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ORIGINAL PAPER

Open reduction and internal fixation versus radial head arthroplasty in the treatment of adult closed comminuted radial head fractures (modified Mason type III and IV)

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Abstract
Background The purpose of our study was to compare the outcome of radial head fractures (modified Mason type III and IV) treated by open reduction and internal fixation (ORIF) versus radial head arthroplasty (RHA).
Patients and methods A retrospective review of 36 patients with closed comminuted radial head fractures treated either by ORIF or RHA with an average of 15-months' follow-up was undertaken. The primary outcome was the QuickDASH, the shortened version of the Dissabilities of the Arm, Shouler and Hand score. Other outcomes included regain of functional range of motion (ROM) of the elbow and duration of surgery. Surgical complications were noted.
Results Thirty-six patients with a mean age of 36 years were evaluated. Nineteen patients underwent ORIF and 17 RHA. The two treatment groups were comparable with regards to gender, side of injury, Mason type and mechanism of injury. Patients who underwent RHA were slightly older ($p<0.001$). At follow-up, the QuickDASH score was similar between groups ($p=0.58$). Regain of functional ROM of the elbow ($p=0.13$) and complication rate ($p=0.57$) were similar.
Conclusion The treatment of closed comminuted radial head fracture (modified Mason type III and IV) with ORIF and RHA demonstrates similar findings despite less surgical time for performing RHA.

Keyword Radial head fracture · Radial head fixation · Radial head arthroplasty

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Introduction

Fractures of the radial head and neck account for 4 % of all fractures and 33 % of all elbow fractures [1, 2]. Ten percent of radial head fractures are associated with elbow dislocation [3]. The modified Mason and Arbeitsgemeinschaft für Osteosynthesefragen (AO) classifications are most commonly used to describe radial head fractures. Modified Mason type I and II fractures are treated nonoperatively or by open reduction and internal fixation (ORIF). However, managing modified Mason type III and IV fractures remains controversial. There is conflicting evidence in the literature regarding managing these fractures with ORIF or radial head arthroplasty (RHA) [4].

Some authors advocate ORIF of modified Mason type III and IV fractures with reconstruction of the native radial head [4–6]. However, such procedures are surgically demanding and associated with complications. Others advocate RHA, and this has become more popular in managing comminuted fractures [1, 7, 8], especially with improved understanding of radial head biomechanics and the availability of different radial head implants. The purpose of our study was to compare the outcome of isolated closed comminuted radial head fractures (modified Mason type III and IV) treated by ORIF versus RHA Figs. 1, 2, 3, 4 and 5.

Patients and methods

A retrospective review over a two year period was conducted on adult patients with isolated closed comminuted radial head fractures (modified Mason type III and IV) at Hamad General Hospital, Doha, Qatar. Thirty-six (32 male and four female) patients were identified. Mean follow-up time was 15 months. Fractures were treated by ORIF or RHA, depending on fracture severity and surgeon experience.

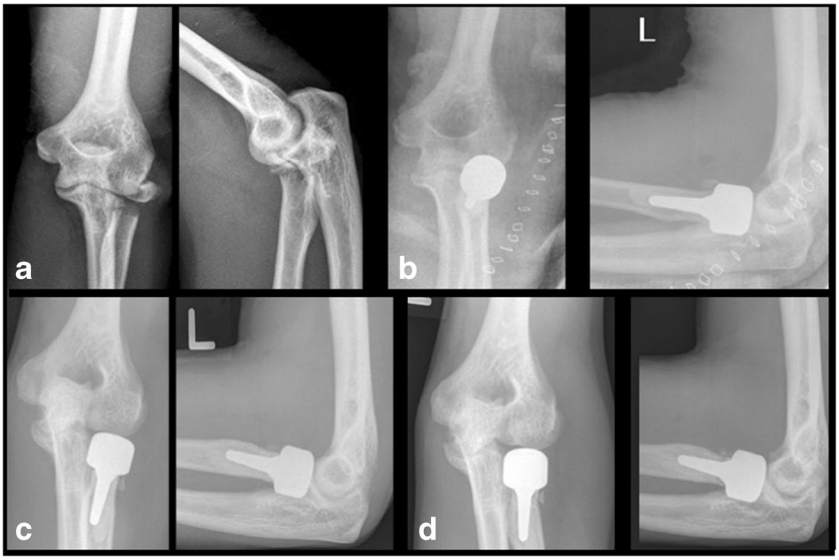

Fig. 1 A 33-year-old man with modified Mason type III radial head fracture (**a**) treated with radial head arthroplasty (**b**). Follow-up radiographs at three and six months, respectively (**c**, **d**)

Patient medical records and radiographs were reviewed. Demographic details, fracture type according to the modified Mason classification, side of fracture, mechanism of injury and associated injuries were collected, and surgical management and duration was recorded. The primary outcome used in our study was the QuickDASH, the shortened version of the Disabilities of the Arm, Shoulder and Hand score. Secondary outcome measures included regain of functional range of motion (ROM) of the elbow (30°–130°) and surgical complications, such as wound infection, heterotopic ossification, stiffness and posterior interosseous nerve injury.

Data was analysed using SPSS statistical software (IBM SPSS version 20; SPSS Inc, Chicago, IL, USA). For comparison of categorical data, Fisher's exact test was used. The Mann–Whitney test was used to compare continuous data between the two groups. To adjust for possible confounders between outcomes, multiple regression analysis was used to identify predictors of the QuickDASH score, whilst logistic regression analyses were applied to identify significant predictors of complications and regain of functional ROM of the elbow. *P* value <0.05 was considered significant.

Results

Of the 36 patients, 26 had a modified Mason type III and ten type IV fracture. Nineteen patients (52.8 %) were treated with ORIF and 17 (47.2 %) with RHA. Patients in both groups were comparable (Table 1): In the ORIF group, 17 (89.5 %) were men and two (10.5 %) were women. In the RHA group,

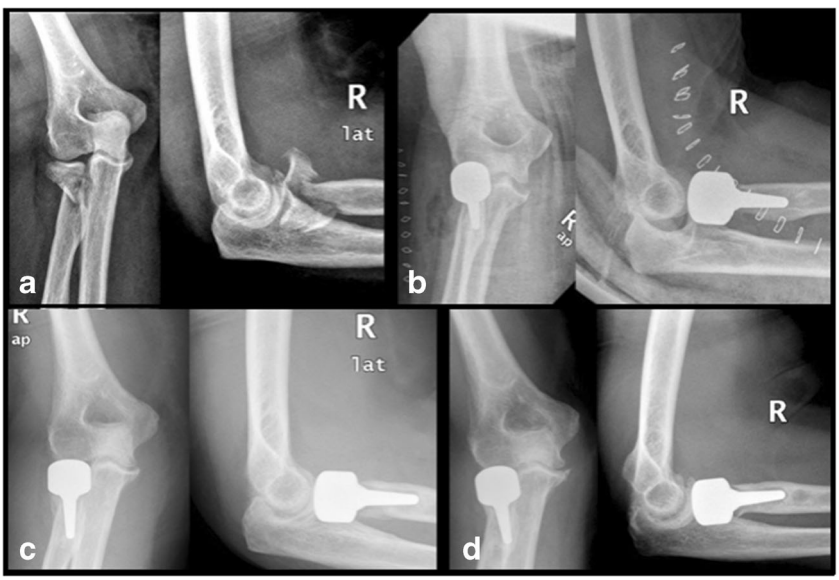

Fig. 2 A 65-year-old woman with modified Mason type III radial head fracture (**a**) treated with radial head arthroplasty (**b**). Follow-up radiographs at three and six months, respectively (**c**, **d**)

Fig. 3 A 45-year-old man with modified Mason type IV radial head fracture with elbow dislocation (**a**) treated with open reduction and internal fixation with screws (**b**). Follow-up radiographs at six months (**c**)

15 (88.2 %) were men and two (11.8 %) were women. The left side was involved in approximately two thirds of patients (68.4 % and 70.4 % for ORIF and RHA, respectively). Most injuries were a result of a fall from a height (84.2 % and 88.2 % for ORIF and RHA, respectively) and were isolated injuries (63.2 % and 76.5 % for ORIF and RHA, respectively). In the ORIF group, 78.9 % (15) had Mason type III and 21.1 % (four) type IV. In the RHA group, 64.7 % (11) had Mason III and 35.3 % (six) had type IV.

Mean patient age was 34.1 years [standard deviation (SD) 1.6] for the ORIF group and 38.1 years (SD 2.6) for the RHA group, and was statistically significant ($P<0.0001$) (Table 2). Mean duration of surgery was 129.2 minutes (SD 16.2) for the ORIF group and 96.8 minutes (SD 7.8) for the RHA group. This difference of approximately 33 minutes was statistically significant.

Mean QuickDASH score was 14.1 (SD 2.6) for the ORIF group and 12.0 (SD 2.6) for RHA group, and the difference was not statistically significant. There was no statistically significant regain in functional ROM of the elbow between groups. With regards to complications, the rate was 78.9 % (15 patients) in the ORIF group compared with 82.4 % (14 patients) in the RHA group, and was statistically insignificant (Table 3). One patient from the ORIF group underwent revision surgery with excision of the previously fixed radial head fracture and RHA because of severe elbow stiffness. No patient from the RHA group required revision or prosthesis removal.

Fig. 4 A 28-year-old man with modified Mason type III radial head fracture (**a**) treated with open reduction and internal fixation with Herbert screws (**b**). Follow-up radiographs at three and six months, respectively (**c**, **d**)

Fig. 5 A 31-year-old man with modified Mason type III radial head fracture (**a**) treated with open reduction and internal fixation with plate and screws (**b**). Follow-up radiographs at three and six months, respectively (**c**, **d**)

After adjusting for age, injury severity (modified Mason type) and surgery duration, there was no significant difference between groups in terms of incidence of complications (p=0.87), regain of functional ROM of the elbow (p=0.78) and QuickDASH score (p=0.98). However, regardless of the type of surgical management, we found a positive correlation between age, QuickDASH score, severity of injury (modified Mason type) and regain of functional ROM of the elbow (i.e. the older the patient, the worse the outcome (coefficient=0.420, p=0.023); the more severe the injury (modified Mason type), the lower functional ROM of the elbow (coefficient=−0.477, p=0.011)). The duration of surgery had minimal effect on the regain of functional ROM of the elbow (coefficient=0.0034, p=0.025) (Table 4).

Table 1 Patient characteristics

		ORIF (n = 19)	RHA (n = 17)	P value
Gender	Male	17	15	0.65
	Female	2	2	
Type	Isolated	12	13	0.31
	Polytrauma	7	4	
Side				
	Left	13	12	0.59
	Right	6	5	
Mechanism				
	Fall form height	16	15	0.56
	RTA	3	2	
Severity				
	Mason type III	15	11	0.28
	Mason type IV	4	6	

ORIF open reduction and internal fixation, *RHA* radial head arthroplasty, *RTA* road traffic accident

Discussion

Biomechanical studies have established the importance of the radial head as a secondary stabiliser of the elbow [9, 10]. In the 1990s, surgical techniques and instrumentation improved substantially with the advent of mini-fragment plates and screws, and ORIF became the preferred treatment [5, 11, 12]. Mason recommended nonoperative treatment of minimally displaced fractures (type I) and excision of displaced comminuted fractures that involved the entire radial head (type III). However, he was uncertain of the best treatment for displaced partial articular fractures of the radial head (type II), recommending consideration of excision of some displaced fractures, particularly those that are comminuted [13]. More recently, some authors have reported encouraging results with ORIF [5, 11, 12]. King et al. reported 100 % good and excellent results in

Table 2 Patient age, duration of surgery and QuickDASH score

		ORIF	RHA	P value
Age	Mean	34.1	38.1	<0.0001
	SD	1.6	2.6	
Duration of surgery	Mean	129.2	96.8	<0.0001
	SD	16.2	7.8	
QuickDASH	Mean	14.1	12.0	0.58
	SD	2.6	2.6	

ORIF open reduction and internal fixation, *RHA* radial head arthroplasty, *DASH* Disabilities of the Arm, Shoulder and Hand

Table 3 Patient outcomes

	ORIF N 19	RHA N 17	*P* value
Complications			
Yes	4	3	0.57
No	15	14	
Gain of functional ROM			
Yes	10	13	0.13
No	9	4	

ORIF open reduction and internal fixation, *RHA* radial head arthroplasty, *ROM* range of motion

Mason II injuries but only 33 % in Mason III injuries [5]. In 1993, Knight et al. suggested that metallic prostheses had a role in the treatment of comminuted fractures in complex elbow fractures [14]. This was followed by poor results with radial head resection reported by Leppilaht and Jalovaara for isolated radial head injuries [15]. Moro et al. concluded that RHA with metal was a viable option for unreconstructible radial head fractures [16]. Furthermore, more recent literature supports the superior functional results in favour of RHA in complex fractures [17–19].

Our study included patients with isolated closed comminuted radial head fractures (modified Mason type III and IV) treated with one of two modalities—ORIF or RHA—and a mean follow-up of 15 months. One patient from the ORIF group developed severe stiffness, with ROM of 30°–70°, and underwent revision surgery with excision of the previously fixed and insertion of an RHA, followed by an active physiotherapy programme that allowed functional ROM (30°–130°). No patient from the arthroplasty group required prosthesis revision or removal. Our study showed no statistical significance between surgical interventions regarding the QuickDASH, regain of functional ROM of the elbow and the incidence of complications. Although this varies from previous recent reports that favour RHA [17, 19], other authors have found similar results to those of our study. We found that the arthroplasty procedures were more common in the elderly patient group (p=<0.0001), which can be explained by the fact that they were mostly associated with poor bone quality and more fracture comminution. RHA procedures were associated with shorter surgical time (33 minutes, p=<0.0001).

The patients in our study experienced complications related to surgical treatment that have been previously reported in the literature [20]. These include residual elbow and wrist pain [9, 21], diminished joint motion [9, 20] and decreased grip strength [9, 22]. We encountered no complications such as proximal migration of the radius [9, 21–23], degenerative osteoarthritis [21, 23], development of heterotopic ossification [20, 24], lateral elbow instability [25], ulnar neuropathy [17], proximal radioulnar synostosis [17, 23, 7] or subluxation of the distal radioulnar joint [9, 21–23, 25]. It is likely that none of these complications occurred in our patients because we included only isolated radial head fractures and our or follow-up period was only 15 months.

Our regression analysis, regardless of type of surgical intervention, showed a positive correlation between patient age and the QuickDASH score and between injury severity and regaining functional ROM of the elbow [i.e. regardless of intervention type, the older the patient, the worse the outcome (coefficient=0.420, p=0.023); the more severe the injury, the lower the regain of functional ROM (coefficient=−0.477, p=0.011)]. This has implications in counseling and decision making for type of surgery and prognosis in elderly patients. The duration of surgery had minimal effect on regaining functional ROM (coefficient= 0.0034, p=0.025) (Table 4).

Our study has several potential limitations. The major ones include being retrospective, with a limited sample size and no randomisation. Others are the short follow-up period, with the inability to comment on the rate of degenerative arthritis and revision surgery. Selection bias of surgical treatment is another major limitation that most likely depended on surgeon experience, patient age and fracture configuration.

In conclusion, there was no significant difference between RHA and ORIF in treating isolated closed comminuted radial head fractures (modified Mason type III and IV) in terms of QuickDASH score, regain of functional ROM of the elbow

Table 4 Results of regression analysis following adjustment for age, severity score (Mason type) and surgery duration

	Complications		ROM		DASH	
	Coefficient	*P* value	Coefficient	*P* value	Coefficient	*P* value
Intercept	0.0838	0.94	2.7422	0.0001	7.4849	0.59
Age	0.0213	0.18	−0.0038	0.66	0.4201	0.02
Mason type	0.1261	0.70	−0.4779	0.01	−5.5488	0.15
Intervention	0.0458	0.88	−0.0448	0.79	−0.0771	0.98
Duration of surgery	0.0025	0.37	0.0034	0.02	0.0782	0.10

ORIF open reduction and internal fixation, *RHA* radial head arthroplasty, *ROM* range of motion, *DASH* Disabilities of the Arm, Shoulder and Hand

and complications. However, our results need to be interpreted with caution because of the retrospective nature of the study and patient selection bias.

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