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Functional Outcome of Open Reduction and Internal Fixation of Radial Head Fractures

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Abstract

1.1 Background:
There is no consensus on the optimum management strategy for radial head fractures (Mason type II, III, IV). Open reduction and internal fixation, radial head arthroplasty and excision without replacement are the currently available treatment options for radial head fractures. We evaluated the radiological and functional outcome of cases with radial head fractures managed with open reduction and internal fixation at a tertiary care center.

1.2 Materials and Methods:
Between January 2016 and December 2018, 20 patients (12 males and 8 females; mean age 33.1 years) with radial head fractures underwent open reduction and internal fixation. These include 6-type II, 8-type III and 6-type IV injuries. The mean follow-up was 25 weeks (16-40 weeks). Patient assessment was done using the Mayo Elbow Performance Score (MEPS) and radiological parameters.

1.3 Results:
All patients showed radiographic union without any evidence of avascular necrosis, heterotrophic ossification or subluxation of distal radioulnar joint. The mean flexion at elbow joint was 130.25º (Range: 120º - 140º) and the mean loss of extension was -4.5º (Range: 0º to -15º). Mean pronation and supination of forearm were 71º (Range: 60º - 80º) and 75.5º (Range: 70º - 80º) respectively. According to the Mayo Elbow Performance score (MEPS), the outcome was excellent in 9 (45%), good in 10 (50%) and fair in one patient with the mean MEPS score of 87.25 (Range: 65-100). One patient with type IV injury required implant removal of broken trans-articular wire.

1.4 Conclusion:
We propose open reduction and internal fixation for the management of radial head fractures (Mason type II, III and IV) to achieve satisfactory clinical outcomes. Proper understanding of the fracture anatomy, early surgery, use of appropriate low-profile implants with excellent soft tissue repair and early mobilisation are the key steps in the management of these complex injuries.

Keywords: Radial head fracture, Open reduction and internal fixation, Functional outcome

1. Introduction

Radial head and neck fractures are common injuries and occur in approximately 2-5% of all fractures and constitute one-third cases of elbow fractures.[1, 2]These injuries typically arise due to axial loading of the forearm causing the radial head to hit against the capitellum of the humerus. The radial head was earlier considered to be an expendable part of human skeleton; although many recent studies have established the role of radial head as an important stabiliser of elbow and forearm.[3, 4] Radial head fractures present in a wide spectrum from isolated low energy undisplaced fractures to comminuted high energy injuries associated with elbow dislocation, terrible triad and ligamentous instability[5]. There is no uniform consensus on the optimal treatment strategy for radial head fractures. The literature describes open reduction and internal fixation (ORIF), radial head arthroplasty (RHA) and excision as available surgical options. The functional outcome of these procedures is controversial as there is conflicting evidence with some authors supporting[6] and others describing a high proportion of unfavourable results with each operative technique[7]. Recent studies have concluded that excision of the radial head without replacement has a deleterious effect on elbow and distal radioulnar joint associated with complications such as proximal radial head migration, cubitus valgus and distal radioulnar joint subluxation.[8, 9] Improved understanding of anatomy, surgical techniques and implants for fixation and replacement have led to major drift from excision of radial head to fixation all majority of cases and prosthetic replacement in some selected ones. We carried out a retrospective analysis of our patients with radial head injuries managed with open reduction and fixation to assess the functional outcome.

2. Materials and methods

Between January 2016 and December 2018, 22 patients who underwent open reduction and internal fixation at a tertiary care hospital for radial head fractures were retrospectively reviewed. The study protocol was approved by the institution's ethics committee. A written informed consent was taken from all patients for participation in the study. Demographic data such as age, sex, mechanism of injury, dominant v/s non-dominant injury, fracture type, associated injures and time interval between trauma and surgical intervention were obtained after a thorough review of our electronic medical records database. Since 2 patients were lost to follow-up, the final study population comprised of 20 patients. These include 12 (60%) males and 8 (40%) females with a mean age of 33.1 years (20-49 years). There were 14 dominant and 6 non-dominant limb injuries. The mechanism of injury was fall from height in 11 cases, motor vehicle accident in 5 cases and contact sports injury in 4 patients.

The Mason's classification is the most widely used and accepted classification system for radial head fractures.[10]The original classification system describes undisplaced fracture (type I), displaced fracture (type 2) and comminuted fracture (type 3). A fourth variant having fracture of radial head with elbow dislocation was added by Johnston.[11]Broberg and Morrey modified the original classification and suggested that fractures with displacement >2mm or involving >30% of articular surface should be classified as type II injuries.[12]In our study, there were 6 (30%) Mason's type II, 8(40%) Mason's type III and 6 (30%) Mason's type IV fracture. Associated injuries include fracture olecranon in one patient, elbow dislocation in 3 patients and terrible triad injury in 2 patients. The coronoid fractures in both the patients with elbow terrible triad injuries were avulsion injuries (Type I as per Regan-Morrey classification). No patient has associated neurovascular injuries.

3.Operative technique

The mean time interval between injury and surgical intervention was 4.1 days (range: 1-10 days). All patients were operated under axillary block anaesthesia and with the help of pneumatic tourniquet. Patients with isolated radial head fractures and those with associated terrible triad injuries were operated in supine position with the arm draped on supportive arm rest. The patient with associated olecranon fracture was positioned in a lateral decubitus position with the limb supported over a bolster. We used the extensile lateral approach (Kocher's interval) for all patients with isolated radial head fracture and patients with elbow terrible triad injuries. A posterior midline longitudinal incision was used in the case of patient with associated olecranon injury. The interval between the anconeus and the extensor carpi ulnaris was identified. A longitudinal incision was made in the anterior part of lateral collateral ligament until just distal to the radial neck through the annular ligament and capsule in the midlateral plane avoiding any iatrogenic injury to the lateral collateral ligament. The radial head fracture and the lateral collateral ligament were exposed and examined. The radial head fracture fragments were identified after thorough irrigation of intra-articular hematoma and carefully mobilised with minimal periosteal stripping to preserve the vascular supply. After reduction, the fracture fragments were held with a small towel clip or forceps and temporarily fixed with 1 mm Kirschner wires. (Figure 1) Bone grafting was performed in two cases (from the lateral epicondyle) between the radial head and neck. Definitive fixation was performed using countersunk mini-screws alone (3 patients) or low profile 2.0 mini-locking plates and screws (17 patients). Care was taken to ensure that screws placed in the particular region are countersunk well below the articular surface and the plates are positioned on the non-articular portion of the radial head. The cartilage overlying the non-articulating zone is comparatively thinner and exhibits a yellow tinge as against wide, white and glistening cartilage which covers the articular zone of radial head.[13] Associated coronoid fracture in 2 patients was fixed using pull-through sutures into the anterior capsule. Associated olecranon fracture in one patient was fixed concomitantly. The lateral collateral ligament was avulsed in 5 cases and repair was carried out using suture anchor placed at the isometric point over the lateral humeral condyle. (Figure 2) After fixation, the elbow was taken through full range of motion to assess stability and check for proper extra-articular screw placement. One patient with Mason's type IV fracture associated with terrible triad injury required both lateral and medial collateral ligament repair which was further protected using a trans-articular k wire for 3 weeks. The capsule and annular ligament were sutured back with absorbable sutures. Adequate hemostasis was achieved after deflating the tourniquet and the wound was sutured over a drain.

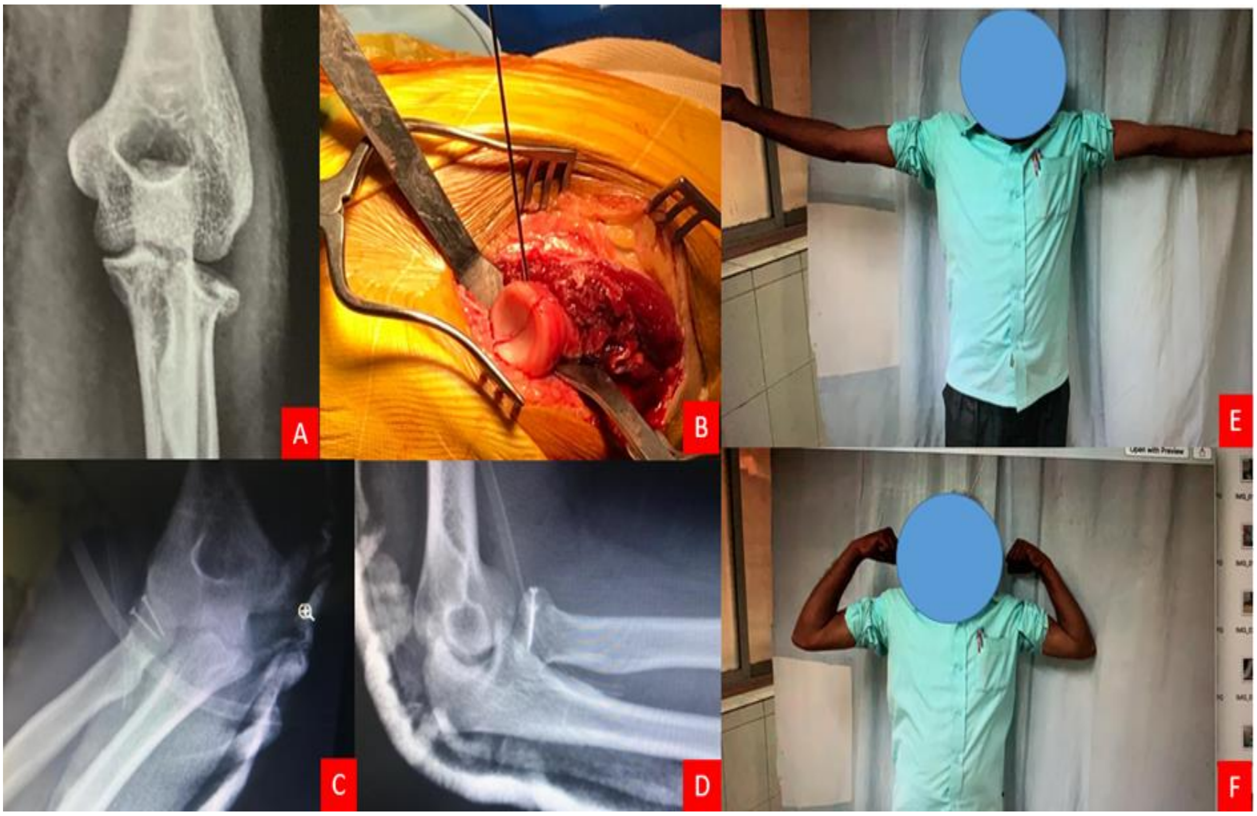

Fig. 1: A) Pre-operative X-ray showing Mason's type II radial head fracture.
B) Intra-operative image showing fracture reduction held with 1 mm K-wire.
C & D) Post-operative X-ray demonstrating ORIF done with screw fixation.
E & F) Clinical photos of the patient demonstrating good functional outcome.

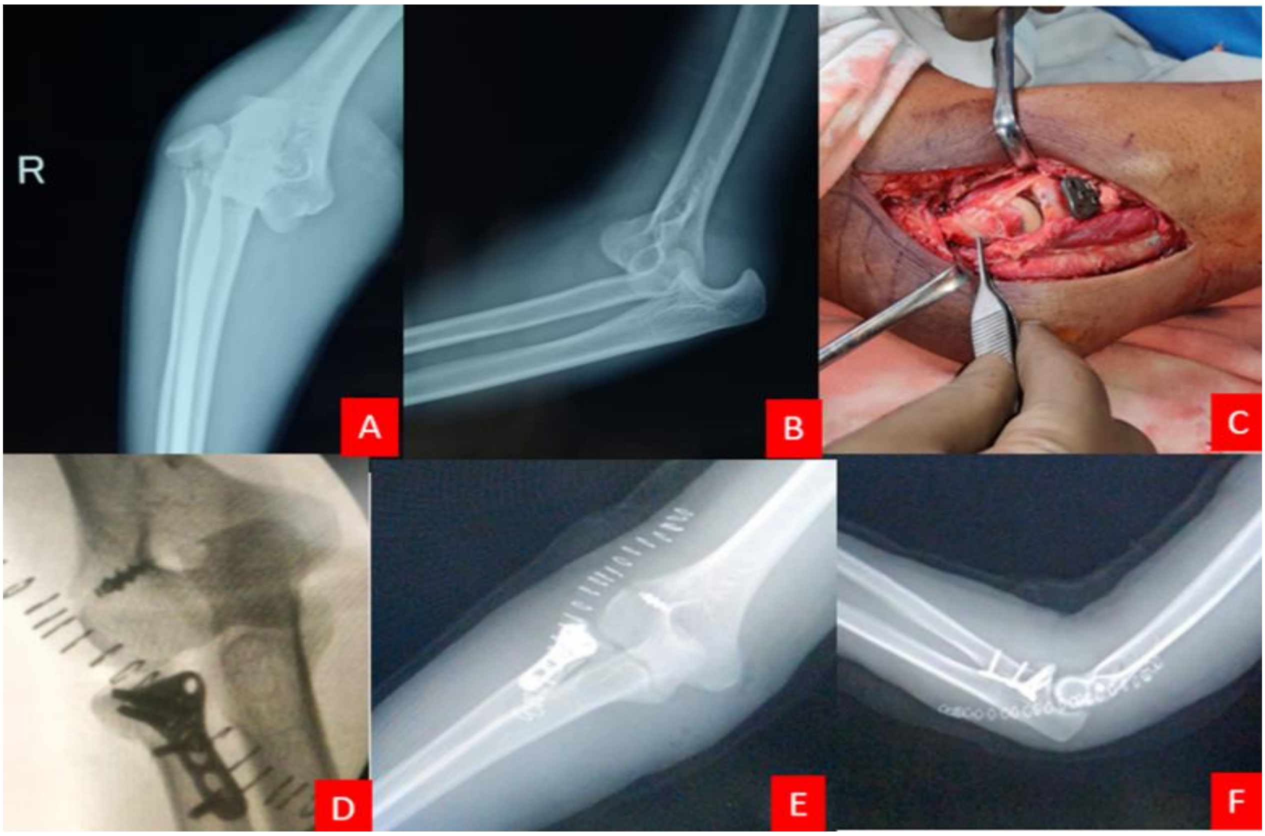

Fig. 2: A & B) Pre-operative X-rays showing Mason's type IV radial head fracture with elbow dislocation.
C) Intra-operative image showing the exposed lateral epicondyle with complete avulsion of lateral collateral ligament.
D) Intra-operative IITV image confirming the position of suture anchor.
E & F) Post-operative X-rays showing appropriate implant position and reduction of fracture-dislocation

4. post-operative assessment

Post-operatively, the limb was immobilised in a long arm plaster splint for 2 weeks followed by initiation of passive flexion-extension (elbow) and pronation-supination (forearm) movements. Active movements were initiated at 4 weeks post-surgery. We did not use indomethacin as a prophylactic medication against heterotrophic ossification. The mean follow-up was 25months (16-34 months). Physical assessment included measurement of range of motion with the help of a standard long limb goniometer. Patient assessment was done by and independent observer (Physiotherapist) on follow-up. Flexion and extension of the elbow was measured with the forearm in neutral rotation while pronation and supination of the elbow was calculated with the elbow in 90º flexion.(Figure 3) The overall functional result was evaluated using the Mayo Elbow Performance Score (MEPS) and the results were categorised as excellent (>90); good (75-90); fair (60-75) and poor (<60).(Table 1) Radiographic parameters such as fracture union, presence of post-traumatic osteoarthrosis, integrity of distal radioulnar joint and implant failure were assessed and recorded.

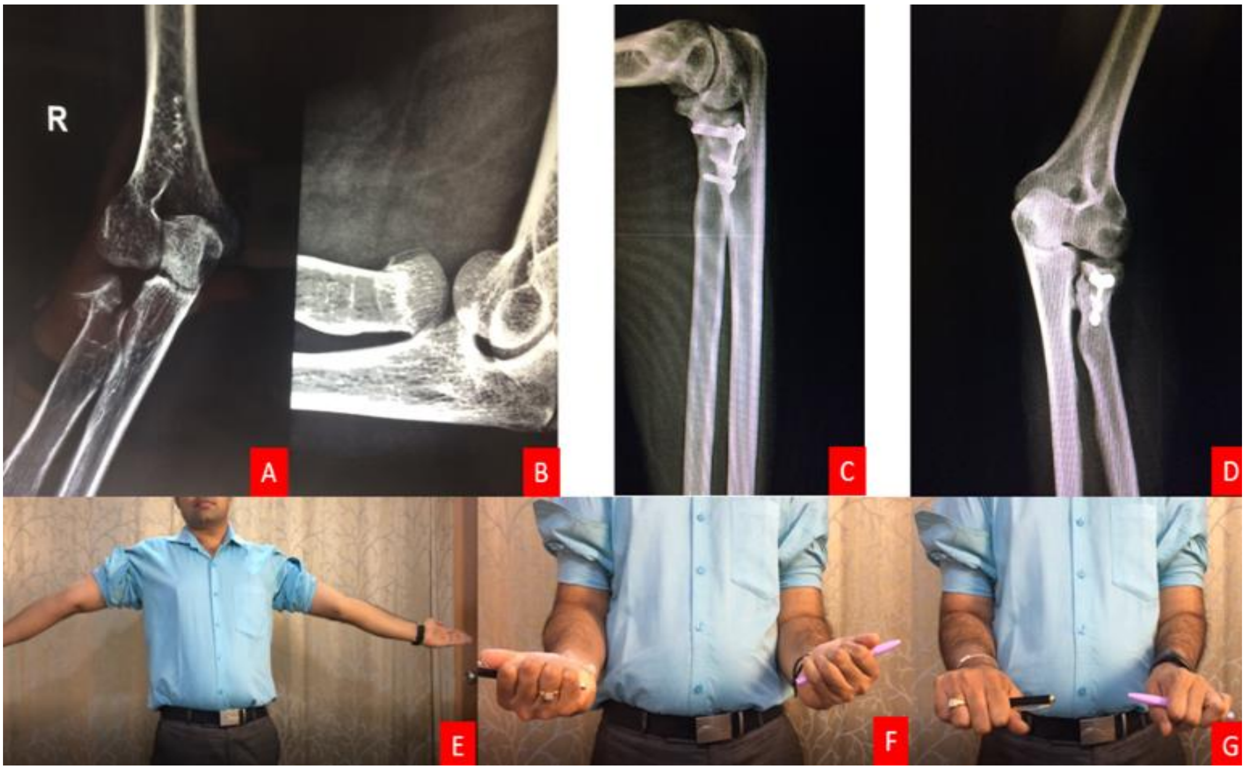

Fig. 3: A & B) Pre-operative x-ray showing a Mason's type II radial head fracture.
C & D) Follow-up X-ray showing union with no features s/o heterotrophic ossification or radio-capitellar arthritis.
E, F & G) Patient assessment at follow-up demonstrating calculation of ROM by physiotherapist.

Table 1: The Mayo Elbow Performance Score (MEPS) along with the score classification

Function	Points	Definition	Points
Pain	45	None Mild Moderate Severe	45 30 15 0
Motion	20	Arc >100 Arc 50-100 Arc <50	20 15 5
Stability	10	Stable Moderate instability Gross instability	10 5 0
Function	25	Comb hair Feed Perform hygiene Don shirt Don shoe	5 5 5 5 5
Total	**100**		

Score classification: Excellent >90, Good 75-89, Fair 60-74, Poor <60

5. Results

Our study involved 20 patients with a mean follow-up of 25 weeks (16-34 weeks). All patients showed radiographic union without any evidence of avascular necrosis, heterotrophic ossification or subluxation of distal radioulnar joint. Clinical examination revealed no evidence of elbow instability, or signs of reflex sympathetic dystrophy. One patient, 20-year male, who sustained type IV injury with terrible triad was managed with ORIF for radial head fracture along with repair of both lateral and medial collateral ligament using PEEK anchors supplemented by a transarticular K-wire. Follow-up examination revealed mild crepitus and breakage of K-wire on radiographs which needed implant removal. (Figure 4)

The demographic details of the patients and the functional results were as shown in Table 2. The mean flexion at elbow joint was 130.25º (Range: 120º - 140º) and the mean loss of extension was -4.5º (Range: 0º to -15º). Mean pronation and supination of forearm were 71º (Range: 60º - 80º) and 75.5º (Range: 70º - 80º) respectively. According to the Mayo Elbow Performance score (MEPS), the outcome was excellent in 9 (45%), good in 10 (50%) and fair in one patient with the mean MEPS score of 87.25 (Range: 65-100)

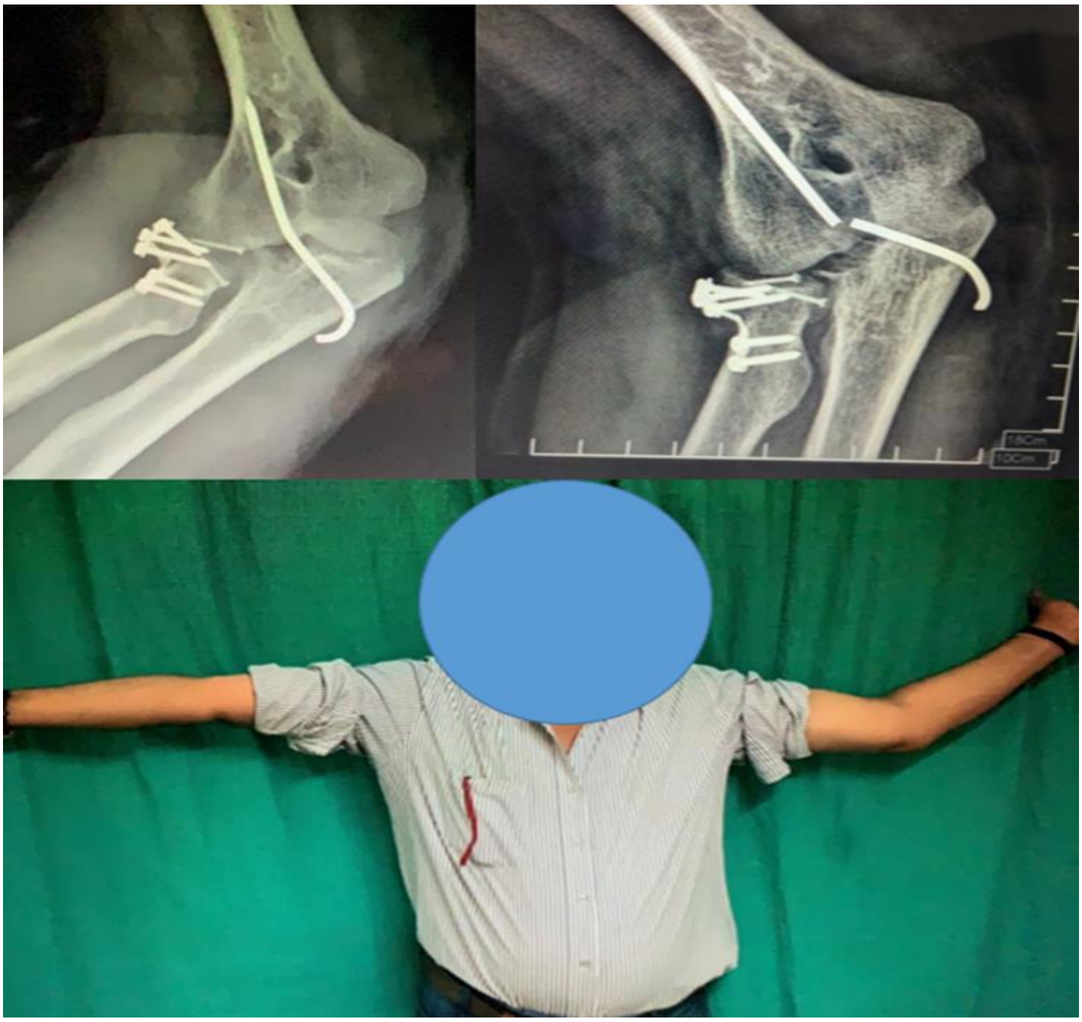

Fig. 4: Follow-up X-Ray showing breakage of Intra-articular K –wire which needed removal. Patient clinical photo showing restricted ROM with loss of extension

Table 2: Record of demographic data and functional outcomes of all patients in this series.

Case	Age	Gender	Mechanism of injury	Fracture side/Dominant side	Coexisting injury	Time from injury to surgery (days)	Mode of fixation	Length of follow-up (months)	Range of motion		Functional score (MEPS)	Results
									Flexion/ Extension	Pronation/ Supination		
1	35	F	Fall from height	R/R		3	Mini-plates and screws	18	135/0	70/80	90	Excellent
2	40	M	Fall from height	L/R		5	Mini-plates and screws	34	140/-5	70/70	85	Good
3	25	M	Motor vehicle accident	R/R		8	Mini-plates and screws	26	125/0	80/80	95	Excellent
4	22	M	Sports injury	R/R	Terrible triad	2	Mini-plates and screws + LCL repair	28	125/-10	75/70	85	Good
5	30	M	Sports injury	R/R		5	Mini-plates and screws	20	135/0	80/80	95	Excellent
6	37	M	Fall from height	R/R	Olecranon fracture	1	Mini-plates and screws	24	130/-10	60/70	80	Good
7	45	F	Motor vehicle accident	R/R		5	Screw fixation	21	120/-10	75/75	90	Excellent
8	49	F	Fall from height	R/R		10	Mini-plates and screws	32	125/-5	70/75	80	Good
9	20	M	Sports injury	L/R		2	Mini-plates and screws	16	140/0	80/80	100	Excellent
10	41	M	Motor vehicle accident	L/R	Elbow dislocation	2	Mini-plates and screws + LCL repair	25	125/-10	60/70	80	Good
11	27	F	Fall from height	R/R		5	Mini-plates and screws	29	135/0	75/80	95	Excellent
12	29	M	Fall from height	R/R	Elbow dislocation	3	Mini-plates and screws + LCL repair	21	130/-10	65/75	80	Good
13	33	M	Fall from height	R/R		8	Mini-plates and screws	30	130/0	75/75	85	Good
14	39	F	Motor vehicle accident	L/R	Elbow dislocation	1	Mini-plates and screws	24	125/-5	65/75	85	Good
15	25	M	Sports injury	R/R		5	Screw fixation	22	140/0	80/80	100	Excellent
16	38	M	Fall from height	R/R		4	Screw fixation	29	130/0	75/80	95	Excellent
17	39	F	Fall from height	L/L		3	Mini-plates and screws	27	130/-5	70/75	85	Good
18	20	M	Motor vehicle accident	R/R	Terrible triad	1	Mini-plates and screws + LCL repair + MCL repair+ Trans-articular wire	20	120/-15	60/70	65	Fair
19	35	F	Fall from height	L/R		6	Mini-plates and screws	29	135/0	75/80	90	Excellent
20	33	F	Fall from height	L/R		3	Mini-plates and screws + LCL repair	25	130/-5	60/70	85	Good

6. Discussion

The aim of treatment in radial head fracture is anatomic reconstruction of articular congruity and restore a good elbow function. Although previously considered an insignificant part of the human skeleton, many recent studies have highlighted the crucial role of the radial head and elbow and wrist joint kinematics.[4, 14] Successful management of radial head fractures require many factors to be taken into consideration such as fracture anatomy, stability, involvement of articular surface, comminution at fracture site and metaphyseal location and other associated bony and ligamentous injuries.

The available treatment options include non-operative treatment, surgical excision of radial head, ORIF and radial head arthroplasty (RHA). Non-operative treatment is considered in cases of simple fractures (Type I and II) with less than 3 mm displacement and involves small duration of immobilisation (maximum 2 weeks) followed by initiation of passive and active elbow and forearm movements.[15] Lapner et al. concluded that radial head fractures which are minimally displaced and not producing a mechanical block to motion can be successfully treated non-surgically.[16]

Resection of the radial head has been accepted as treatment modality in Mason's type III injuries and has demonstrated acceptable outcomes.[17] Janssen et al. reported excellent outcome in 17 out of 30 patients with type III fractures at 16-30 years follow-up.[18] However, recent literature has highlighted significant complications with excision such as pain and instability at wrist and elbow joints, proximal migration of radial head, and development of post traumatic arthritis.[19] Ikeda et al. reported significant loss of strength in patients undergoing radial head excision as against the ORIF group.[9] In view of these shortcomings, the current trend is to achieve anatomic reconstruction and fixation of radial head in all cases and to perform radial head replacement in cases not amenable for ORIF. Radial head excision can be considered a viable option for fractures in elderly population with poor bone quality and associated comorbidities.[20]

Since many biomechanical studies have proven that preservation of radial head has a positive influence on elbow and wrist function, ORIF is now the preferred mode of treatment for radial head fractures and associated lesions. Zwingmann et al. performed a systematic review and meta-analysis of 58 studies in order to compare the clinical outcomes after various operative treatment methods for radial head fractures.[6] ORIF showed better results in type II and type III fractures with a success rate of 98% and 92% respectively. Ring et al. evaluated 56 cases of radial head fractures and suggested that ORIF is best suited for fractures with three of less articular fractures and associated fracture-dislocations can compromise the long-term results.[14] On the contrary, Nalbantoglu et al. found that elbow dislocation had no significant effect on the functional outcomes.[4] They proposed that the rate of chondral damage is less in cases of dislocation as the energy of trauma is redirected to the bones and ligaments causing less cartilage injury. Our results also provide evidence that ORIF should be considered as the choice of treatment in Mason type II, III and even type IV fractures (95% good to excellent results) . Anatomic reduction, appropriate implant selection, soft tissue repair or reconstruction along with early rehabilitation can provide good to excellent outcomes even in cases with dislocation or comminution.

The role of radial head replacement in the management of radial head fractures has been discussed in literature in a controversial manner. Ruan et al. compared the outcomes of ORIF and bipolar metal head prosthesis in 22 patients with Mason type III injury.[21]They reported satisfactory outcome in 92.9% cases with prosthesis as against 12.5% in cases with ORIF at a mean follow-up of 14-15 weeks. Sun et al. conducted a meta-analysis comparing RHA and ORIF in cases with radial head fractures type III and IV and concluded that RHA has better outcomes in medium-short term follow-up.[7] However, long-term data studies will be needed to substantiate these findings. Complications such as loosening, over-stuffing of the radio-capitellar joint, instability and osteoarthritis are not uncommon with RHA.[22] Cristofaro at al. reported a re-operation rate of 25% after RHA done for radial head fractures with a peak appearing at one year following surgery.[23] We advocate that RHA should be considered only in cases with unreconstructable radial head fractures after proper counselling of the patient regarding possible need for secondary intervention. Further research into anatomical population-based and patient specific implant designs is warranted to reduce the surface mismatch and lack of modularity of the commercially available RHA prosthesis.[24]

The time interval between injury and trauma has also been considered as an important factor in the management of radial head injuries. Edwards et al. reviewed seven cases with radial head fractures with acute distal radio-ulnar dislocation and reported excellent results when the surgery was performed within one week.[25]Ozkan et al. reported excellent and good outcomes in 12 cases of ORIF and attributed early surgery as one of the factors responsible for the clinical outcome.[26] Even though we did not perform any comparative study, we agree that early surgery (mean time interval from injury to surgery was 4 days in our series) should be aimed at in call cases of radial head injuries to obtain good functional results.

However, there are a few limitations to our study. Larger sample size and a longer follow-up period could have yielded more in-depth analysis and basis for our results. Also, we did not perform any comparison between different surgical methods in our study (ORIF v/s excision v/s replacement)

7. Conclusion

Open reduction and internal fixation of radial head fractures is a satisfactory mode of treatment and provides excellent to good functional outcomes. Proper understanding of the fracture anatomy, early surgery, use of appropriate low-profile implants with excellent soft tissue repair and early mobilisation are the key steps in the management of these complex injuries. In view of the complications with radial head excision and problems with the use of RHA, we propose ORIF for the management of radial head fractures (Type II, III and IV) to achieve excellent clinical outcomes.

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