Original article

Modified Mason type III and IV radial head fractures: results of different surgical treatments

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Summary. *Background and aim*: Fractures of the radial head account for 4% of all fractures and 33% of all elbow fractures. Their treatment is somewhat challenging and diversified, especially in more complex fractures (type III and IV of modified Mason's classification). The aim of this study was to identify the best surgical treatment for patients having sustained these latter lesions and outline possible predictive factors of worse outcomes. *Material and Methods*: Data were retrospectively collected for 63 patients affected by radial head fracture and operated between 2006 and 2014 at the University Hospital of Parma. In 34 patients open reduction and internal fixation (ORIF) was used, in 20 radial head arthroplasty (RHA) was the treatment choice and radial head resection (RHR) was done in the remaining 9. Clinical and radiographic assessments were done at a minimum follow-up of 1 year. Clinical evaluation was performed with the Mayo Elbow Performance Score (MEPS). *Results*: No statistical differences were observed in either type between the MEPS of affected and unaffected elbow. Multiple regression analysis showed that modified Mason IV fractures were a predictive factor of worse outcome and that an associated coronoid fracture can lead to a higher instability of elbow. Type IV fractures treated with primary RHA are associated to better outcomes. *Conclusion:* According to this retrospective clinical study, it was not possible to identify the optimal surgical treatment for modified Mason type III fractures. However, RHA seems to be the preferred choice for type IV fractures. These latter types of lesions are associated to worse outcomes. (www.actabiomedica.it)

Key words: elbow, fracture, radial head, resection, prosthesis, osteosynthesis

Introduction

Fractures of the radial head (RHF) account for 4% of all fractures and 33 % of all elbow fractures (1, 2).

Lateral elbow pain, swelling, overall elbow stiffness are the main complaints made by patients.

This type of lesion is often underappreciated and considered a simple fracture, misleading the inexperienced physician to overlook its diagnosis and management, which would ultimately lead to dysfunction. In fact, these fractures can be very difficult to treat, especially in cases when the RHF is comminuted and associated with elbow dislocation (10% of all RHF) or concomitant fractures and are often associated to poor outcomes (3, 4).

Many classifications have been proposed throughout the years but the one introduced by Mason in 1954 is still the most commonly utilized (5). This simple classification system is useful for the preoperative planning and as a prognostic tool. It was later modified by Johnston in 1962 (6) and includes 4 types of RHF:

- Type I: marginal fracture with minimal displacement and no mechanical block to movement.
- Type II: marginal fracture with displacement.

• Type III: comminuted fracture.
• Type IV: associated elbow dislocation.

Modified Mason types I and II fractures management is universally accepted and consists in nonoperative treatment (Type I) or ORIF with screws (Type II) (7-11).

On the other hand, the management of modified Mason Type III and IV fractures remains controversial. Some authors advocate for ORIF in these lesions after reconstruction of the native radial head (3,12-15). However, such procedures are surgically demanding and often associated with a high rate of complications (16). Others suggest that RHA is the best choice for these comminuted fractures (3,4,15,17-20), especially after recent advancements of elbow biomechanics knowledge and radial head implants technology. Furthermore, some authors suggest RHR in selected categories of patients such as people older than 65 years of age and with low functional demands (21).

The purpose of this study was to retrospectively compare the outcomes between different treatments approaches for patients having sustained Type III or IV RHF. Furthermore, an attempt is made to identify predictive factors of worse outcomes.

Material and methods

This retrospective case series study was conducted on patients affected by closed comminuted RHF (modified Mason type III and IV) and operated at the University Hospital of Parma over a 9 year period between January 2006 and December 2014. Subjects were eligible for the current study if they had no other concomitant fracture in the ipsilateral shoulder and wrist/hand, were younger than 75 years but had reached skeletal maturity.

A total of 72 patients respected the eligibility criteria but only 63 were available to return for follow-up and were included in the study.

Their medical records and radiographs at the time of trauma were analyzed. Demographic details (age and gender), side of lesion, fracture type according to the modified Mason classification, mechanism of injury, presence or absence of associated injuries of the elbow, interval between trauma and surgical treatment, choice of surgical procedure and duration of postoperative rehabilitation were collected. Fractures were treated by ORIF (Group 1), RHA (Group 2) or RHR (Group 3), depending on type and severity of the lesion, clinical conditions of the patient and also surgeon beliefs and experience. All patients were submitted to clinical and radiographic assessments at a minimum follow-up of 1 years (range 12-108 months). Clinical outcomes were evaluated using the MEPS (22) for both elbows.

Antero-posterior and latero-lateral elbow radiograph projections were taken to assess insurgence of osteoarthritis (classified according to Broberg and Morrey's scale) (23), heterotopic ossification and signs of prosthesis mobilization.

Furthermore, postoperative complications such as wound infections, stiffness and posterior interosseous nerve injuries were registered.

Statistical Analysis

Results were statistically analyzed using SPSS 20.0 software (IBM corp, Armonk, NY, USA).

Univariate analyses with the Mann–Whitney test were performed thus comparing MEPS of the affected versus unaffected elbow at follow-up.

Mann-Whitney tests were also selected in order to investigate if any single surgical procedure could be considered preferable over another according to the type of fracture. Multiple linear regression analyses were performed to identify predictive factors of worse outcome (age, gender, side and type of fracture, presence of other associated lesions of the elbow, interval between trauma and surgical treatment, type of treatment, grade of osteoarthritis, duration of postoperative physiotherapy). Finally, 3 different multiple linear analyses were completed for each of the parameters of the MEPS with the same dependent variables. The difference was considered significant when the P value was $< .05$.

Results

The mean follow-up time was 52 months (range 12-108, SD 44). Of the 63 patients, 38 (60.3%) had a modified Mason type III and 25 (39.7%) a type

IV fracture. Thirty-four patients (34.9%) were treated with ORIF (31 with plate and screws and 3 with screws) (Figure 1), 20 (31.7%) with RHA (Figure 2) (SBI rHead or rHead Recon - Small Bone Innovations Inc, Morrisville, PA, USA), and 9 (14.4%) with RHR (Figure 3).

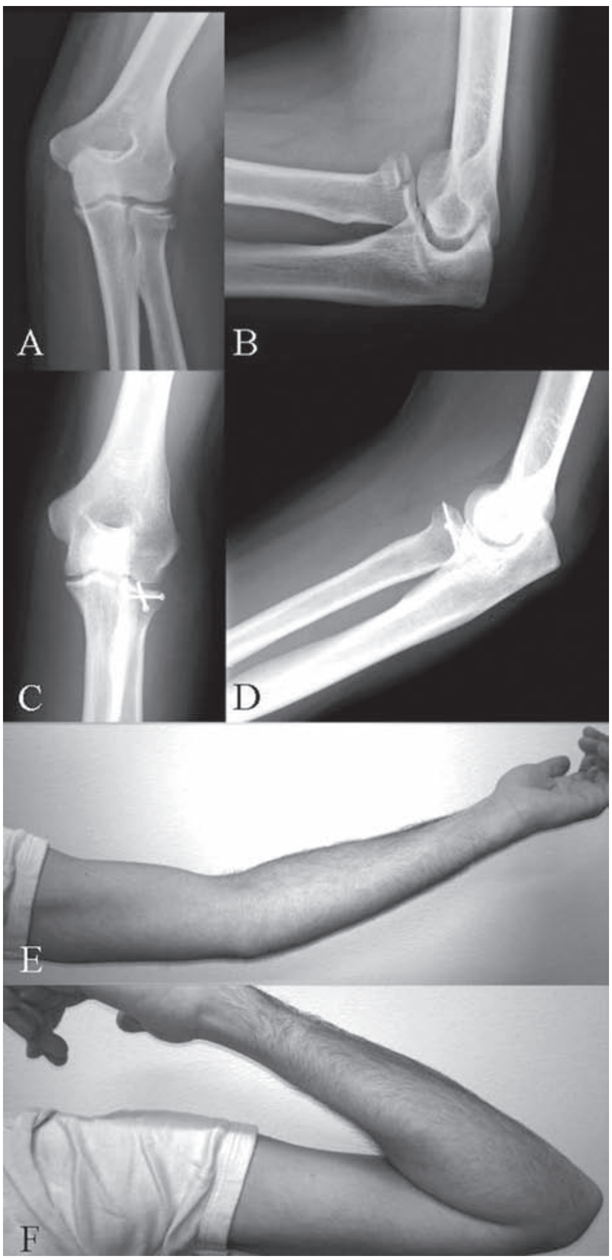

Figure 1. Modified Mason III type fracture of the left elbow. Preoperative x-ray (A and B); radiographs at follow-up of three years (C and D) and satisfactory clinical outcome (E and F)

Gender, side of lesion, fracture type, mechanism of injury and associated fractures of the elbow are summarized in Table 1. The mean age of the patients was 55.8 years (range 28-74, SD 11.1). In particular, the average patient age was 41.2 years (range 28-49, SD 8.7) for the ORIF group, 58.4 years (range 51-63, SD 5.9) for the RHA group, and 67.7 (range 65-74, SD 3.1) for the RHR group.

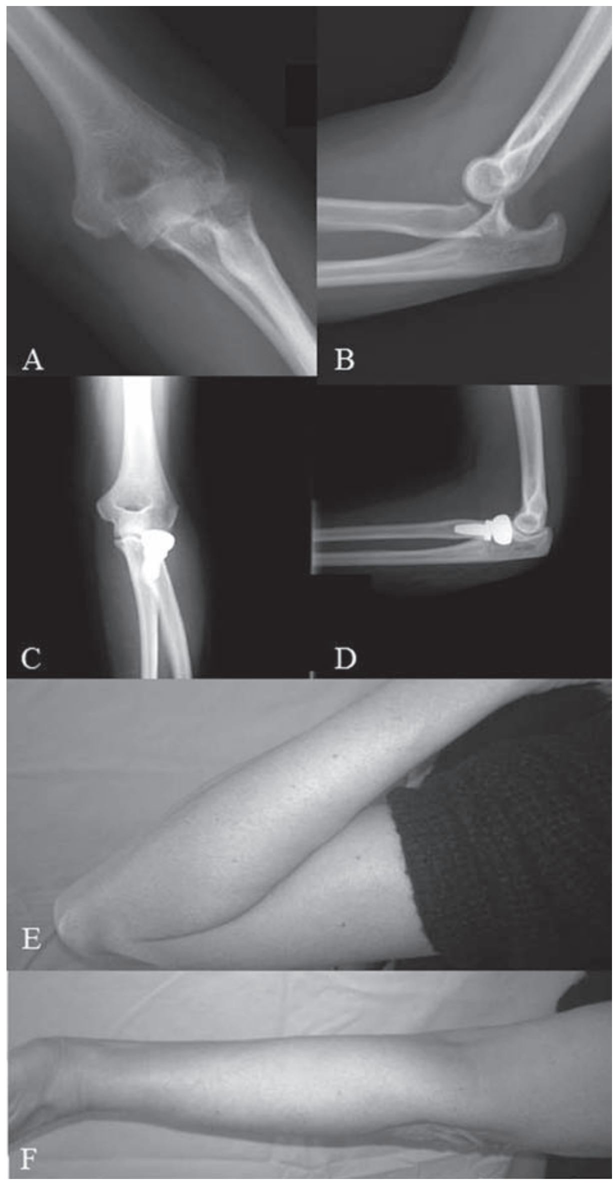

Figure 2. Left modified Mason IV type fracture. Preoperative x-ray (A and B); radiographs at follow-up of 4 years without signs of mobilization of the implant (C and D) and satisfactory clinical outcome (E and F)

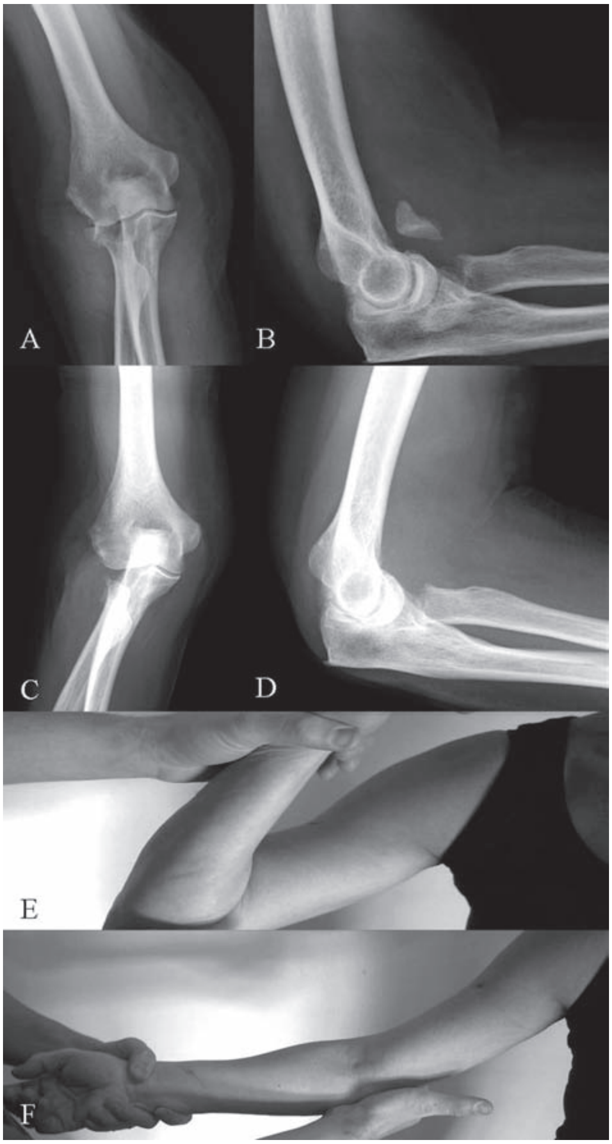

Figure 3. Modified Mason III type fracture of the right elbow. Preoperative x-ray (A and B); radiographs at follow-up two years after RHR (C and D) and good clinical outcome (E and F)

Concomitant fractures at the elbow were found in the condyles (N=6), at the coronoid process (N=10) and on the olecranon (N=2). The mean interval between trauma and surgery was 72 hours (range 14-120, SD 13.5).

The average MEPS at follow-up in the 63 patients was 89.4 (range 57-98, SD 23.4), excellent in 50 patients (79.4%), good in 6 (9.5%), fair in 4 (6.3%) and poor in 3 (4.8%). MEPS's of the contralateral elbows were excellent in all patients. In particular, the mean MEPS was 88.2 (range 57-98, SD 12.5) for the ORIF group, 90.5 (range 82-98, SD 5.1) for RHA group, and 88.7 (range 57-94, SD 6.7) for RHR group.

After surgery the mean duration of rehabilitation was 64 days (range 42-84, SD 18.4). It consisted, after an initial period of rest and immobilization, in a guided progressive passive and active mobilization program in order to recover strength and range of motion of the elbow and wrist.

The rate of osteoarthritis and heterotopic ossification and signs of mobilization are reported in Table 2. A superficial wound infection developed in 2 patients, which were treated with antibiotics. Three patients referred a partial transitory impairment of the posterior interosseous nerve, which resolved spontaneously. No patients required revision surgery. Statistical analysis did not show significant differences for MEPS at follow-up between fractured and contralateral elbow. Mason type IV fracture seems to be a predictive factor of worse outcome. Age, gender, side of fracture, presence of other associated lesions of the elbow, interval between trauma and surgical treatment, type of treatment, grade of osteoarthritis, and duration of postoperative therapy were not predictive factors of poor MEPS (Table 3). Moreover, multiple regression analyses identified no predictive factors for pain and motion; however, concomitant coronoid fracture was associated to a lower stability of the elbow (Table 4). When comparing the 2 different types of fracture with the opted surgical procedure, only modified Mason type IV fractures treated with RHA was associated with higher outcomes (p=0.012).

Discussion

In many instances, RHF can be managed in a simplistic manner from both a diagnostic point of view and therapeutic approach. However, RHF can be comminuted and associated to other elbow and forearm injuries such as multiple fractures, dislocations, and/or ligamentous ruptures. These circumstances render RHF management more complex as a higher rate of complications are expected. To facilitate the attending surgeon, we believe the modified Mason classifica-

Table 1. Patients characteristics, type and mechanism of injury and surgical procedures

Surgical procedure		ORIF (34 pts)	RHA (20 pts)	RHR (9 pts)
Gender	Male (N=45, 71.4%)	25	17	3
	Female (N=18, 28.6%)	9	3	6
Side	Dominant (N=35, 55.5%)	18	16	1
	Non-dominant (N=28, 45.5%)	16	4	8
Type of fracture	Mason III (N=38, 60.3%)	26	5	7
	Mason IV (N=25, 39.7%)	8	15	2
Mechanism	Fall (N=46, 73%)	29	11	6
	Other (N=17, 27%)	5	9	3
Associated fracture of the elbow	Yes (N=18, 28.6%)	9	8	1
	No (N=45, 71.4%)	25	12	8

Table 2. Osteoarthritis, heterotopic ossification, and radiographic signs of mobilization observed at follow-up

Surgical procedure		ORIF (34 pts)	RHA (20 pts)	RHR (9 pts)
Osteoarthritis	Grade 0 (N=40, 63.5%)	19	17	4
	Grade 1 (N=14, 22.2%)	9	3	2
	Grade 2 (N=9, 14.2%)	6	0	3
Heterotopic ossifications	Absent (N=61, 96.8%)	32	20	9
	Present (N=2, 3.2%)	2	0	0
Lines of radiolucency	Absent (95%)	-	19	-
	Present (5%)	-	1	-

Table 3. Variables that influence MEPS outcomes

Multivariate analysis	P value
Age	*.121*
Gender	*.782*
Side of fracture	*.086*
Type of fracture	***.036***
Other associated lesions of the elbow	*.541*
Interval trauma /surgery	.352
Type of treatment	*.096*
Grade of osteoarthritis	*.256*
Duration of postoperative physiotherapy	.601

Table 4. Variables that influence stability of the elbow regardless of treatment type

Multivariate analysis	P value
Age	*.254*
Gender	*.310*
Side of fracture	*.087*
Type of fracture	*.096*
Associated coronoid fracture	***.025***
Associated condyles fracture	.074
Associated olecranon fracture	*.410*
Interval trauma/surgery	*.230*
Type of treatment	.101
Grade of osteoarthritis	*.471*
Duration of postoperative physiotherapy	*.520*

tion is still valid for the preoperative planning and as a prognostic tool (24).

While many options are universally accepted and employed in the treatment of the simple RHF (type I and II), the best procedure in more complex and multifragmented fractures (type III and IV) is still debatable. Treatment choice in these latter forms of RHF is greatly influenced by the characteristics of the associated injuries, but its ultimate purpose is always to restore elbow stability and arm function.

Biomechanical studies have shown the critical importance of the radial head as a stabilizer of the elbow joint (25). Moreover, this structure is not only important for radio-humeral joint (1, 14), but also for the stability of the distal radio-ulnar joint. In fractures of the radial head, especially complicated with forearm soft tissue injuries, proximal migration of radius frequently appears and results in wrist strength weakening and chronic elbow pain. As consequence, many orthopedic surgeons suggest to preserve the radial head during fracture treatment and abandoned RHR that can lead to pain in the forearm and wrist, joint instability and cubitus valgus (26-29).

Preventive and salvage strategies of the native radial head include non-operative treatment and ORIF. Immobilization in plaster or orthosis was never utilized in this case series of complex RHF because of the risk of obtaining poor results and ultimately having to resort to secondary radial head excision or arthroplasty, as reported in more than 35% of the patients (30,31).

Anatomic and stable fixation, mainly performed by plate and screws, sometimes leads to high rate of complications such as postoperative stiffness and instability and hardware impingement with implant failure (32,33).

The potential complications from ORIF should be weighed against the potential benefits. Ring (3) in a study of 56 patients described worse results when RHF with more than three fragments were treated by ORIF. Furthermore, Pike (34) sustained that the risks of disabling stiffness, subsequent capsular release and elbow instability appear to be greater in the multifragmented displaced fractures which are operated by internal osteosynthesis, especially in those cases associated to concomitant elbow fractures and dislocations or ligamentous disruption.

We agree in preserving the integrity of the radiohumeral joint for biomechanical purposes and preservation of the native radial head is always attempted in our facility. Consequently, as suggested by Solarino (21), we only recommend RHR in selected cases characterized by more than 65 years of age and low functional demands.

In this study postoperative stiffness of the elbow was observed only in 4 patients all affected with modified Mason type IV lesion and operated with ORIF. Our finding is lower than outcomes reported in the literature and we believe that it could be the consequence of a standardized rehabilitation protocol that should be preferably managed by specialized hand upper extremity therapists (35,36).

Elbow instability related problems were encountered in 3 modified Mason type IV patients, all of which had concomitant fractures. Nevertheless, we suggest to assess elbow stability under anesthesia before and during the surgical procedure and, if necessary, proceed with ligamentous repair or reconstruction and concomitant fracture reduction and fixation.

In some cases stable osteosynthesis cannot be performed and in these irreparable conditions we recommend resorting to RHA.

In 1993, Knight (37) suggested that prostheses had a role in the treatment of comminuted fractures of the radial head and Moro (38) concluded that RHA was a viable option for RHF.

Furthermore, recent randomized prospective trials demonstrated that replacement in modified Mason type IV fractures is superior in comparison to ORIF, underlying that prostheses provide good stability thus allowing early rehabilitation (20,39). Biomechanical studies seem to confirm the validity of RHA choices. King and Watters found that the stability and load transfer of the elbow with RHA are equal to those of a native head (40,41).

Inagaki in 2002 (42) reported the effects of a radial head component on total elbow arthroplasty kinematics and stability using an anatomical design unlinked total elbow prosthesis through an electromagnetic tracking device, which recorded motion and varus and valgus movements in ten cadaveric specimens. He concluded that radial head replacement restores elbow stability when fracture of the radial head occurred in combination with dislocation of the elbow, rupture of the medial collateral ligament, fracture of the proximal ulna and/or fracture of the coronoid process.

On the basis of these studies from the early 90's surgical techniques, instrumentation and prosthesis materials improved substantially. In this study RHA was limited to 20 cases of irreparable RHF (15 type IV and 5 type III). Different prosthetic designs are available on the market (bipolar vs monopolar, anatomical vs non-anatomical). In the current series anatomic implants were always used and available in multiple sizes to accommodate the anthropomorphic variations in radial head measures.

There are several issues that need attention when opting for RHA. First, the osteotomy plane of the proximal radius determines whether the prosthesis will fit and the osteotomised length of the proximal radius must be adjusted accordingly. If the osteotomy is too long, the implanted prosthesis will be compressed against the capitulum humeri. If it is too short, the implanted prosthesis will be unable to make contact with the capitellum and lose its advantage. Moreover, good axial alignment of the radial prosthetic stem should prevent eccentric rotation of the radius during pronation and supination.

The neck of the radius makes an angle of approximately 15° opposing the radial tuberosity with the long axis of the proximal radius. The prosthetic stem should be in accord with this angle. Finally, management of ligament and soft tissue is a critical step, which will determine the results of the surgery.

Reconstruction of the annular ligament is a precondition for proximal ulno-radial joint stabilization as well as medial and lateral collateral ligament and articular capsule repair.

In this case series these guidelines were followed. RHA outcomes where satisfactory in the majority of the cases as demonstrated by MEPS at follow-up and by the presence of asymptomatic radiolucent lines in only 1 case. Overall results were satisfactory with a rate of complications similar to those reported in the literature (10,21,44). No patients underwent to revision surgery.

Several variables may be responsible for this high success rate and we consider patient and surgical procedure and technique selection to be the key factors for good outcomes.

Most modified Mason III fractures were treated with ORIF and presented good/excellent MEPS results at follow-up. However, statistical analysis did not show differences in outcomes between the three different techniques.

In modified Mason type IV fractures the results of our study indicated that RHA is associated to better outcomes.

Furthermore, statistical analyses showed that type IV fractures were predictive factors of worse results and an associated fracture of the coronoid of elbow instability.

Our results have been presented on the basis of a retrospective analysis, and a larger randomized controlled trial is suggested to corroborate our findings. Another limitation of our study is the short follow-up period, with the inability to comment on the rate of degenerative arthritis and revision surgery. Finally, the 3 surgical procedures under study were performed by different surgeons of our Unit which definitely can introduce a bias to our study.

Conclusions

In our study, outcomes are similar for modified Mason type III fractures operated either with ORIF, RHA or RHR. However, modified Mason IV fractures present better outcomes in patients that received a RHA.

Moreover, elbow instability was seen at follow-up in cases of concomitant coronoid fractures, which reinforces our belief that careful preoperative planning is needed in these cases of RHF.

However, our results need to be interpreted with caution because of the limitations of this retrospective study.

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