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Cemented Radial Head arthroplasty in management of unreconstructable radial head fractures

Bishoy W.Ibrahim, Mohamed E.Al-Ashhab, Mohamed A.Meselhy and Ahmed I.Elkady.
Orthopedic Surgery Dept., Faculty of Medicine, Benha Univ., Benha, Egypt.
E-mail: bishoywadieibrahim222@gmail.com

Abstract

Background: Fractures of the radial head and neck accounts for up to one third of the elbow fractures. Incidence is estimated to be 2.5 to 2.9 per 10,000 per year. In comminuted radial head fracture excision of radial head may lead to loss of strength, valgus instability, & proximal migration of radius leads to wrist pain. Radial head replacement restores normal anatomy and functions of elbow, radioulnar & wrist joints. Radial head fractures with more than three fracture fragments have been shown to be difficult to fix and have a high predilection towards hardware complications, malunions, nonunions, and the need for re-operation after ORIF. In response to these difficulties, radial head arthroplasty is quickly gaining popularity for the treatment of comminuted radial head fractures. **Methods:** This study includes 20 cases of severely unreconstructable radial head fractures managed by cemented radial head replacement. The cases were operated on at Department of Orthopaedics at Benha University hospital and Shebin El-kom hospital for specialized surgeries between January 2023 to April 2024. **Results:** Cemented radial head arthroplasty was done for Mason types III and IV fractures and functional outcome was calculated postoperatively with Mayo elbow performance score on follow-up at 3-, 6- and 12-month intervals. **Conclusions:** A cemented radial head prosthesis may be chosen in order to avoid/reduce the risk of an intraoperative radius fracture, in cases of revision surgery and in cases where rigid fixation is not sufficiently obtained during surgery using a press-fit method but is strictly required.

Keywords: radial head fractures, radial head arthroplasty**,** proximal migration of radius**.**

1. Introduction

The head of radius has an important contribution in support of the elbow. The principal supports of the elbow are the connection between the ulna and the humerus and collateral ligaments. The second supports involve the head of radius, capsule of the elbow joint and common flexor and extensor muscle root. The dynamic supports include muscles around the elbow joint. The head of radius turns into a serious support if the ulnar coronoid or the medial elbow ligaments are damaged. [1]

Fracture of the head of radius ordinarily affect youthful, energetic persons after intense landing on extended upper limb with a prone lower part of the limb and minimal bending of the elbow. Fractures of the radial head have accompanying damages in more than 90% of cases. [2]

Scientists showed that the medial elbow ligaments are usually damaged with lonely fractures of the head of radius, while the lateral elbow ligaments are damaged in associated head of radius and ulnar coronoid damage. Therefore, accurate checkup of the traumatized elbow should be done. Assessment of the elbow movements should be done and any movements obstruction is noted. [3]

Primary radiological investigations of fractures of the head of radius involve x-ray imaging in posteroanterior, lateral, oblique, and capitelloradial imaging of the joint of the elbow. Computerized tomography scan (CT) of the elbow joint with three-dimensional (3D) reconstructions should be done for more accurate assessment of the fracture and operative strategy.

Numerous classifications for radial head fractures are present. Of these Mason classification which includes • **Grade I**: Minimal border fissure of the head of radius without displacement • **Grade II**: Displaced border fracture of the head of radius • **Grade III**: Comminuted fracture affecting the entire head. •**Grade IV**: Radial head fracture accompanied with dislocation of the elbow joint. [4]

Indications of the radial head arthroplasty involve:

- Comminuted fracture of the head of radius which cannot be reconstructed accompanied with inconstant fracture of the ulnar coronoid.
- After extraction of the head of radius with presence of inadequate medial elbow ligament or humeroulnar incostancy.
- Comminuted fracture of the head of radius which cannot be reconstructed accompanied with damage of the interosseous radioulnar

connection and partial dislocation of the distal radioulnar joint (Essex-Lopresti injury).

The aims of radial head arthroplasty can be separated on a brief principle into:

- *Provisional period:* during the initial 14-21 days postoperative the radial head prosthesis function is to preserve the reduction and constancy of the elbow, guiding ligamentous constrains (medial and lateral elbow ligaments, the interosseous radioulnar connection and distal radioulnar joint) to relive properly. During this duration, the radial head prosthesis (RHP) gives constancy to the elbow joint permitting movements and minimizing elbow stiffness.

- *Moderate/extended period:* during the following months and years the radial head prosthesis participate in load transmission acoss the elbow joint and decrease excess load on the humeroulnar joint and medial elbow ligament during the valgus tension, precluding humeroulnar joint arthritis, valgus abnormality, and late ulnar nerve problems [5]

Variations of outer approaches include Kocher's, Kaplan, Boyds and extensor digitorum (EDC) split approaches. Kochers approach has many virtues. In contrast to Kaplan approach, kochers approach is less danger to the posterior interosseous nerve and expansion of the kocher approach to address the lateral distal part of the humerus. In contrast to Kaplan or the extensor digitorum split approaches, the Kocher approach reaches the supinator ridge of the proximal ulna to manage its fracture or detachment of the lateral ulnar collateral ligament which present in 6% of terrible injuries of the elbow [6]

2. Patients and methods

The current study is a prospective therapeutic study. This study includes twenty cases of severely unreconstructable radial head fractures managed by cemented radial head replacement. The cases were operated on at Department of Orthopaedics at Benha University hospital and Shebin El-kom hospital for specialized surgeries between January 2023 to April 2024.

All patients were followed up for 14 months (range 12-16 months). All of them fulfilled the inclusion criteria. Informed written consent of the cases or family member was taken before the surgery after approval of medical ethical committee (study code MD 11/1/2023). An accidental sampling method was used. The study collection comprised of cases between twenty to fifty years of age with lonely fractures of the head of radius. Average age of the cases in the study was 37.9 years (span 24– 49 years). Sex distribution of fractures showed twelve (12) males & eight (8) females. Fourteen (14) patients had fractures involving the right sided elbow & six (6) had fractures on left sided elbow. Fourteen (14) patients had fractures involving the dominant elbow & six (6) had fractures on the non-dominant elbow.

Cemented radial head arthroplasty was done for fracture of the head of radius Mason grades III and IV and functional outcome was estimated postoperatively with Mayo elbow performance scale on follow-up visits at three, six and twelve months periods. Point estimate and 95% Confidence Interval were calculated.

2.1 Inclusion criteria

- 1.Fractures of the radial head Mason grade III&IV .
- 2. Age 20-50 years.

2.2 Exclusion criteria

- 1.Concomitant neurovascular injuries.
- 2.Compound fractures.
- 3.patients with any coexisting major comorbid conditions.

2.3 Methods

The study was done on patients viewed at orthopedic emergency ward. Clinical and radiological evaluation were done before entrance to the hospital as follows:

2.3.1 Initial clinical evaluation

2.3.1.1 History

- Personal informations: age, gender, job and special practice of medical significance (for example, smoking).
- History of the past illness: preceding diseases and operations (diabetes mellitus, heart, kidney and peripheral vasculopathy).
- Analysis of the injury: mode of injury, and period passed before presentation.

2.3.1.2 Physical examination

1-General checkup: vital signs, revitalization, and whole body checkup.

2- Local checkup:

- Injuries of the elbow and fractures of head of radius suspected by appearance of distortion, puffiness, tender palpation and motion restriction.
- Assessment of status of the overlapping skin.
- Neurovascular condition of the arm.

2.3.1.3 Radiological assessment

- Digital x-ray of the elbow joint (posteroanterior and lateral projections).
- Computerized tomography imaging for better delineation of fracture shape.

The upper arm was then put in long posterior slab with arm sling. Routine investigations before operation were done.

2.4 *Surgical techniques:*

➢ Type of anaesthesia used: general anaesthesia.

➢ Single dose of antibiotics is given 1 hour prior to surgery.
➢ The patient lies supine on the surgery table, with the injured upper limb settled above his trunk for Kochers approach and lies on his lateral side with his injured upper limb assisted by arm support in Boyds approach.
➢ Tourniquet was used in all patients.
➢ **Approaches:**
• Kochers approach for lonely fractures of the head of radius.
• Boyds approach for corresponding ulnar olecranon fracture.

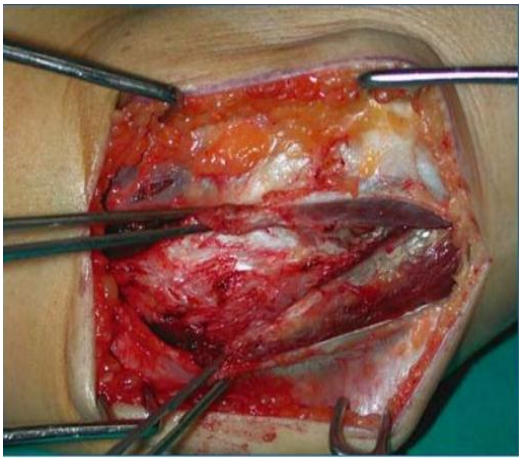
Kochers surgical approach: (Fig.1a,1b)

• Start the skin cut at the back aspect of the lateral margin of the humerus, and run it downward and ulnarly over the back surface of the ulna three to five centimeter away from the olecranon process.
• Superficial dissection of the underlying tissues is done at the same direction of the skin cut, and proceeds an intermuscular plane between the anconeus and the extensor carpiulnaris
• Exihibit the joint capsule by pulling the anconeus muscle medially and the extensor carpiulnaris laterally.
• The supinator muscle lies perpendicular to the cut and under the extensor carpiulnaris muscle. pull the upper part of the supinator muscle downward.
• Cut the capsule of the elbow joint and identify the proximal part of the radius.
• The posterior interosseous nerve presents among muscle fibers of the supinator and is safe.

(Fig.1a) Kochers surgical approach. the kochers skin cut extends from the humeral supracondylar aspect to the outer humeral condyle above the head of radius up to the back aspect of the ulna.

Averting injury to radial nerve:

• Withdraw the posterior interosseous nerve far from the operation area by complete pronation of the hand.
• Guard against cutting the elbow capsule extreme antecedently because the radial nerve overlays the frontal outer side part of the capsule of the joint.
• Guard against excessive manipulation far from the radial annular fibers, as the posterior interosseous nerve presenting inside the supinator fibers is endangered.
• Guard against putting retractor in circumference of the neck of radius.



(Fig.1b) Kochers surgical approach. the kochers interval is distinguished among the extensor carpiulnaris and the anconeus and the lateral elbow ligament is defined.

Boyds approach: (Fig.2a,2b)

• Begin the skin cut 2.5 centimeter above the elbow and to the outer side to the tendon of triceps, and extended downward above the outer part of olecranon and the ulnar margin beneath the skin, and it finishes at the connection of upper and central thirds of ulna.
• The space among the extensor carpiulnaris and anconeus on the outer aspect and the ulnar shaft on the inner aspect is created.
• The anconeus is dissected out of ulna in the upper portion of the field to show the head of the radius, the anconeus is kept laterally.
• Lower to the head of radius, reach the radioulnar interosseous sheet after dissecting the portion from the supinator attached to the ulna.
• Dissect the supinator at the upper part of the radius, and keep the whole muscle fibers laterally, in conjunction with upper portion of the extensor carpiulnaris and the anconeus.

This approach reveals the outer aspect of the ulna and the upper part of the radius entirely. The deep division of the radial nerve is preserved by the muscle fibers of the supinator.

Procedure of the head of radius substitution:

• Cut the radial annular fibers for revealing the whole head of radius.

(Fig.2a) Boyds surgical approach. line of incision.

(Fig.2b) Boyds surgical approach, deep dissectin was done parallel to the skin cut to reach the outer aspect of the ulna among the extensor carpiulnaris and the anconeus.

• Remove the fracture parts, the radial cut is done between the head of the radius an the neck or at the fracture area. **(Fig.3a,3b)**

• The Collection of the removed parts for sizing of the prosthesis of the radial head and ensuring total excision of the head of radius. **(Fig.4)**

• The ideal circumference of the implant is the smaller circumference of the ovoid local head of radius, usually two millimeter lesser than the greatest circumference. If it occurs among circumferences, lesser implant is used. [7]

• The back surface of the neck of radius is elevated by a retractor opposed to the ulna to move the upper radius in outer direction to prepare the canal of the radius and to introduce the prosthesis.

(Fig.3a) Sectioning of the radial head.

(Fig.3b) Radial head sectioned.

(Fig.4) Measurement of the exact circumference and girth of the prosthesi of the head of radius.

• The neck of radius is rasped and stem circumference is one millimeter lesser than rasp.

• Application of the trial.

• Suitable sized prosthesis needs to meet the following criteria to evade over compression of the capitelloradial joint, or restriction and looseness.

a.➢ upper part of the implant is aligned with the outer coronoid boundary or two millimeter shorter than the coronoid process on the anteroposterior view of fluoroscopy..

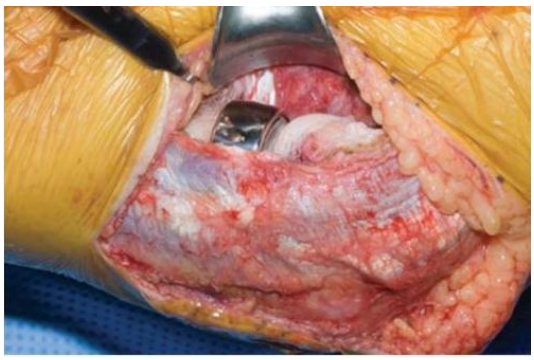
b.➢ Carry Move the elbow across bending ,stretching, and twisting to detect the correlation among the prosthesis and the capitellum in posteroanterior and side radiographs. **(Fig.5a,5b)**

c.➢ Examination of the steadiness of the elbow is done. The implant is altered in case the elbow is over compressed or very loose.

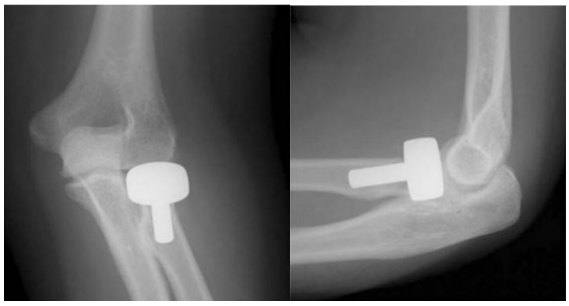
d.➢ Examination of the opposite wrist is done by radiograph and correlation with the affected extremity.

e.➢ The inner distance of the humeroulnar joint has to be aligned. The outer part of the humeroulnar joint increase in distance with over compressed implant.

- Insertion of the implant of the radial head is done following cementation.
- Reconstruction of the radial annular fibers and accompanying damage is done.
- Following the operation: application of above elbow slab. Cases were told to raise the extremity and digital motion. Intravenous antimicrobials and pain killer were prescribed in the initial 5 days after the operation then oral for another 5 days.



(Fig.5a) Relationship between the capitellum and the radial head implant. a picture demonstrating an implanted radial head replacement with appropriate joint reduction.



(Fig.5b) Relation among the prosthesis of the radial head and the capitellum. Posteroanterior and side views show aligned inner space of humeroulnar joint and the prosthesis congruent to the capitellum.

- Sutures Removal of the stitches is done at the tenth to twelfth day after the operation. Radiological imaging posteroanterior and side views were done. After that cases leave the hospital with the extremity in a sling and taught to make motions of the shoulder, elbow, wrist and digits. Avoid elevation of the weighty things and effort on the injured extremity.

2.5 Estimation of the results

2.5.1 Assessment after the operation

- Clinical assessment:

- The amount of movements.
- Ache
- Constancy
- Complications after the operation.

- Imaging assessment:

- Antero-posterior and side radiographs of the elbow.

- Follow up:

- Patients were followed up two weeks postoperative, monthly for 6 month and every 6 month.
- Functional assessment according to the Mayo elbow performance score (MEPS).

3. Results

- According to Mason classification, all fractures were Mason type III.
- Six (6) patients had associated olecranon fractures.
- Mean time elapsed between trauma and surgical intervention is 6.6 days (range 2 to 18 days).
- There were no pre-operative and postoperative nerve injuries.
- The average duration of surgery was 60 minutes, ranging from 45-120 minutes. Radial head fractures with associated injuries took longer duration.
- **Complications:** Six (6) patients developed elbow stiffness and was managed by regular physiotherapy. **(Table 1)**

Complications	Frequency	Percentage
ELBOW STIFFNESS	6	30%
Posterior Interosseous nerve (PIN) PALSY	0	0%
Heterotopic ossification	0	0%
Capito-humeral arthritis	0	0%
Periprosthetic osteolysis	1	5%
Superficial wound infection	2	10%

(Table 1) complications in the study.

- One (1) patient developed periprosthetic osteolysis but still fixed implant stability and functional range of motion and when implant instability occurs revision will considered.
- Out of 20 patients, 2 (10%) cases devolp surface infected wound that cured by daily dressing with empirical antibiotics till culture and sensitivity. Out of 20 patients, 6 (30%) patients develop firmness of the elbow in the initial four weeks of check, (three 3 of them improve flexion from 60 degree to 110 degree after twelve 12 sessions of physiotherapy and

the remaining three 3 improve flexion from 80 degree to 120 degree after 18 session of physiotherapy). All six cases improved later to functional range of movement.

- One (1) patient developed periprosthetic osteolysis but still fixed implant stability and functional range of motion and when implant instability occurs revision will considered.

Assessment of the outcome: includes functional and radiological

(A) • FUNCTIONAL OUTCOME:

The clinical result was established by applying the Mayo elbow index. **(Table 2)**

Mayo Elbow index:

Characters	Degrees	Explanation (Degree)
Ache	45	Nul (45) Little (30) Medium (15)
Range of movement	20	Bend more 100 degree (20) Bend among 50-100 degree (15) Bend less 50 degree (5)
Constancy	10	Constant (10) Medium loosening(5) Extreme loosening (0)
Daily action	25	Brush hair (5) Eat (5) Achieve cleanliness (5) Wear dress (5) Wear boot (5)
Sum	100	

Distribution: ➢excellent – more than 90; good among 75-90; fair among 60-74; poor less than 60.

➢Constant =no obvious varus –valgus loosening, medium loosening = less than ten degree of varus –valgus loosening ,and extreme loosening not less than ten degree of varus –valgus loosening.

(Table 2) Mayo elbow index.

The evaluation involved a mark of the case ache degree, extent of motion of the elbow, steadiness of the elbow, and degree of practice. Each case's concerned degree of motion was matched with the opposite elbow. The Mayo elbow index outcomes were distributed into excellent (≥90), good (75-89), fair (60-74), or poor (<60). **(Table3)**

According to the Mayo elbow index, from the twenty (20) cases, fourteen (14) cases exhibited excellent, five (5) exhibited good and one (1) exhibited fair index at six months check. **(Table 4, Fig.6)**

- Initially At the beginning the greatest number of the cases showed fair Mayo elbow index. At 15 months check, 19 patients (95%) had excellent Mayo elbow performance (MEP) score and only one patient (5%) had good Mayo Elbow performance (MEP) score. Fair outcome and poor outcome according to the Mayo elbow index was not observed. • The mean Mayo elbow index was 96.33±7.74 at twelve months of checkup.
- Functional result was superior in lonely fractures of the head of radius matched to combined fractures with fracture of the radial head.

At the termination of 15 months, the affected arm has mean supination of 85.8±1.576°, pronation of 83.8±2.397°, and mean bending of 115.7±8.436°. **(Table 5).**

(B) • Radiological outcome:

- Out of twenty (20) cases, no implant failure occurs, no implant cut through during operative fixation. Implant position after fixation within normal range of coaptation with the capitellum of the humerus.

3.2 Discussion

Management of comminuted fractures of the radial head with combined ligament injuries is debatable. Various treatment methods involve internal fixation, removal of the head of radius, and arthroplasty of the radial head. [8]

The upper epiphysis of the radius presents inside the capsule of the joint. This part has little blood supply via tiny vascularization inside the joint across the neck of radius and limited intraosseous vascularization nourish the head of radius. One vessel of the main intraosseous vascularization reaches the head of radius across the front outer nonarticular aspect. Radial head fractures disrupt the main vascularization. [9]

Besides, internal fixation of comminuted fractures of the radial head is challenging. Thus, internal fixation is not favored due to hazards involving avascular necrosis and ununited separated fragments. [10]

Removal of the head of radius in cases with combined radioulnar interosseous injury or medial elbow ligament tear leads to elbow or wrist unsteadiness. [11]

Scientists observed posterior and lateral rotational unsteadiness in 17% of the patients. Thus, latest articles determine the contraindication of removal of the head of radius in cases of insufficient medial elbow ligament, tear of radioulnar interosseous sheet, or dislocation of the elbow joint. Removal of the head of radius causes valgus unsteadiness of the elbow, firmness of the elbow and upward movement of the radius. [12]

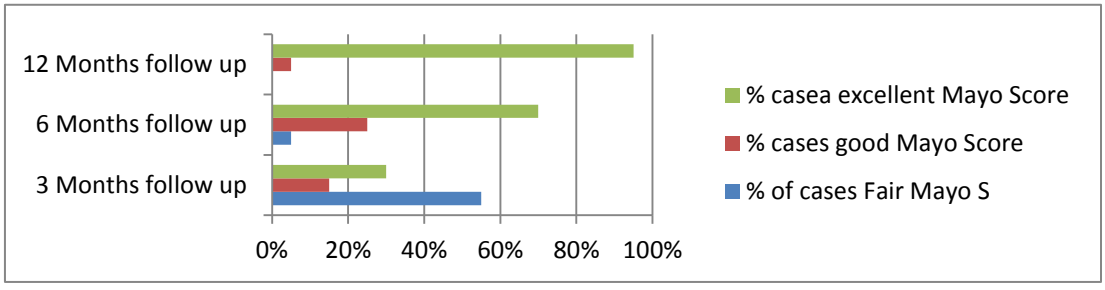
Radial Arthroplasty of the radial head is suggested in separated comminuted fractures

Patient	Sex	Age	Post.op. bending	Supination post.op.	Pronation post.op.	pain	Steadiness	ADL	Total MEPS
1	Male	34	123	84	81	non	normal	normal	100
2	Male	49	105	87	85	non	normal	normal	100
3	Male	39	124	86	87	non	normal	normal	100
4	Female	36	120	85	86	non	normal	normal	100
5	Female	48	123	85	85	non	normal	normal	100
6	Male	41	120	84	84	non	normal	normal	100
7	Female	45	120	88	87	non	normal	normal	100
8	Male	29	110	84	80	mild	normal	normal	95
9	Female	39	113	87	86	non	normal	normal	100
10	Male	42	120	86	85	non	normal	normal	100
11	Male	27	115	88	88	non	normal	normal	100
12	Female	47	120	87	84	non	normal	normal	100
13	Male	25	90	84	80	mild	normal	Mild loss	75
14	Female	24	121	88	83	non	normal	normal	100
15	Male	32	111	84	82	non	normal	Mild loss	95
16	Female	39	103	85	84	non	normal	normal	100
17	Male	35	117	87	81	non	normal	normal	100
18	Male	38	119	84	83	non	normal	normal	100
19	Female	46	122	85	84	non	normal	normal	100
20	Male	43	118	88	81	non	normal	normal	100

(Table 3) Results of the group of patients. (ADL, activities of daily living , MEPS, Mayo elbow performance score).

CHECK UP	Number of patients with fair Mayo index	Number of patients with good Mayo index	Number of patients with excellent Mayo score
3 Months	11	3	6
6 Months	1	5	14
12 Months	0	1	19

(Table 4) Functional outcome in the study.



(Fig.6) Graph of functional outcome in the study.

Examination	Mean±SD	Least	Greatest
Bending	115.7±8.436	90	124
Supination	85.8±1.576	84	88
Pronation	83.8±2.397	80	88
Ache	43.5±4.617	30	45
Degree of movement	19.5±1.539	15	20
Steadiness	10	10	10
Daily routine	24.25±1.832	20	25
Total MEPS	97.25±7.691	75	100

Table 5. Individual condition of the arthroplasty of the radial head at the termination of 16 months checkup (n= 20).(SD, standard deviation, MEPS, mayo elbow performance score).

of the radial head not reparable by fixation, fractures combined with dislocation of the elbow and comminuted fractures with tear of the lateral or medial elbow ligamentsor radioulnar interosseous. [13]

Osteoarthritis of the elbow occurs due to damage to the articular surface of the capitellum and radial depression of ulna in cases of ununited fracture of the radial head. Radial head replacement regains steadiness and movements of the elbow. [14]

Different artificial substances, involving silicone rubber, acrylic, cobalt-chromium, vitallium, and titanium have been used. The drawbacks of Silicone prosthesis include breakage, inflammation and unsteadiness of the elbow. Metallic prostheses recover steadiness of the elbow nearly like the original head of radius. Recent modular implants have enhanced dimensions and retrieve the architecture of upper radius, besides simple application in the operation. [15]

The drawbacks of the bipolar metallic implants are inaccurate analogous dimensions and challenging application due to requirement to partially dislocate the elbow. An immediate collapse occurs with dissociated prosthesis due to elevated tension on joint surface. The other drawbacks are polyethylene abrasion, bending beneath stress, minimizing the steadiness of the elbow in case of ligament tears. [16]

The current study consists of twenty (20) cases with unreconstructable fractures of the head of radius managed by a cemented radial head prosthesis and followed up for fifteen (15) months. Corresponding to the Mayo elbow index, from the twenty (20) cases, 19 cases (95%) had excellent Mayo Elbow performance (MEP) score and only one patient (5%) had good Mayo Elbow performance (MEP) score at 15 months follow up. Fair and poor outcome were not seen. The mean Mayo elbow index was 96.33±7.74 at one year of checkup. Practical results was superior in lonely fractures of the radial head matched to combined fractures with fracture of the radial head. At the termination of 15 months, the affected arm has mean supination of 85.8±1.576°, pronation of 83.8±2.397°, and mean bending of 115.7±8.436°.

On comparison of the current study and a study done by Burkhart et al. in 2010, the current study showed improved mean Mayo elbow index was 96.33±7.74 at one year of checkup while the study done by Burkhart et al. showed Mayo elbow index was 87 at terminal checkup (average 2.8 years). The causes include the cases were of grade III Mason fractures in the current study and a less number of patients in the current study with associated elbow injuries.

3.2.2 Study limitations:

The current study limitations include a relatively small number of patients, short follow up periods and no control group of patients. Future prospective includes larger number of patients included in the study and longer periods of follow up to evaluate clinical and imaging results following intricate elbow injuries.

3.2.3 Future prospect:

Conservative treatment of unreconstructable radial head fractures will be obsolete and the arthroplasty of the radial head will be the preferred method of management of these fractures.

4. Conclusion

Replacement of the radial head in grades III & IV mason fractures increases the steadiness to valgus load to the elbow, improve longitudinal burden through the elbow, provides better range of movement and allows good recovery of the soft tissue preventing upward movement of the radius.

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