthroplasty can also be a salvage procedure after failed osteosynthesis or failed conservative treatment.

Current radial head prosthesis designs can be classified as loosely or rigidly fitting.[2] Loose, or “unfixed” stems, have smooth shafts and are placed in an uncemented fashion, which allows stem motion to occur within the medullary canal . Press-fit, cemented, or other “fixed” stem designs intend to rigidly secure the implant within the canal of the radial neck.[2]

Prosthesis can also be classified as monobloc and modular. Modular prostheses can be categorized as monopolar or bipolar. Moreover, intramedullary stems can be cemented or uncemented or can have a “controlled expansion shaft.” The uncemented stems can be loose in the medullary canal or fixed with a porous design.[4] Instability, implant overstuffing, periprosthetic osteolysis, ectopic bone formation, degenerative arthritis, and capitellar wear are recognized complications of the procedure, regardless of the prosthetic design.[5]

Aim
To assess the functional outcome of radial head replacement in comminuted Radial head fractures.

Material and Methods
This study is a prospective study conducted at Gandhi medical college and Hamidia hospital, between November 2019 to May 2021, includes 28 cases of comminuted radial head fractures.

Inclusion criteria :
- Comminuted Radial head fractures
- Age group 18-60 years
- patients who are medically fit for surgery

Exclusion criteria :
- Mason grade I and II
- Open fractures
- Age group <18 and >60 years
- patients medically unfit for surgery

On presentation, a detailed history and clinical examination were done. Radiological examination was done by taking anteroposterior and lateral x-ray of the involved elbow and fractures were classified by using Broberg and morrey modification of Mason’s classification.

Broberg and Morrey modification of the Mason classification[17]
Type 1 Non-displaced fracture, < 2 mm displacement
Type 2 Displaced partial head fracture, ≥ 2 mm displacement and ≥ 30% articular surface
Type 3 Comminuted fracture
Type 4 Radial head fracture with elbow dislocation
(Type 4 was described by Johnston in 1962)[17]
The limb was immobilized in the above elbow plaster of paris slab with a sling. All routine investigations were done after admission. Medical and pre-anaesthetic fitness were taken for all patients.

Operative procedure
All the patients were positioned in supine position and surgeries performed under regional or general anaesthesia. Pneumatic tourniquet was used in all cases. After routine painting and draping, the limb exsanguination was done using eshmarch bandage. The radial head fracture was exposed using Kocher's approach and internervous plane was made between the anconeus and extensor carpi ulnaris. The forearm was kept fully pronated to move posterior interosseous nerve away from the operative field .Proximal fibers of supinator were split and joint capsule was incised longitudinally. Radial head fracture fragments were removed and radial neck was osteotomized a centimetre below the articular surface. Under fluoroscopy, stress test examination was done to rule out collateral and interosseous ligament injuries. The diameter

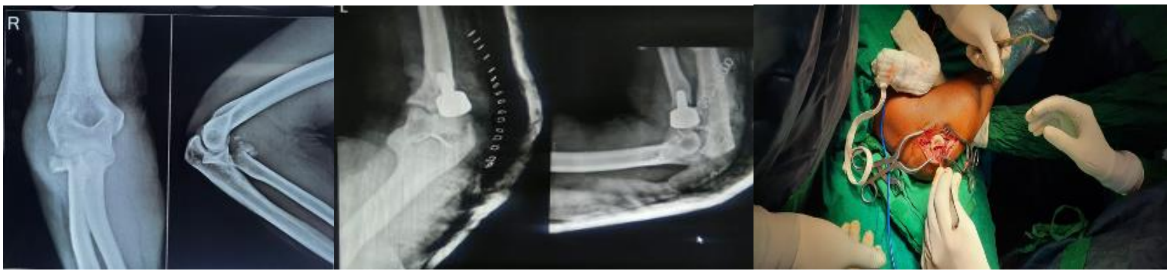
of the excised radial head was measured and appropriate size trial prosthesis was used after rasping the medullary canal. Monobloc , cemented prosthesis was used. Overstuffing of the radio-capitellar joint was avoided by adjusting the depth of insertion and assessed under direct vision. Following insertion of the definitive radial head prosthesis, careful repair of the annular ligament and any concomitant osseous and ligament injuries were done to maintain elbow stability.(picture 1 and 2)

Post-operative care

Patients were advised to keep the limb elevated and move their fingers and shoulder joint. Suction drain was removed after 2 days and the wound was inspected. Intravenous antibiotics and analgesics were given for the first 3 days of the postoperative period and then discharged with the forearm in an arm pouch, advised to perform shoulder, elbow, wrist and finger active range of movements. Sutures were removed on the 12th postoperative day. check X Ray in anteroposterior and lateral views were taken. Patients were advised not to lift heavy weight or exert the affected upper limb.

Follow-up

After suture removal, patients were advised to review in ortho OPD for follow up after 1month, 3month and 6 months. In each follow up a detailed clinical examination was done and patients were assessed for pain on VAS score, range of movements of elbow. The functional assessment of the patients were done according to Broberg and Morrey functional scores.
Patients were instructed to carry out physiotherapy in the form of active flexion-extension and pronation-supination movements.



Picture 1: preoperative, post-op x-ray and excised radial head

Picture 2: preoperative and post-op x-ray

Result

In our study 28 patients of comminuted radial head fractures were included from December 2019 to May 2021. The follow-up rate was 89.28% till completion of study. Paired t-test was used to find the significance between various variables. The observed results were determined to be significant if the P value was <0.05 and not significant if it was >0.05.

1. Incidence as per Age: Mean age of the patients were 38.07 years (SD±3.08). (Figure 1)

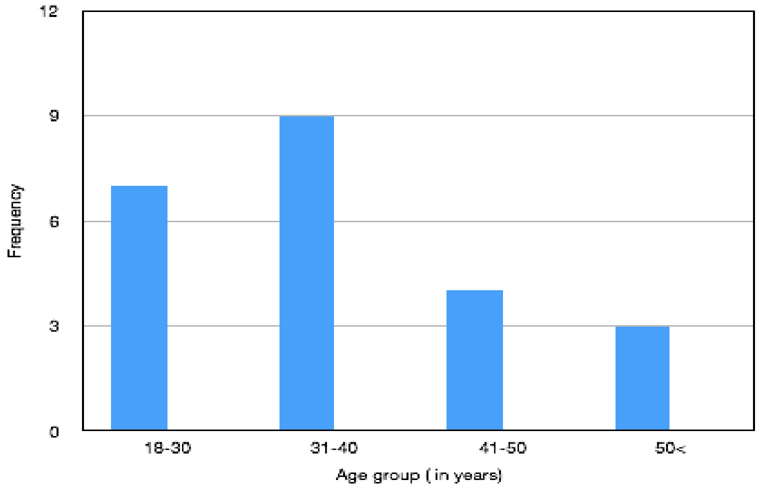


Figure 1: Distribution of cases according to Age

2) **Sex distribution**: this study included 19 male(67.8%) patients and 9 female patients. (Table 1)

Table 1: Distribution of cases according to Sex

Sex	Frequency	Percentage
Male	19	67.8%
Female	9	32.1%

3) **Side of injury**: Right side was involved in 60.7% cases. (Table 2)

Table 2: Distribution according to side of injury

Side	Frequency	Percentage
Right	17	60.7%
Left	11	29.3%

4) Mode of injury : most common mode of injury (50%) was accidental fall and least common was sports injury (7.1%). (Table 3)

Table 3: Distribution according to Mode of injury

Mode	Frequency	Percentage
RTA	12	42.9%
Accidental Fall	14	50%
Sports injury	2	7.1%

5) Fracture Type: All the cases were classified using Broberg and Morrey's modification of Mason's radial head fractures.(Figure 2)

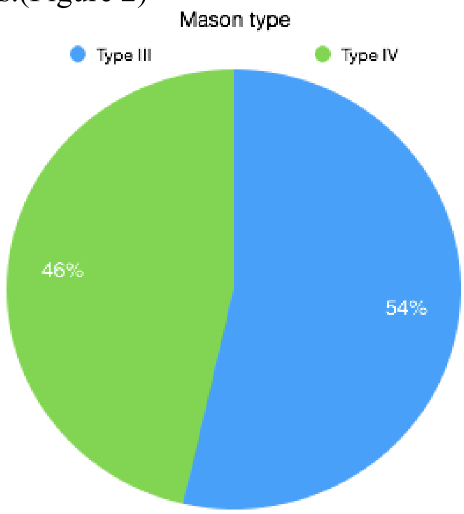


Figure 2: Distribution according to Mason's type

6) Injury-Surgery interval: Most (89.2%) of the patients operated within one week of injury.(Table 4)

Table 4: Distribution according to Injury -Surgery interval

Time interval	Number of cases	Percentage
0-7	25	89.2%
8-14	2	7.14%
14<	1	3.5%

7) VAS score : preoperatively all 28 patients were graded severe on VAS score. The mean VAS score at preoperative and 6 months were 9.14 (SD±0.52) and 0.12 (SD±0.33) respectively. (Figure 4)

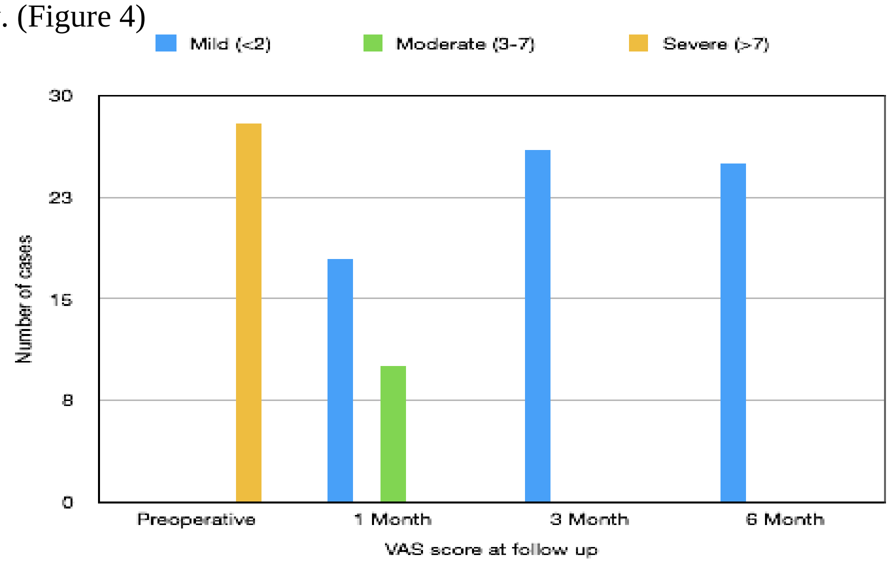


Figure 4 : Graph shows comparative VAS score at follow up

8) Functional Outcome : Broberg and Morrey score is graded as excellent (95-100), good (80-94), fair (60-79) and poor (<60). The mean scores at preoperative, 1month, 3 month and 6 months were 10.64 (SD±4.29), 64.58 (SD±4.05), 80.85 (SD±2.63) and 89.96 (SD±4.96) respectively. The mean preoperative and 1 month, 1 month and 3 month, 3 month and 6 month, preoperative and 6 month scores were compared using 'paired t test' and P value is found to be <0.01, and is statistically significant.(Figure 5)

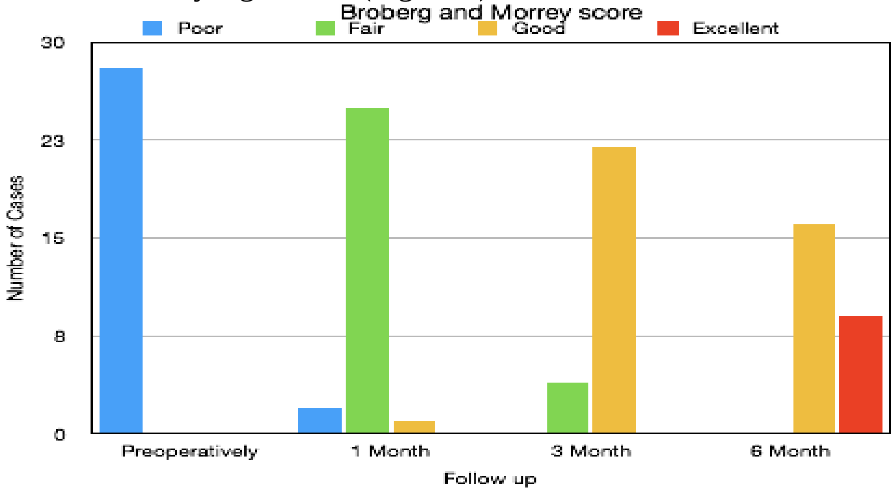


Figure 5: Shows comparative Broberg and morrey scores at periodic follow-up

9) Range of Motion:

Elbow and forearm ROM i.e flexion , pronation , supination and fixed flexion deformity assessed by using goniometer at 1, 3 and 6 months. (Table 5,6,7 and 8)

Table 5: Flexion ROM at follow-up 1,3 and 6 months

Flexion ROM	**1 month**	**3 month**	**6 month**
<90°	18	2	0
90-120°	10	24	8
>120°	0	0	17

Table 6: Pronation ROM at follow-up 1,3 and 6 months

Pronation ROM	**1 Month**	**3 Month**	**6 Month**
<45°	28	4	0
>45°	0	22	25

Table 7: Supination ROM at follow-up 1,3 and 6 months

Supination ROM	**1 Month**	**3 Month**	**6 Month**
<45°	28	2	0
>45°	0	24	25

Table 8: Fixed flexion deformity at follow-up 1,3 and 6 months

Fixed Flexion Deformity	1 Month	3 Month	6 Month
<30°	25	26	25
>30°	3	0	0

The mean flexion, pronation , supination and FFD at 1 month were found to be 85.14° (SD±7.25), 35.32° (SD±4.06), 38.19° (SD±3.78) and 27.23° (SD±3.02) respectively. At 3 months, the mean flexion, pronation , supination and FFD were 107.15° (SD±8.78), 48.92° (SD±3.05), 51.62° (SD±3.43) and 18° (SD±2) respectively. At 6 months, the mean flexion, pronation , supination and FFD were 124° (SD±5.51), 68.52° (SD±2.47), 70.12° (SD±2.82) and 10.88° (SD±1.54) respectively.
Statistically significant difference found between mean elbow flexion, forearm pronation/supination and FFD noted at 1 month, 3 month and 6 month follow up, by using "paired t-test" (p value<0.01).

Discussion

Radial head prosthesis restores elbow stability to a level similar to that of the normal elbow when a fracture of the radial head occurs alone or in combination with dislocation of the elbow, rupture of the medial collateral ligament, fracture of the proximal ulna, or fracture of the coronoid process. The radial head implant acts as a spacer, allowing early soft tissue healing and restoration of mobility similar to native radial head. Results of our study corroborates well with available evidence in existing literature.

Age : Mean age in our study was 38.07 years (SD±3.08). Similar results were found by Chung-Sin Baek et al 49.8 years[6], B. Hari Krishnan et al 36 years[15], Yves Gramlich et al 48 years[13] , Alvin Chao-Yu Chen et al 43.91 years[11] , Alessandro Nosenzo et al 56 years[14], Arash Moghaddam et al 55.9 years[12], Klaus Josef Burkhart et al 44.1 years[7]. Most common age group involved in our study was 30-50 years (67%). This may be owing to the common involvement of adults in road traffic accidents, outdoor activities and sports. Therefore most likely to suffer from these injuries.

Sex : A majority of our patients were males, comprising 19 (67.8%) as compared to 9 (32.1%) females. This result is consistent with previous studies. Study done by Chung-Sin Baek et al had 13 males as compared to 11 females[11], B. Hari Krishnan et al had 21 males (70%) as compared to 9 females[15], Yves Gramlich et al had 41 males (62.1%) as compared to 25 females[13] , Alessandro Nosenzo et al had 10 males (58.82%) as compared to 7 females[14], Alvin Chao-Yu Chen et al had 18 males (56.25%) as compared to 14 females[11], Klaus Josef Burkhart et al had 14 male patients (82.35%) as compared to female patients[7]. This high proportion can be explained by the tendency of higher involvement of male patients in road traffic accidents, outdoor activities and sports activities. Age and sex of the patients had no significant statistical association with any of the outcome variables.

Mode of trauma : Most common mode of trauma in our study was accidental fall 14 patients (50%), road traffic accident 12 patients (42.9%), sports injury 2 patients (7.1%). Similar results were seen in different studies. B. Hari Krishnan et al reported road traffic accident (66.66%) as commonest cause[15], Yves Gramlich et al reported high-energy trauma (61%) as commonest cause[13] , Klaus Josef Burkhart et al reported trauma due to fall from heights (36.8%) or stairs

(15.78%) and bicycle accidents (31.57%).[7] The difference in mode of trauma may be owing to the variability in occupational, recreational and daily lifestyle activities between different populations.

Fracture Type: 15 patients (53.57%) of Mason's Type III and 13 patients (46.4%) of Mason's Type IV radial head fractures were included in our study. Associated injuries seen were 2 posterior elbow dislocation, 13 terrible triad of elbow, 1 proximal ulna fracture. 5 coronoid fractures needed fixation by single 4mm cancellous cannulated screw. All posterior elbow dislocations were reduced at the time of presentation and the above elbow slab was applied. 1 Proximal ulna fracture was fixed using ulna plating. Study done by Chung-Sin Baek et al included 12 patients (50%) of Mason's Type III and IV each[6]. Yves Gramlich et al included 80% Type IV cases, and 18% Mason's Type III cases. In one case (2%), the RHP was used as a salvage procedure after an osteosynthesis failure of a Mason II fracture[13] . Alessandro Nosenzo et al included 9 patients of radial head fractures Mason type IV and 8 of Mason type III[14]. Study done by Arash Moghaddam et al included 2 (2.7%) Mason's type II fractures, 21 (28%) type III and 52 (69.3%) Mason's type IV fractures.[12] Emanuel Van Hoecke et al included 14 fractures (primary indication), 7 were classified as Mason type III, 7 were classified as Mason type IV with dislocation of the elbow joint.[10] Our fracture type inclusion is similar to the literature. The difference found by Yves Gramlich et al and Arash Moghaddam et al could be because of variability in mode of trauma.[12]

Injury surgery interval : Our study included all acute trauma patients with mean injury surgery interval 5.46 days (SD±0.926), among which 25 patients (89.2%) were operated within one week of injury. Only 1 patient (3.5%) operated after 2 weeks. There was no statistically significant difference found between functional outcome scores at 6 months follow up. Study by Chung-Sin Baek et al had a mean interval from initial trauma to surgery of 8.7 days [6]. Alvin Chao-Yu Chen et al had a mean time from trauma to surgery was 10.13 (SD±29.21) months[11]. Klaus Josef Burkhart et al reported a mean period of 8.1 days after trauma for primary implantation (range, 2-14) and secondary implantation was performed within 266 days (range, 70-515) [7]. This difference in injury surgery interval could be because in our study we included only acute trauma patients for primary implantation whereas in other studies they have included secondary implantation cases i.e after radial head resection, osteosynthesis or revision implantation also. Delay could also be because of late presentation to hospital, patient's awareness, income and affordability of health resources.

VAS score : In our study the mean VAS score at preoperative, 1 month, 3 month and 6 month follow-up were 9.14 (SD±0.52), 2.5 (SD±0.88), 0.92 (SD±0.56) and 0.12 (SD±0.33) respectively. There were statistically significant differences found in mean preoperative VAS score to mean 1, 3 and 6 month follow-up VAS scores with ($p<0.001$). Results of our study were comparable with other studies. Study done by B. Hari Krishnan et al reported the median VAS score at 6 weeks postoperatively was 5; 02 patients (6.66%) had VAS between 3 and 7, while 28 patients (90.5%) had VAS <2. At 6 month follow-up the median VAS score was 1 and all patients had VAS score <2.[15] Chung-Sin Baek et al reported the mean VAS score for pain was 0.6 ± 1.1 at final follow-up. 15 patients had no pain, 8 had mild pain, and 1 had moderate pain.[6] Melissa Laflamme et al reported the mean VAS score for was 1.11 at final follow up.[4] Alvin Chao-Yu Chen et al reported 24 patients (75%) showing residual pain in elbow and mean VAS scores was 1.25 (SD±1.16) (range, 0 to 5).[11]All of the studies have shown significant improvement in VAS score. This improvement in VAS score can be taken as a measure of patient satisfaction.

Broberg and Morrey score : In our study mean scores at preoperative, 1month, 3 month and 6 months were 10.64 (SD±4.29), 64.58 (SD±4.05), 80.85 (SD±2.63) and 89.96 (SD±4.96) respectively. The mean preoperative and 1 month, 1 month and 3 month, 3 month and 6 month, preoperative and 6 month scores were compared using 'paired t test' and P value is found to be <0.01, and is statistically significant. Arash Moghaddam et al reported a mean score of 85.7 at a mean follow-up duration of 41.5 months.[12] Ioannis K. Sarris et al found broberg and Morrey score results were excellent in 33% of the patients, good in 44%, fair in 23%; and bad in 0% at mean follow-up of 27 months.[8] Andrew D. Duckworth et al reported a mean Broberg and Morrey score of 80 (SD 12), 4 (5.4%) patients had excellent and 39 (52.7%) patients had good scores, after a mean follow-up of 1.1 years.[9] Hong-Jiang Ruan et al found excellent results in 9 cases, good in 4, and fair in 1. The outcome was satisfactory in 92.9% of prosthesis replacement patients.[16] Results of our study are similar with literature and have shown significant improvement in functional outcome after prosthesis replacement. Major improvement is seen at one month follow-up post operatively.

Range of motion : In our study the mean flexion, pronation , supination and FFD at 1 month were found to be 85.14° (SD±7.25), 35.32° (SD±4.06), 38.19° (SD±3.78) and 27.23° (SD±3.02) respectively. At 3 months, the mean flexion, pronation , supination and FFD were 107.15° (SD±8.78), 48.92° (SD±3.05), 51.62° (SD±3.43) and 18° (SD±2) respectively. At 6 months, the mean flexion, pronation , supination and FFD were 124° (SD±5.51), 68.52° (SD±2.47), 70.12° (SD±2.82) and 10.88° (SD±1.54) respectively. Alessandro Nosenzo et al found average active flexion of 132° (range 105°–140°); average active extension deficit of 17° (range 0°–60°); average active pronation of 81° (range 10°–90°); average active supination of 74° (range 5°–90°) after a mean follow-up of 27.7 months.[14] Arash Moghaddam et al reported a mean elbow flexion of 125.7°, mean pronation of 70.5° , mean supination of 83.6°, mean FFD of 16.5° after a follow-up of 41.5 months.[12] B. Hari Krishnan et al reported mean elbow flexion of 126°, mean forearm pronation of 71°, mean forearm supination of 73°, mean fixed flexion deformity of 14°, after a follow-up of 6 months[15] . Study by Chung-Sin Baek et al found a mean elbow flexion of 132.7° ± 7.4°, mean extension of 4.7° ± 10.8°, mean pronation of 76.2° ± 10.6°, mean supination of 77.5° ± 5.3° after a mean follow-up of 58.9 months.[6] Ioannis K. Sarris et al found a mean elbow flexion of 130° (range, 105 -150), a mean pronation of 74° (range, 60 -80), and a mean supination of 72° (range, 60 - 80), after a mean follow-up of 27 months (range, 21-46 months).[8] Andrew D. Duckworth et al reported a mean elbow flexion of 133° (range, 90°–159°), a mean pronation of 84° (range, 0°–90°), a mean supination of 73° (range, 0°–90°), after a mean short-term follow-up of 1.1 years (range, 0.3–5.5 years).[9] Increased mean range of motions achieved by Alessandro Nosenzo et al[14], Arash Moghaddam et al[12], Andrew D. Duckworth et al[9], Ioannis K. Sarris et al[8], Chung-Sin Baek et al[6], could be because of longer follow-up duration, use of different designs of prosthesis, population variability, their education level, income and adherence to rehabilitation protocol. Results of our study and study by B. Hari Krishnan et al[15] have similar results after a follow-up duration of 6 months. This could be because of a similar patient population and their adherence to rehabilitation. Implant used by B. Hari Krishnan et al[15] was a titanium bipolar radial head prosthesis whereas we used a monobloc prosthesis.

Complications: our study is associated with few postoperative complications, i.e 1 patient developed postoperative posterior interosseous nerve palsy which recovered over 3 weeks duration. Patient was given a tab methylcobalamin 1500 microgram twice daily, along with cock-up slab. 2 patients developed deep wound infections, managed by daily dressing and culture sensitive antibiotics. 2 patients developed heterotopic ossification managed by tablet indomethacin 25 mg thrice daily and post operative physiotherapy. Study by Arash Moghaddam et al had developed periprosthetic radiolucency in 58 patients, periarticular ossification in 26 patients, 4 required revision surgery for loosening of implant and chronic pain, 1 developed neobursa, 1 patient developed severe swelling and blisters.[12] In study by B. Hari Krishnan et al, 1 patient developed heterotopic ossification, implant removal was done for 2 patients at 03 month follow up for not gaining satisfactory range of motion.[15] The lesser incidence of heterotopic ossification could be because of prophylactic indomethacin given to all patients for 3 weeks by B. Hari Krishnan et al.[15]

Limitations : our study has few limitations which includes small sample size, single center based, no control or comparison group. It does not consider the complexity of pre-operative soft tissue injuries associated. The study does not compare differences in the outcomes of isolated radial head fractures and those with associated ligamentous and other complex injuries. Long-term complications were not considered, such as painful implant loosening, capitellar wear, and degenerative arthritis.

Conclusion

From our study , we have found that radial head replacement using monobloc, cemented prosthesis in comminuted radial head fractures produce satisfactory results in terms of elbow stability, pain relief, elbow range of motion. We have found good to excellent short term functional outcomes despite the severity of comminution. Our results are in accordance with literature on radial head replacement. However, comparative studies are needed to assess the benefits of radial head replacement over radial head excision , to assess benefits of different types of prosthesis. Larger sample size and longer follow up duration studies are required to assess rate of improvement and long term complications of radial head replacement.

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