Evaluation of Treatment of Recent Comminuted Head Radius Fractures in Adults by Prosthetic Replacement

Tarek A. Mahmoud MD

Assistant Professor of Orthopaedic Surgery, Suez Canal University, Ismailia, Egypt.
Author correspondence:
Tarek Abdel Aziz Mahmoud MD
Assistant Professor of Orthopaedic Surgery, Suez Canal University, Ismailia, Egypt.
Email: Tareksh64@yahoo.com
Tel: 00201224156281

The Egyptian Orthopedic Journal; 2020 supplement (1), June, 55: 18-27

Abstract

Background
The important function of the radial head in keeping stability of the elbow and forearm has led to its preservation after comminuted fracture either by surgical fixation or prosthetic replacement and radial head replacement leads to restoration of elbow function with stability of the elbow joint.
Aim of the study
Evaluation of the functional and radiological results of treatment of recent comminuted radial head fractures in adults by radial head replacement.
Patients and Method
This prospective study was done on 10 patients 8 males and 2 females attended in Saudi German hospital in Saudi Arabia between June 2012 and July 2014 and the mean age was 48 years (range 40 - 62) at the time of surgery. The mean interval between injury and surgery was 6 days (range 2 to 10 days). Inclusion criteria in this study were patients had comminuted fracture head radius classified as Mason type III with complete displacement and there were two patients had concomitant radial collateral ligament injuries. Follow-up evaluation of the results after one year of surgery was done using the Mayo Elbow Performance Score (MEPS), the score of disabilities of the Arm, Shoulder and Hand (Quick DASH) and the visual analog scale (VAS) of pain and radiological evaluation was rated for arthritis after one year follow-up according to Morrey.
Results
The outcome after one year of follow-up was excellent results in eight patients (80%), good in one patient (10%) and fair result in one patient (10%). In addition, the mean Mayo Elbow Performance Score (MEPS) was 94 (range 85-100) and the mean Disabilities of the Arm, Shoulder and Hand (Quich DASH) was 6.5 (range 0-14) and the visual analog scale (VAS) for pain score was 1 (range 0-2). The average Flexion/extension arc of the affected side was 135^0 (range 145^0/-5^0) and the average of pronation was 65^0 (range 60^0 – 70^0) and the average of supination was 80^0 (range 75^0-85^0). Radiological evaluation of the medial and lateral ulnohumeral spaces after one year shows congruent elbow joint and no arthritic changes of the radiocapitellar joint and no implant loosening was identified. No post-operative vascular or neurological complications were found and one patient had superficial infection that improved by frequent dressing.
Conclusion
Radial head replacement using the anatomical radial head prosthesis is an effective method to restore stability of the elbow joint and excellent functional outcome with minimal complications.

Key words
Radial Head, Fracture, Arthroplasty, Prosthesis.

Introduction

Radial head fractures are found in 20% of elbow injuries after a fall on outstretched hand with forearm pronation. [1] In addition, the radial head is considered as an important stabilizer of the elbow joint and forearm. [2]

The radial head is not round; instead, it has a conical shape and the longest axis is perpendicular to the radial notch of the ulna in neutral rotation. The neck of the radius is about 13 mm long and forms an angle of about 17^0 with the radial shaft. The blood supply to the radial head is abundant in the periphery, where it receives from metaphyseal arterial branches and this arrangement is important in the risk of post-traumatic necrosis and non-union. [3-5]

The first classification of fracture head radius was developed by Mason [6] as Type I, non-displaced marginal fissure or fracture, Type II, displaced marginal fracture with separation or impaction and Type III, displaced comminuted fracture involving the en-

tire radial head. More recently, Broberg and Morrey [7] added a Type IV classification including fracture head radius combined with elbow dislocation. Later on, Hochkiss [8] modified Mason's classification by adding clinical criteria that depends on clinical evaluation. (Table 1)

Table 1: Hotchkiss modified Mason's Classification

Type I	Fracture of the radial head or neck, with little or no displacement. Range of pronation / supination limited only by pain and oedema. Articular fracture < 2 mm or marginal fracture of the radial head.
Type II	Displaced fracture (2 mm) or fracture of the neck with angulation. Motion range limitation as a result of mechanical impingements or loss of joint congruity. No severe comminution (internal fixation possible)
Type III	Severe comminuted fracture of the radial head or neck and reconstruction is not feasible according to criteria assessed intra-operatively or radiologically. Radial head excision or prosthetic replacement is required.

More recently, Mayo clinic classification add all concomitant lesions of the radial head fracture as described in Mason's classification and latters are added to clarify the concomitant lesions, in upper case if the lesion is treated and lower case if not. For example, a Type III Mlc is a Mason Type III fracture of the radial head with a repair of the ulnar collateral ligament, and untreated tear of the radial collateral ligament and untreated coronoid fracture. [9] (Table 2)

Table 2: Mayo clinic classification

Type of RH fracture	Associated injury suffixes	Surgical treatment suffixes	
I	m	M	F
II	l	L	X
III	d	D	P
	c	C	
	o	O	

Type I, non-displaced fracture; Type II, displaced fracture (2 mm); Type III, comminuted fracture;

M, medial collateral ligament; l, Lateral collateral ligament; d, distal radio-ulnar disruption;

c, coronoid fracture; o, olecranon fracture; F, fixation; X, excision; P, radial head prosthesis.

Non-displaced radial head fractures are treated by conservative measures. In displaced fractures anatomic reduction and internal fixation are indicated and is common in 80% of cases and is considered a good choice when there are three or less fragments without deformity and with sufficient size and bone quality for screw fixation and no marked metaphyseal bone loss. [10]

A displaced and comminuted fracture of the head radius is part of complex injury of three joints which is elbow, radio-ulnar and wrist joints and if associated with injury of collateral ligaments, simple excision of the head radius may lead to pain and elbow instability. [11] In addition, comminuted radial head fractures affects stability of elbow and forearm and when internal fixation is not accepted, the choices are either radial head excision or radial head replacement. The complications after excision of the radial head had been reported in many series as proximal migration of the radial head and ulnohumeral arthritis. [12,13]

Radial head replacement was first recommended at 1970 as a better choice than radial head resection with better mechanical elbow stability. [14] In addition, many authors reported that radial head replacement for severe comminuted fractures of head radius is considered as the basic treatment to avoid elbow instability. [6,15,16]

Many types of implant were used for radial head replacement and none has been proven to be superior over the others. [17] The first implants used for radial head replacement were Swanson-type silastic implants. It is semi-rigid cementless implants that used

sometimes as temporary spacers to prevent proximal migration of the radius. The advantages of using this implant are good tolerance and greater ease of removal in comparison to rigid implants. The disadvantages that the implants cannot act as a secondary valgus stabilizer in patients has injury of the ulnar collateral ligament and also the high rates of osteolysis caused by silicone particles and finally implant fractures. For all the above reasons, many authors did not recommend Silastic radial head implants. [18,19]

Later on, Metal implants with long-term outcomes are more popular and classified according to three main criteria that are modularity, intra-prosthetic mobility and stem fixation as cemented or cementless. [20] In the study of Ring [10] a few prosthetic radial head designs try to resemble radial head anatomy, most are either spacers with a loose smooth stem in the radial neck or bipolar with mobile articulation between the head and neck of the prosthesis. A bipolar implant has the advantages of improving the proximal radioulnar congruity but the disadvantage is less stability than the monoblock implants. In addition, many reports of cup disassembly related to retention within the implant and residual elbow instability are disadvantages of bipolar implants. [21]

In addition, some implants allow adjustment of the angle between head and neck of radius to be closely similar to the patient's native anatomy and fixation of the implant within the intra-medullary canal is achieved either by a cemented stem or a cementless press-fit stem. Some authors reported also that press-fit stems have the disadvantage of micro-fractures especially if the stem diameter is oversized by 1 mm or more. Also, they reported peri-prosthetic osteolysis in some patients. [22] In the study of Doornberg et al., [23] they reported that the development of radiolucencies around the stem is clinically irrelevant and satisfactory medium-term outcomes were achieved. In another study implants made of pyrolytic carbon with a fixed head-neck angle have a good early outcome and well tolerated when placed in contact with the capitellar cartilage. [24]

In the current study Modular implants was used as it has two advantages, first is the optimal head size can be selected and second the height of the head and neck of radius can also be selected to match height of the resection.

Patients and Methods

This prospective study was done on 10 patients 8 males and 2 females attended in Saudi German hospital in Saudi Arabia between June 2012 and July 2014 and the mean age was 48 years (range 40 - 62) at the time of surgery. The mean interval between injury and surgery was 6 days (range 2 to 10 days). Inclusion criteria in this study were patients had comminuted fracture head radius classified as Mason type III with complete displacement and there were two patients had concomitant radial collateral ligament injuries. There were no patients had associated coronoid fracture, elbow dislocation, Essex-Lopresti injury and neurovascular injuries.

History of trauma with fall on the outstretched hand with extension of the elbow and pronation of the forearm is suggesting fracture head radius. Standard Antero-posterior and lateral views were done in all patients and a radial head-capitellum view (modified lateral view with the tube angled 45^0 towards the radial head) as described by Greenspan and Norman. [25] In addition C.T. Scan was done for all patients to give more accurate diagnosis of comminuted fracture head radius and concomitant fracture as fracture coronoid. Finally, MRI was done also for diagnosis of any associated interosseous membrane rupture and ligament injury.

In the current study, the anatomical radial head prosthesis used before by Shawn W O'Driscoll et al., [5] was used for all patients. Clinical evaluation was done after one year follow-up using the Mayo Elbow Performance Score (MEPS). This system uses patient outcome parameters and objective clinical data. Scores of pain, motion, stability and daily function was used for evaluation of each patient at follow-up after one year post-operative. [26] (Table 3)

Also evaluation was done using the score of disabilities of the Arm, Shoulder and Hand (Quick DASH) and it depends on patient's symptoms as well as the ability to perform certain activities. It consists of eleven questions scored on a 5-point scale similar to the DASH and a lower score indicates less disability. [27] In addition, The visual analog scale (VAS) pain score was used also for evaluation of the degree of pain post-op after one year of follow-up (no pain = 0 and severe pain = 10). [28]

Radiological examination for subluxation or dislocation of the ulnohumeral joint was done after one year of follow-up and evaluation for arthritis was rated according to Morrey et al., [29]. (Table 4)

Operative technique:

Under General anesthesia and tourniquet, the Kaplan approach was used in a line from the lateral epicondyle towards lister's tubercle with the forearm in neutral rotation and deep dissection between the extensor carpi radialis longus and extensor digitorum communis. This approach preserves the collateral

ligaments if not injured. The extensor carpi radialis longus is released proximally with anterior capsule to expose the radial head. The annular ligament is spared to allow for suturing if needed at the end of operation. Then resection of the radial head with a power saw close to the surgical neck was done while the forearm in pronation to keep the interosseous nerve at a safe distance during resection. After that a 5 mm awl was used to enter the canal and then with smallest broach 6 mm preparing the canal for the stem. Then larger broaches were used sequentially until a tight fit. The diameter of the last broach is 0.5 smaller sizes than the used implant stem for a tight press fit. The collar reamer was used that matches with the stem diameter that determined by the last broach used and avoiding removal of too much bone from the radial canal.

Table 3: Mayo Elbow Performance Score

Function	Point Score
Pain (45 Points)	
None	45
Mild	30
Moderate	15
Severe	0
Motion (20 Points)	
Arc 100^0	20
Arc 50^0 -100^0	15
Arc < 50^0	5
Ankylosis	0
Stability (10 Points)	
Stable (no apparent varus-valgus laxity)	10
Moderate instability (< 10^0 instability)	5
Gross instability (10^0 instability)	0
Daily Function (25 Points)	
Self-feeding	5
Putting on shirt	5
Putting on shoes	5
Self-hygiene	5
Combing hair	5
Maximum possible total score	100
Excellent	90
Good	75-89
Fair	60-74
Poor	< 60

Table 4: Radiological evaluation of arthritis

Grade	Arthritic changes
Grade 0	No significant changes
Grade I	Minimal osteophytes or joint space narrowing
Grade II	Moderate osteophytes or joint space narrowing
Grade III	Severe joint destruction

The resected radial head was placed in the sizing pockets on the impactor base and the comminuted fragments are reconstituted to confirm that no intra-articular fragments had left and to be a guide for the diameter of the radial head implant. If the radial head is not fit in the sizing pockets, smaller size was selected. Now the head and stem size was determined and assembly was used now before final set up of the permanent prosthesis. For determination of the collar height, the stem assembly was inserted into the bone canal and we started with + 0 end of the trial gauge and increasing sequentially the height of the trial gauge until the head reaches the capitellum and in the same time the coronoid contacts the trochlea. Then the number on the trial gauge will determine the collar height on the stem. There is a laser mark on the trial head and stem and the laser mark on the stem determines the Right and Left for proper orientation during insertion. Finally the trial implant was inserted into the radius with keeping the laser marks on the head and stem aligned with the lateral aspect of the radius and the forearm in neutral position. Proper articulation of the capitellum and coronoid is very important for proper positioning of the trial and C-arm

was used for evaluation. At the end, the implant stem was fixed to the impactor base with alignment of the laser marks for proper positioning and inserted into the radius.

Finally, the capsule and annular ligament were sutured. Then stability of the collateral ligaments was assessed in 30^0 of elbow flexion by applying valgus and varus stress test. In the current study two patients had torn radial collateral ligament and repair was done using osseous non-absorbable sutures.

For patients had isolated head radius fractures without ligament injury, early movement was started from the first few days post-operative. For the other two patients, long arm splint was applied for one week and then elbow movement flexion and extension was started with the elbow at the patient's side and shoulder adducted to protect the elbow form varus stress for 6 weeks. Standard radiographs of the elbow and wrist joints in neutral rotation were done for evaluation of the medial and lateral ulnohumeral space and development of arthritic changes at the radiocapitellar and ulnohumeral joint. In addition, to assess any change in the implant stem position and development of peri-prosthetic lucencies.

Statistical analysis:

Statistical analysis was performed with SPSS software (version 11.0; SPSS, Chicago, IL, USA). Preoperative and postoperative indices for this study were compared by paired t test. $P < 0.05$ was defined as a significant difference.

Results

In the current study the outcome after radial head replacement using the modular anatomical radial head prosthesis for 10 patients with follow-up for one year was excellent results in eight patients (80%), good in one patient (10%) and fair result in one patient (10%). In addition, the mean Mayo Elbow Performance Score (MEPS) was 94 (range 85-100) and the mean Disabilities of the Arm, Shoulder and Hand (Quich DASH) was 6.5 (range 0-14) and the visual analog scale (VAS) for pain score was 1 (range 0-2).

Clinical evaluation of the range of movement of the affected elbow after one year of follow-up shows that the average Flexion/extension arc was 135^0 (range $145^0/-5^0$) and for the range of movement of the forearm shows that the average of pronation was 65^0 (range $60^0 – 70^0$) and the average of supination was 80^0 (range 75^0-85^0).

Radiological evaluation of the medial and lateral ulnohumeral spaces shows a congruent elbow joint and no arthritic changes of the radiocapitellar joint and no implant loosening was identified and no proximal migration of the prosthesis (the proximal edge of the prosthetic head was on the same level with proximal edge of the radial notch of the ulna in antero-posterior radiograph). No post-operative vascular or neurological complications were found and one patient had superficial infection that improved by frequent dressing.

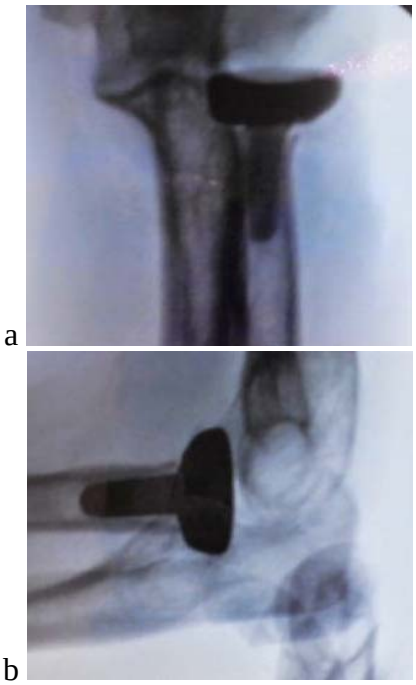

Figure: a male patient had comminuted head radius fracture type III and managed by head radius replacement with good alignment of the stem and preserved joint space after one year of Follow-up.
a: Post-operative X-ray AP view after one year of head radius replacement, b: Post-operative x-ray Lateral view after one year of head radius replacement.

Discussion

The indications for surgical treatment of fracture head radius are Mason types II and III as type one is managed by non-operative measures. For type II open reduction and internal fixation is indicated while in type III radial head replacement is indicated as anatomic reduction and stable fixation is difficult to achieve. In addition many authors consider that radial head replacement is an alternative for radial head excision with more mechanical stability. [15,30]

Many authors reported also in their studies that internal fixation of fracture head radius having more than three fragments can result in early failure with broken metals, non-union and loss of forearm movement and the best option for this fracture is radial head re-

placement by metallic prosthesis. [31,32] In addition, severe elbow injuries as the terrible triad that consists of radial head fracture, postero-lateral elbow dislocation and fracture coronoid process needs reconstruction of the lateral column of the elbow that includes the radial head and the radial collateral ligament and if internal fixation is not indicated, the only option is radial head replacement in addition to fixation of the coronoid and re-attachment of the radial collateral ligament. [33]

In the study of Chemama et al., [30] fracture head radius that accompanied by fracture proximal ulna requires strong plate fixation of fracture ulna and if internal fixation of fracture head radius is not feasible, radial head replacement should be performed to add stability and helping union of fracture ulna. In another study of Chen et al.,[34] demonstrated that patients managed by open reduction and internal fixation for comminuted radial head fractures had failure of healing in 17% of patients and heterotopic ossification in 8% and the complication rates was 47.9%. In addition, Cai et al.,[35] reported also that the results of treatment of patients had Mason type III head radius fracture by internal fixation are satisfactory in only 22% of patients.

Bonnevialle [17] reported in his series that radial head replacement is not enough to confirm stability of the elbow if there are concomitant lesions left untreated. So, to prevent elbow instability it is important to repair the radial collateral ligament if torn which is often detached proximally in addition to the muscles inserted to the lateral epicondyle using trans-osseous suture fixation. Also, it is important to internally fix a coronoid fracture in terrible triad injury of the elbow. Many biomechanical studies had confirmed also that excision of the head radius will alter elbow joint stability and kinematics even when the collateral ligaments are intact and the instability becomes more severe when the collateral ligaments are torn. [36,37,38] In addition, many complications was occurred following resection arthroplasty of the head radius type III as proximal migration in 50% of cases, humero-ulnar arthritis in 50% and cubitus valgus deformity in 30% of cases. For that reasons, many authors did not recommend resection of head radius on an emergency basis as ligament damage which is very common can result in instability of the elbow. [30,39]

Many authors confirmed that the mean age of patients has comminuted fracture head radius and require radial head replacement was 50-60 years. On the other hand, younger age patients had a higher risk of revision surgery and the main reason is implant loosening. [21,40,41,42] Two basic principles must be fulfilled in radial head replacement as the implant must be similar in the diameter and thickness of the original radial head, and it must be applied at the same height as low implant position may result in residual elbow instability, while high implant position creates excessive stress on the condyle that rapidly causes joint damage with pain and limited range of motion at the elbow. [43] In addition, Yian et al., [44] reported in their series that accurate positioning of these prosthesis is crucial to establish proper tracking of the prosthetic head on the capitellum as abnormal tracking can cause arthritic radiocapitellar joint and stem loosening.

Some authors confirmed that metallic radial head prosthesis was able to restore near normal elbow joint biomechanics and stability and limit proximal migration of the radial head. [45,46] Other authors reported also that the metallic mono-block implants are not adaptable and their implantation my lead to lateral elbow subluxation. [47,48]

Bipolar radial head prosthesis were developed to improve implant tracking on the capitellum and the disadvantages of this design are the risk of wear of the bipolar implant with production of polyethylene debris and the stability effect may be not enough in patients had damaged collateral ligaments and elbow instability. [49,50] In other studies, many authors confirmed that metallic modular radial head implants which are available in different sizes of the head and stem were developed to improve adaptability and facilitate implantation. [42,51] According to Bonnevialle [17] there is now a recommendation not to use Swanson-type implants. In addition, no clinical studies have established that any of the other implant types is superior over the others.

Current and past designs of radial head prosthesis have had a round radial head component which is not similar for the radial head of the patients. In the current study, the anatomic radial head prosthesis that resembles the patient's natural head geometry provides better articulation with more mechanical advantages and less wear effects on the capitellum.

For evaluation of the outcome of radial head replacement, Cusick et al., [52] confirmed that the mean Mayo Elbow Performance Score (MEPS) has strong reliability when evaluated at different times and also when compared with a validated elbow outcomes instrument. In addition, many studies reported recently that the outcomes are satisfactory in 88% of patients who did operation in acute fractures and 66% are satisfactory in late fractures treated by head radius replacement. [22,40,53]

Previously published studies did not give comparison between the implants used for head radius replacement. In the study of Allavena et al., [21] reported

that the outcomes are not different significantly according to the implant design as for mono-block prosthesis range between 66% to 94% of satisfactory results, for bipolar prosthesis range between 67% to 86% of satisfactory results and for modular monopolar prosthesis range between 61% to 82% of satisfactory results.

Many authors reported the results of using bipolar design for head radius replacements in acute fractures with different satisfactory results that may be related to different follow-up period. In the study of Doornberg et al., [23] the satisfactory results were 82% and the follow-up of patients was 3.5 years. In another study of Chien et al., [54] the satisfactory results were 90% and the follow-up of patients was 3 years. In the study of Sarris et al.,[24] the satisfactory results were 94% and the follow-up of patients was 2 years. In another study of Flinkkilä et al., [40] with follow-up of patients for 4 years, the satisfactory results were 62%.

In the study of Zunkiewicz et al., [55] the outcome after radial head replacement used bipolar implant for 30 patients with follow-up for 34 months (range 24-48 months) was satisfactory as the average MEPS was 92.1 (range 65-100), the VAS for pain was 1.4 (range 0-5) and DASH was 13.8 (range 0-52). The average pronation of the affected side was 69^0 (range 45^0 – 90^0) and the average of supination was 74^0 (range 60^0-85^0) and the Flexion/extension arc was 126^0 (range 95^0 – 150^0) in the affected elbow. Radiographic analysis after two years follow-up of the affected and unaffected elbows revealed no significant difference for the average lateral ulnohumeral space of both sides and also for the medial ulnohumeral space of both sides. In another study of Alnot et al., [41] the outcome after radial head replacement used bipolar implant for 18 patients with follow-up for 1.5 years was satisfactory in 100% of patients and the Grip strength vs. the contralateral upper limb was 75% and the pronation/supination range of movements in the affected side was (77/79) degrees and Flexion/extension was (126/-18) degrees.

In the study of Allavena et al., [21] with longer follow-up period they used the bipolar radial head prosthesis and the mean MEPS assessment was 79 (range 30-100) and 77% of patients had satisfactory results and according to Quick DASH score, 77% of patients had little or no functional impairment and according to VAS values, 61% had little or no pain. In addition, the mean motion arcs were 143^0 in pronation-supination and 100^0 in flexion-extension. The mean wrist strength of the operated side was 86% and the mean elbow strength was 67% in comparison to the normal contralateral side. In a long term study of Burkhart et al., [56] the outcome after radial head replacement using bipolar implant for 9 patients with follow-up for 8.8 years was satisfactory in 100% of patients and the Grip strength vs. the contralateral upper limb was 75% and the pronation/supination range of movements of the affected side was (64/64) degrees and Flexion/extension was (124/-21) degrees.

Many authors reported the outcome of radial head replacement with modular implants. In the study of Lamas et al., [57] the outcome after radial head replacement using Modular implant for 47 patients with follow-up for 3 years was satisfactory in 86% of patients and the Grip strength vs. the contralateral upper limb was 85% and the pronation/supination range of movements of the affected side was (75/67) degrees and Flexion/extension was (140/-6) degrees. In a similar study of Doornberg et al., [23] using Modular implant, the outcome after radial head replacement for 27 patients with follow-up for 3.5 years was satisfactory in 82% of patients and the Grip strength vs. the contralateral upper limb was 85% and the pronation/supination range of movements of the affected side was (73/57) degrees and Flexion/extension was (131/-20) degrees.

In the study of Grewal et al., [51] the outcome after radial head replacement using Modular implant for 26 patients with follow-up for 2 years was satisfactory in 75% of patients and the Grip strength vs. the contralateral upper limb was 85% and the pronation/supination range of movements of the affected side was (71/56) degrees and Flexion/extension was (138/-15) degrees and. In another study of Flinkkilä et al., [40] the outcome after radial head replacement using Modular implant for 42 patients with follow-up for 4.5 years was satisfactory in 62% of patients and the Grip strength vs. the contralateral upper limb was 85% and the pronation/supination range of movements of the affected side was (75/73) degrees and Flexion/extension was (136/-20) degrees. The lowest satisfactory result in this study may be related to the longer Follow-up period in comparison to other studies.

In the current study the outcome after radial head replacement using the modular anatomical radial head prosthesis for 10 patients with follow-up for one year was excellent results in eight patients (80%), good in one patient (10%) and fair result in one patient (10%). In addition, the mean Mayo Elbow Performance Score (MEPS) was 94 (range 85-100) and the mean Disabilities of the Arm, Shoulder and Hand (Quich DASH) was 6.5 (range 0-14) and the visual analog scale (VAS) for pain score was 1 (range 0-2).

Clinical evaluation of the range of movement of the affected elbow after one year of follow-up shows that the average Flexion/extension arc was 135^0 (range 145 /-5^0) and for the range of movement of the fore-

arm shows that the average pronation was 65^0 (range 60^0 – 70^0) and the average of supination was 80^0 (range 75^0-85^0). Radiological evaluation of the medial and lateral ulnohumeral spaces shows a congruent elbow joint and no arthritic changes of the radiocapitellar joint and no implant loosening was identified and no proximal migration of the prosthesis. These results are comparable to the results of Lamas et al., [57] and Doornberg et al., [23] with better outcome may be for the shorter follow-up period of the current study as one year in comparison to the other studies as 3 and 3.5 years respectively.

Many complications were reported after radial head replacement and in the study of Van Riet et al., [58] they demonstrated that preoperative osteoporosis of the capitellum was associated with the risk of erosion and arthritis by the prosthetic radial head. In the study of Flinkkilä et al., [40] they reported the complication of aseptic loosening that manifested by a radiolucent line around the stem and pain in the forearm radiating to the wrist and developed early within 12 months in cementless press-fit stem and later on with cemented implants especially bipolar design. In addition, many authors confirmed also the complication of radiocapitellar arthritis that resulted from excessive pressure of the radial head on the humeral condyle and the most common cause is too high implant with malposition. [1, 30] In the study of Doornberg et al [59] they reported that the correct size of the radial head can be achieved through matching as possible the removed fragments and for avoiding radio-capitellar arthritis through keeping the edge of the prosthesis not be more than 1 mm proximal to the coronoid at the lesser sigmoid notch. In another study of Zunkiewicz et al., [55] follow-up radiographs revealed small ulnohumeral bone spurs in 64% of patients and stem lucency in 70% of patients and there were no cystic lesions suggestive of polyethylene wear was noted. Complication rate was overstuffed radiocapitellar joint in one patient (3%) that needs revision and another patient (3%) had elbow instability that needs reduction and stabilization of the joint with external fixator.

Another complication is elbow instability that caused by incomplete treatment of concomitant lesions as failed attachment of the radial collateral ligament and also internal fixation of fracture coronoid process in terrible triad injury. [30] In the study of Chanlalit et al., [20] they reported also that the type of implant affects elbow stability as the fixed-cup implants have a greater degree of stability than bipolar mobile cup implants.

In a study of Duckworth et al., [33] on evaluation of monoblock cementless implants, they found that the revision rate was 28% and the reasons were young age and the use of silicone implants. In addition, Allavena et al., [21] reported in their study that radiolucent lines were seen in follow-up radiographs around the prosthesis in 28% of patients and capitellar erosion in 38% of patients and revision surgery to manage elbow instability was done in 33% of patients. They reported also in conclusion that the outcomes of bipolar radial head prosthesis for treatment of comminuted radial head fractures were disappointing and treatment of associated injuries influence the prognosis.

In the current study no post-operative vascular or neurological complications were found and one patient had superficial infection that improved by frequent dressing. In addition, no implant loosening or proximal migration of the prosthesis was identified.

Conclusion

Head radius replacement is the principle treatment for multi-fragment radial head fractures (type III fractures) for which reliable internal fixation is not feasible and great care is essential to determine the optimal height of the implant to avoid pain and stiffness of the elbow in high implant and for residual instability of short implant. In addition, management of the concomitant lesions is very important to keep stability of the elbow and the complication rate is affected also by the implantation technique and the duration of follow-up.

The current study demonstrates that radial head replacement using the anatomical radial head prosthesis with selection of the proper size of the radial head and stem and accurate level of the radial head will ensure proper tracking and the press-fit technique will avoid the stem loosening that may happen for the cemented design. In addition, it is an effective method to restore stability of the elbow and excellent functional outcome with minimal complications.

References

1. Van Riet RP, Van Glabbeek F and Morrey BF: Radial head fracture. In: Morrey BF, editor. The elbow and its disorders. 4th ed. Philadelphia, PA: Saunders Elsevier, 2009; 359–81.
2. Ikeda M, Yamashina Y and Kamimoto M: Open reduction and internal fixation of comminuted fractures of the radial head using low profile mini plates. J Bone Joint surg Br. 2003; 85: 1040-1044.
3. Captier G, Canovas F, Mercier N, Thomas E and Bonnel F: Biometry of the radial head: biomechanical implications in pronation and supination. Surg Radiol Anat 2002; 24: 295–301.
4. Koslowsky TC, Germund I, Beyer F, Mader K, Krieglstein CF and Koebke J: Morpho-metric parameters of the radial head: an anatomical study. Surg Radiol Anat 2007; 29: 225–30.
5. Van Riet RP, Van Glabbeek F, Neale PG, Bortier H, An KN and

O'Driscoll SW: The noncircular shape of the radial head. J Hand Surg Am 2003; 28: 972–8.
6. Mason ML: Some observations on fractures of the head of the radius with a review of one hundred cases. Br J Surg 1954; 42(172): 123–32.
7. Broberg MA and Morrey BF: Results of treatment of fracture-dislocations of the elbow. Clin Orthop Relat Res 1987; 216: 109–19.
8. Hotchkiss N: Displaced fractures of the radial head: internal fixation or excision? J Am Acad Orthop Surg 1997; 5:1–10.
9. Van Riet RP, Morrey BF: Documentation of associated injuries occurring with radial head fracture. Clin Orthop Relat Res 2008; 466:130–4.
10. Ring D: Radial head fracture: open reduction-internal fixation or prosthetic replacement. J Shoulder Elbow Surg. 2011; 20: S107-S112.
11. Krishna AM and Reddy NS: The role of prosthetic replacement in the management of comminuted radial head fractures. Apollo Medicine. 2012; 9:336-338.
12. Ikeda M, Sugiyama K and Kang C: Comminuted fractures of the radial head: Comparison of resection and internal fixation. J Bone Joint Surg Am. 2006; 88: 11-23.
13. Lindenhovius AL, Felsch Q and Doornberg JN: Open reduction and internal fixation compared with excision for unstable displaced fractures of the radial head. J Hand Surg Am. 2007; 32: 630-636.
14. King GJ: Management of comminuted radial head fractures with replacement arthroplasty. Hand Clin 2004; 20(4): 429-41.
15. Duckworth AD, Wickramasinghe NR, Clement ND, Court-Brown CM and McQueen MM: Long-term outcomes of isolated stable radial head fractures. J Bone Joint Surg Am 2014; 96: 1716–23.
16. Van Riet RP, Morrey BF, O'Driscoll SW, Van Glabbeek F: Associated injuries complicating radial head fractures: a demographic study. Clin Orthop Relat Res 2005; 441: 351–5.
17. Bonnevialle N: Radial head replacement in adults with recent fractures. Orthopaedics & Traumatology: Surgery & Research, 2016; 102: S69-S79.
18. Morrey BF, Tanaka S and An KN: Valgus stability of the elbow. A definition of primary and secondary constraints. Clin Orthop Relat Res 1991; 265:187–95.
19. Petitjean C, Thomazeau H, Dréano T, Huten D and Ropars M: Mid-term results of a Silastic prosthesis used as a temporary spacer for unreconstructable radial head fractures. Chir Main 2013; 32:373–9.
20. Chanlalit C, Shukla DR, Fitzsimmons JS, An KN and O'Driscoll SW: The biomechanical effect of prosthetic design on radiocapitellar stability in a terrible triad model. J Orthop Trauma 2012; 26:539–44.
21. Allavena C, Delclaux S, Bonnevialle N, Rongières M, Bonnevialle P and Mansat P: Outcomes of bipolar radial head prosthesis to treat complex radial head fractures in 22 patients with a mean follow-up of 50 months. Orthop Traumatol Surg Res 2014; 100:703–9.
22. Chanlalit C, Shukla DR, Fitzsimmons JS, An KN and O'Driscoll SW: Stress shielding around radial head prostheses. J Hand Surg Am 2012; 37:2118–25.
23. Doornberg JN, Parisien R, van Duijn PJ and Ring D: Radial head arthroplasty with a modular metal spacer to treat acute traumatic elbow instability. J Bone Joint Surg Am 2007; 89:1075–80.
24. Sarris IK, Kyrkos MJ, Galanis NN, Papavasiliou KA, Sayegh FE and Kapetanos GA: Radial head replacement with the MoPyC pyrocarbon prosthesis. J Shoulder Elbow Surg 2012; 21:1222–8.
25. Greenspan A and Norman A: The radial head, capitellum view: useful technique in elbow trauma. AJR Am J Roentgenol 1982; 138: 1186–8.
26. Morrey BF: Functional evaluation of the elbow. In: Morrey BF, editor. The elbow and its disorders. Philadelphia: Saunders W.B.; 2000. p. 74–83.
27. Beaton DE, Wright JG and Katz JN: Development of the Quick dash: comparison of three item-reduction approaches. J Bone Joint Surg Am, 2005; 87:1038-46.
28. Jensen MP, Chen C and Brugger AM: Interpretation of visual analog scale ratings and change scores: a reanalysis of two clinical trials of postoperative pain. J Pain 2003; 4: 407–14.
29. Morrey B, Chao E and Hui F: Biomechanical study of the elbow following excision of the radial head. J Bone Joint Surg, 1979; 61A, 6368.
30. Chemama B, Bonnevialle N, Peter O, Mansat P, Bonnevialle P: Terrible triad injury of the elbow: how to improve outcomes? Orthop Traumatol Surg Res 2010; 96:147–54.
31. Ring D: Displaced, unstable fractures of the radial head: fixation vs. replacement: what is the evidence? Injury 2008; 39(12):1329–37.
32. Ruan HJ, Fan CY, Liu JJ and Zeng BF: A comparative study of internal fixation and prosthesis replacement for radial head fractures of Mason type III. Int Orthop 2009; 33(1):249–53.
33. Duckworth AD, Wickramasinghe NR, Clement ND, Court-Brown CM and McQueen MM: Radial head replacement for acute complex fractures: what are the rate and risks factors for revision or removal? Clin Orthop Relat Res 2014; 472: 2136–43.
34. Chen X, Wang SC and Cao LH: Comparison between radial head replacement and open reduction and internal fixation in clinical treatment of unstable, multi-fragmented radial head fractures. Int Orthop. 2011; 35: 1071-1076.
35. Cai PH, Mei HG and Fan YC: Clinical efficacy of internal fixation on Mason type III radial head fractures. Clin J Orthop Trauma. 2004; 5: 496-498.
36. Jensen SL, Olsen BS, Tyrdal S, Sojbjerg JO and Sneppen O: Elbow joint laxity after experimental radial head excision and lateral collateral ligament rupture: efficacy of prosthetic replacement and ligament repair. J Shoulder Elbow Surg 2005; 14(1):78–84.
37. Johnson JA, Beingessner DM, Gordon KD, Dunning CE, Stacpoole RA and King GJ: Kinematics and stability of the fractured and implant-reconstructed radial head. J Shoulder Elbow Surg 2005; 14(1 Suppl S):195S–201S.
38. Morrey BF and An KN: Stability of the elbow: osseous constraints. J Shoulder Elbow Surg 2005; 14(1 Suppl S):174S–8S.
39. Mikíc ZD and Vukadinovíc SM: Late results in fractures of the radial head treated by excision. Clin Orthop Relat Res 1983; 181: 220–8.
40. Flinkkilä T, Kaisto T, Sirniö K, Hyvönen P and Leppilahti J: Short- to mid-term results of metallic press-fit radial head arthroplasty in unstable injuries of the elbow. J Bone Joint Surg Br 2012; 94:805–10.
41. Alnot JY, Katz V, Hardy P and Guepar M: Guepar radial head prosthesis for recent and old fractures: a series of 22 cases. Rev Chir Orthop Reparatrice Appar Mot 2003; 89:304–9.
42. Shore BJ, Mozzon JB, MacDermid JC, Faber KJ and King GJ: Chronic post traumatic elbow disorders treated with metallic radial head arthroplasty. J Bone Joint Surg Am 2008; 90:271–80.
43. Van Glabbeek F, Van Riet RP, Baumfeld JA, Neale PG, O'Driscoll SW and Morrey BF: Detrimental effects of overstuffing or understuffing with a radial head replacement in the medial collateral-ligament deficient elbow. J Bone Joint Surg Am 2004; 86-A: 2629–35.
44. Yian E, Steens W, Lingenfelter E and Schneeberger AG: Malpositioning of radial head prostheses: an in vitro study. J Shoulder Elbow Surg 2008; 17(4):663–70.
45. Pomianowski S, Morrey BF, Neale PG, Park MJ, O'Driscoll SW and An KN: Contribution of mono-block and bipolar radial head prostheses to valgus stability of the elbow. J Bone Joint Surg Am 2001; 83(12):1829–34.
46. Markolf KL, Tejwani SG, O'Neil G and Benhaim P: Load-sharing at the wrist following radial head replacement with a metal implant. A cadaveric study. J Bone Joint Surg Am 2004; 86(5):1023–30.
47. Wretenberg P, Ericson A and Stark A: Radial head prosthesis after fracture of radial head with associated elbow instability. Arch Orthop Trauma Surg 2006; 126 (3):145–9.
48. Lim YJ and Chan BK: Short-term to medium-term outcomes of cemented Vitallium radial head prostheses after early excision for radial head fractures. J Shoulder Elbow Surg 2008; 17(2):307–12.
49. Dotzis A, Cochu G, Mabit C, Charissoux JL and Arnaud JP: Comminuted fractures of the radial head treated by the Judet floating radial head prosthesis. J Bone Joint Surg Br 2006; 88(6):760–4.
50. Popovic N, Lemaire R, Georis P and Gillet P: Mid-term results with a bipolar radial head prosthesis: radiographic evidence of loosening at the bone-cement interface. J Bone Joint Surg Am 2007; 89(11):2469–76.
51. Grewal R, MacDermid JC, Faber KJ, Drosdowech DS and King GJ: Comminuted radial head fractures treated with a modular metallic radial head arthroplasty. Study of outcomes. J Bone Joint Surg Am 2006; 88: 2192–200.
52. Cusick MC, Bonnaig NS, Azar FM, Mauck BM, Smith RA and Throckmorton TW: Accuracy and reliability of the Mayo Elbow Performance Score. J Hand Surg Am. 2014 Jun; 39(6):1146-50.
53. Rotini R, Marinelli A, Guerra E, Bettelli G and Cavaviocchi M: Radial head replacement with unipolar and bipolar SBI system: a clinical and radiographic analysis after a 2-year mean follow-up. Musculoskelet 2012; 96(Suppl I):S69–79.
54. Chien HY, Chen AC, Huang JW, Cheng CY and Hsu KY: Short- to medium-term outcomes of radial head replacement arthroplasty in posttraumatic unstable elbows: 20 to 70 months follow-up. Chang Gung Med J 2010; 33(6):668–78.

55. Zunkiewicz MR, Clemente JS, Miller MC, Baratz ME, Wysocki RW and Cohen MS: Radial head replacement with a bipolar system: a minimum 2-year follow-up. J Shoulder Elbow Surg. 2012; 21: 98-104.
56. Burkhart KJ, Mattyasovszky SG, Runkel M, Schwarz C, Küchle R and Hessmann MH: Mid- to long-term results after bipolar radial head arthroplasty. J Shoulder Elbow Surg 2010; 19: 965–72.
57. Lamas C, Castellanos J, Proubasta I and Dominguez E: Comminuted radial head fractures treated with pyrocarbon prosthetic replacement. Hand (N Y) 2011; 6: 27–33.
58. Van Riet RP, Van Glabbeek F, Verborgt O and Gielen J: Capitellar erosion caused by a metal radial head prosthesis. A case report. J Bone Joint Surg Am 2004; 86 (5):1061–4.
59. Doornberg JN, Linzel DS, Zurakowski D and Ring D: Reference Points for radial head prosthesis size. J Hand Surg Am. 2006; 31: 53-7.