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Original Article

The outcome comparison of arthroplasty and ORIF for Mason type III radial head fractures

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Abstract: Many controversies still exist with regard to surgical treatment of Mason type III fractures. In this study, we compared the mid-term clinical outcomes of radial head arthroplasty (RHA) and open reduction-internal fixation (ORIF) for treating Mason type III radial head fractures. From 2006 to 2012, 55 patients with Mason type III fractures were retrospectively included and divided into RHA group and ORIF group. Range of motion (ROM) was evaluated at 3rd, 6th and 12th month post-operatively. Functional recovery assessment using Mayo Elbow Performance Score (MEPS), the Disabilities of the Arm, Shoulder and Hand score (DASH), Visual analog score (VAS) were reviewed at the last follow-up. The risk factors influencing outcomes following surgery were analysed using logistic regression. Every patient received a minimum of 2 years-follow-up. No significant differences were in complication rate, VAS and DASH between RHA and ORIF. Better ROM of elbow joint and higher MEPS were achieved in RHA group. Through logistic regression analysis, concomitant injuries, RHA, ORIF and age were not independent risk factors influencing outcomes following surgery. Our findings demonstrated that RHA was superior to ORIF on elbow function in treating Mason type III radial head fractures at mid-term follow-up, but RHA alone was not a guarantee of better clinical outcomes.

Keywords: Arthroplasty, open reduction and internal fixation, radial head fractures, mason type III

Introduction

Radial head fractures account for 3% of all fractures and are the most common type of elbow joint fractures [1]. There are four types of radial head fractures according to Mason classification [2]. Many controversies still exist with regard to the treatment of Mason type III fractures. Since the importance of radial head in maintaining stability of the elbow has been appreciated extensively, radial head resection (RHR) is seldom adopted [3]. The two frequently used surgical procedures are open reduction and internal fixation (ORIF) and radial head arthroplasty (RHA). Lot of clinical research have been conducted to compare the two surgical procedures, still no consensus has been reached [4, 5]. However, when osteosynthesis of the radial head is impossible due to the severity of comminution of fracture, the only promising surgical option is RHA. Up to present, the reported clinical outcomes regarding application of RHA and ORIF for radial head fractures have been variable. In this study, we performed a mid-term follow-up study to compare the functional and radiographic outcomes of ORIF and RHA in treating Mason type III comminuted radial head fractures.

Material and methods

Design of the study

This was a retrospective cohort study of Mason type III radial head fractures we performed in our Lever I trauma center.

Inclusion criteria

Mason type III radial head fractures with or without ligament injury, treated with ORIF or RHA, patients aged between 20-80, not limited to gender, fresh fractures and no previous injuries or surgery in that joint.

Exclusion criteria

Open fractures, pathological fractures, duration between injury and surgery was > 14 days,

Figure 1. Representative case of ORIF. A. A 44-year old man with Mason type III radial head fracture. B. 3D reconstruction of the fracture. C and D. Postoperative image of mini plate fixation.

incomplete clinical records, children with radial head fractures, multiple fractures in the elbow, severe cognitive impairment. Between 2006 and 2012,166 patients with radial head fractures were surgically treated.

Among these cases, 10 patients with a complex elbow fracture-dislocation, 76 patients with fracture type other than Mason type III, 8 patients with multiple fractures in the elbow, 5 patients with open factures, 17 patients with incomplete clinical records or Lost of follow-up, were excluded in this study. The remaining 55 patients with Mason type III radial head fractures were included in the study and divided into 2 groups: ORIF (25 cases) and RHA (30 cases) (Supplementary Table 1). All the operations were completed by the same medical team and the study design was approved by the Institutional Review Board of the Shanghai Tenth People's Hospital of TongJi University.

Preoperative preparation

All patients were received carefully physical examination and imaging examination to determine whether ligament injuries exist. F3 mini locking plates (Biomet & zimmer) and monopolar titanium radial head prostheses (Wright Medical Technology) were used for ORIF and RHA repectively.

Surgical techniques

RHA: Patients with general anesthesia were supine on the operating table with abducted upper limb. The Kocher approach was applied for radial head excision. The incision of the joint capsule and the annular ligament was done to expose the radial head. After removing the bone fragments, osteotomy was done 0.5 cm above the radial tuberosity. Enlarging the medulla until the intra-medullary bone cortex was reached. Suitable prosthesis was carefully selected and then inserted into the medulla followed by checking the mediolateral stability and ROM of elbow. Medial collateral ligament (MCL) and lateral collateral ligament (LCL) should be repaired or reconstructed. After replacement, the annular ligaments were sutured using absorbable suture material but not too tight, otherwise it would affect the ROM of the forearm.

ORIF: The Kocher approach was applied to expose the radial head. Pronating the forearm to protect deep branch of radial nerve. Using temporary Kirschner wires to fix fracture fragments, and the plate should be placed in the "safety zone" of the radius head. After checking the stability and ROM of the elbow (repairing MCL and LCL if injured), suture the annular ligaments.

Figure 2. Representative case of RHA. A. A 72-year old woman with Mason type III radial head fracture. B. 3D reconstruction of the fracture. C and D. Postoperative image of radial head arthroplasty.

Table 1. Demographic and clinic feature

Items	RHA	ORIF	P
Number of case	30	25	/
Type of fracture	Mason type III	Mason type III	/
Male	19 (63%)	15 (60%)	0.509
Female	11 (37%)	10 (40%)	0.509
Average age	58.63 ± 9.93	57.84 ± 9.19	0.762
Smoking	3 (10%)	3 (12%)	0.573
Hypertension	4 (13%)	3 (12%)	0.604
Ligament injury	9 (30%)	6 (24%)	0.425
IOM injury	7 (23%)	3 (12%)	0.233
Operative time (min)	95.83 ± 4.91	109.28 ± 5.51	0.001**
Hospital stay (d)	8.9 ± 1.45	8.96 ± 1.31	0.874
Follow-up (months)	49.67 ± 13.08	46.92 ± 12.17	0.427

Note: RHA-radial head arthroplasty, ORIF-open reduction and internal fixation. **<0.01.

Postoperative management

All patients were received postoperative routine use of antibiotics for 3 days. In RHA group, finger flexion and extension exercise were carried out with the help of doctors at the 1st day after operation. The passive flexion-extension and rotation training of the elbow was recommended at 1 week after operation, while the active non-load rehabilitation program with active movements and muscular strengthening started at the third week.

In ORIF group, if no obvious pain, finger flexion and extension exercise were initiated at the 1st postoperative day. Patients suffering from soft tissue damage were immobilized in a plaster cast for 7 days followed by related rehabilitation training practice.

Radiographic and functional evaluation

For ORIF, bilateral anteroposterior and lateral radiographs of the elbows were used for radiographically fracture healing assessment and evaluation of posttraumatic osteoarthritis as well as the identification of periarticular ossification. Degenerative changes were evaluated using the Broberg and Morrey classification. For RHA, the presence of dislocation, periprosthetic fractures, elbow stiffness, radial nerve injury, prosthesis loosening, implants failure and heterotopic ossification were recorded.

ROM of the elbow joint (flexion-extension, pronation-supination) was evaluated at 3rd, 6th and 12th month post-operatively while functional recovery assessment using VAS, MEPS and DASH were assessed at the last follow-up. Patients with MEPS > 85 were considered ex-

Figure 3. Representative case of implant failure. A and B. A 63-year old man with Mason type III radial head fracture. C. 6 months after surgery fracture displacement occurred.

Table 2. Complications

Items	RHA	ORIF	P
Elbow stiffness	2 (6.7%)	3 (12%)	0.412
Radial nerve injury	0	0	/
Prosthesis loosening	0	0	/
Implants failure	0	1 (4%)	/
Heterotopic ossification	0	2 (8)	0.202
Valgus instability	1 (3.3%)	0	0.545
Posttraumatic osteoarthritis	0	0	0.545
Total	3 (10%)	6 (24%)	0.151

Note: RHA-radial head arthroplasty, ORIF-open reduction and internal fixation.

cellent, risk factors including ligament injury, Interosseous membrane (IOM) injury, RHA, ORIF, age were analyzed by logistic regression.

Statistical analysis

All statistical analyses were performed using the SPSS 19.0 in the study. A box plot was applied to explore the statistical distribution. T test was used to compare the difference between groups for normally distributed data. Logistic regression analysis was used to analyze independent risk factors influencing outcomes. For abnormally distributed data, Mann-Whitney U test was performed to compare the difference. Chi-square test was applied to compare complication incidence. $P<0.05$ was considered to be statistically significant.

Results

55 patients with Mason type III radial head fractures surgically treated with ORIF (25) or RHA (30), were included in the study (**Figures 1**, **2**). All of these patients had complete preoperative evaluations, operation records, and a minimum of 2 years follow-up data, 49.67 ± 13.08 months in RHA and 46.92 ± 12.17 months in ORIF respectively. The operative time in RHA was significantly lower than in ORIF (**Table 1**).

2 elbow joint stiffness, 1 valgus deformity were found in RHA while 3 elbow joint stiffness, 2 heterotopic ossification and 1 implant failure (received revision surgery later) (**Figure 3**) occurred in RHA. There were no posttraumatic osteoarthritis, probably due to the short follow-up duration. However, no significant difference was in complication rate between the two groups (**Table 2**).

Comparable ROM of elbow was observed between RHA and ORIF at 3rd (supination), 6th (Flexion, Pronation), 12th (Flexion, Extension deficit, Supination, Pronation) month postoperatively (**Table 3**).

There was no significant difference in VAS and DASH between two groups. At the last follow-up, the MEPS averaged 84.10 ± 5.16 in RHA, that was higher than 80.92 ± 5.72 in ORIF ($P=0.035$) (**Table 4**).

Concomitant injury (ligament injury or IOM injury), different surgical procedures (RHA and ORIF) and age were not regarded as independent risk factors influencing outcomes (**Table 5**).

Discussion

The controversy over the surgical treatment in Mason type III comminuted radial head fractures has not been in progress since variety of the results were achieved by RHA, ORIF and RHR. The radial head serves to limit elbow

Table 3. Range of motion assessment

Time	Items	RHA	ORIF	P
3 months	Flexion	104.40 ± 14.01	98.12 ± 11.35	0.077
	Extension deficit	12.73 ± 3.342	12.48 ± 3.54	0.787
	Supination	70.73 ± 3.05	68.16 ± 3.83	0.008*
	Pronation	71.03 ± 5.44	70.52 ± 2.97	0.675
6 months	Flexion	110.10 ± 11.16	101.00 ± 8.87	0.002*
	Extension deficit	10.30 ± 1.95	10.20 ± 2.14	0.857
	Supination	70.96 ± 3.02	69.20 ± 3.66	0.061
	Pronation	73.66 ± 3.077	71.36 ± 2.70	0.005*
12 months	Flexion	110.77 ± 10.33	105.12 ± 7.87	0.029*
	Extension deficit	7.60 ± 1.22	9.84 ± 1.86	<.001**
	Supination	72.50 ± 2.90	69.24 ± 3.66	0.001**
	Pronation	74.06 ± 3.02	72.56±2.18	0.043*

Note: RHA-radial head arthroplasty, ORIF-open reduction and internal fixation. *P<0.05, **P<0.001.

Table 4. Functional outcomes evaluation

Time	Items	RHA	ORIF	P
Last follow-up	VAS	0.47 ± 0.23	0.51 ± 0.22	0.535
	DASH	11.25 ± 1.24	11.40 ± 1.09	0.641
	MEPS	84.10 ± 5.16	80.92 ± 5.72	0.035*

Note: RHA-radial head arthroplasty, ORIF-open reduction and internal fixation, VAS-visual analog score, MEPS-Mayo Elbow Performance Score, DASH-Disabilities of the Arm, Shoulder and Hand score. *P<0.05.

external rotation and transfers nearly 60% of the axial force load. Resection of the radial head will change the physiologic elbow kinematics leading to humeroulnar joint degeneration. Furthermore, removal of the radial head will increase IOM pressure and result in possible detrimental changes to the lower arm [5, 6]. The important role of radial head in maintaining elbow stability has been appreciated extensively, RHR is seldom adopted to avoid related complications. Several studies compared RHA and RHR in treating 'isolated' (without instability) comminuted radial head fracture and recommended RHR for the final surgical procedure [7, 8]. On the other hand, some preferred RHA in consideration of RHR related complications (articulation instability, joint dislocation and post-traumatic arthritis) [9, 10]. Chen X et al. proposed that once ligament rupture happened, ligament looseness would occur accompanying with a greater possibility of rupture again [11]. Actually, no strong evidence favor RHR as a better treatment of radial head fractures, despite Hackl M et al. hold that a 2.5 mm shortening osteotomy of the radial neck does not affect primary lateral stability [2].

With continued progress in artificial joint technology innovation and surgical techniques, RHA has become increasingly popular and indeed, was the routine surgery when ORIF is impossible due to the severity of comminution of fracture. Nevertheless, the reported clinical outcomes regarding RHA have been far different than expected, and not always satisfactory [12]. There are also many studies comparing the outcomes of RHA and ORIF. Duckworth AD reported a higher revision rate following RHA for treating acute unstable compound fractures. Several biomechanical research suggested that RHA improves elbow stability but is incapable of restoring lateral stability. In addition, RHA leads to many complications including dislocation, prosthesis loosening, valgus deformity and the heterotopic ossification [13-15]. Elbow stiffness and Valgus instability were the main complications found in RHA in our study, probably due to the incorrect selection of prosthesis and alteration of elbow kinematics. Apart from these shortcomings, some research reported excellent or good results following RHA and regarded RHA as a safe and effective operative methods with satisfactory outcomes and least function impairments, considering a more appropriate option to reconstruct elbow function for treating comminuted radial head fractures [16, 17]. For ORIF, varying satisfactory rates were observed, range from 22% to 65.2%. Unfavorable outcomes such as implant failure, nonunions, ROM deficit, elbow joint stiffness would occur more frequently following ORIF [14, 15, 18]. Research conducted by Al-Burdeni S showed no significant difference between RHA and ORIF in terms of DASH score, ROM and complications [19]. In a meta-analysis performed by Zwingmann, in which ORIF, RHR and RHA for treating Mason III fractures in 302 patients were assessed. The best

Table 5. Logistic regression analysis

Items	OR	P
Ligament injury	0.67	0.78
IOM injury	0.77	0.74
ORIF	1	/
RHA	2.56	0.11
Age	0.97	0.45

Note: IOM-Interosseous membranes, RHA-radial head arthroplasty, ORIF-open reduction and internal fixation.

functional outcomes were obtained in ORIF [20]. Nevertheless, the difference was not significant. In our study, patients receiving RHA achieved a better forearm rotation, a higher MEPS and a lower DASH than those with ORIF. 50% of patients in RHA and 28% in ORIF reached excellent according to MEPS. However, unlike other studies, no significant difference was in complication rate or VAS between two groups.

Not all the studies evaluated the radial head fractures by classifying them as 'isolated' or 'with associated injuries. Radial head fracture concomitant injuries are common, the incidence ranges from 39% to 92% according to clinical examination and radiologic examination [6]. These may affect the overall clinical outcomes following RHA and ORIF, but very few studies assessed these risk factors. Comminuted radial head fracture often accompanied with ligament injury (MCL, LCL) and/or IOM injury, the MCL/LCL is vital to mediolateral stability of the elbow and the main function of IOM is to transfer axial load from the radius to the ulna, to maintain the longitudinal stability of the forearm providing the fulcrum in the process of forearm rotation. Besides, outcomes of comminuted radial head fractures may vary widely following different operative methods and age. Hence, we evaluated these risk factors using logistic regression analysis. Our results showed that these factors were not verified to be independent risk factors for prognosis.

This study has several limitations that should be mentioned. Firstly, only a small number of patients was included. Secondly, the retrospective design along with the variable time of follow-up. Finally, too few patients were included to perform regression analysis. However, we believe our data provide valuable prognostic information to all surgeons managing these injuries, as we have more detailed and longer follow-up.

In conclusion, RHA was superior to ORIF for elbow function restoration in treating Mason type III radial head fractures, but RHA alone was not a guarantee of better clinical outcomes.

Disclosure of conflict of interest

None.

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References

[1] 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: 2136-2143.

[2] Hackl M, Wegmann K, Kahmann SL, Heinze N, Staat M, Neiss WF, Scaal M and Muller LP. Radial shortening osteotomy reduces radiocapitellar contact pressures while preserving valgus stability of the elbow. Knee Surg Sports Traumatol Arthrosc 2017; 25: 2280-2288.

[3] Hao W, Cheng L and Ming C. Loose-fitting radial head prosthesis replacement for treatment of comminuted fracture of the radial head. Minerva Chir 2017; 72: 31-35.

[4] Ikeda M, Sugiyama K, Kang C, Takagaki T and Oka Y. Comminuted fractures of the radial head: comparison of resection and internal fixation. Surgical technique. J Bone Joint Surg Am 2006; 88 Suppl 1: 11-23.

[5] Lopiz Y, Gonzalez A, Garcia-Fernandez C, Garcia-Coiradas J and Marco F. Comminuted fractures of the radial head: resection or prosthesis? Injury 2016; 47 Suppl 3: S29-S34.

[6] Awan H and Goitz R. MRI correlation of radial head fractures and forearm injuries. Hand (N Y) 2017; 12: 145-149.

[7] Pike JM, Grewal R, Athwal GS, Faber KJ and King GJ. Open reduction and internal fixation of radial head fractures: do outcomes differ between simple and complex injuries? Clin Orthop Relat Res 2014; 472: 2120-2127.

[8] 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: 249-253.

[9] Moghaddam A, Raven TF, Dremel E, Studier-Fischer S, Grutzner PA and Biglari B. Outcome of radial head arthroplasty in comminuted radial head fractures: short and midterm results. Trauma Mon 2016; 21: e20201.
[10] Solarino G, Vicenti G, Abate A, Carrozzo M, Picca G and Moretti B. Mason type II and III radial head fracture in patients older than 65: is there still a place for radial head resection? Aging Clin Exp Res 2015; 27 Suppl 1: S77-83.
[11] Chen X, Wang SC, Cao LH, Yang GQ, Li M and Su JC. 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.
[12] Viveen J, Kodde IF, Koenraadt KL, Beumer A, The B and Eygendaal D. Clinical and radiographic outcome of revision surgery of radial head prostheses: midterm results in 16 patients. J Shoulder Elbow Surg 2017; 26: 394-402.
[13] Sun H, Duan J and Li F. Comparison between radial head arthroplasty and open reduction and internal fixation in patients with radial head fractures (modified Mason type III and IV): a meta-analysis. Eur J Orthop Surg Traumatol 2016; 26: 283-291.
[14] Tarallo L, Mugnai R, Rocchi M, Capra F and Catani F. Mason type III radial head fractures treated by anatomic radial head arthroplasty: is this a safe treatment option? Orthop Traumatol Surg Res 2017; 103: 183-189.
[15] Van Hoecke E, Van De Vijver A, Van Glabbeek F and Gielen J. Long term results after bipolar radial head arthroplasty. Acta Orthop Belg 2016; 82: 382-388.
[16] Watters TS, Garrigues GE, Ring D and Ruch DS. Fixation versus replacement of radial head in terrible triad: is there a difference in elbow stability and prognosis? Clin Orthop Relat Res 2014; 472: 2128-2135.
[17] Bigazzi P, Marenghi L, Biondi M, Zucchini M and Ceruso M. Surgical treatment of chronic essex-lopresti lesion: interosseous membrane reconstruction and radial head prosthesis. Tech Hand Up Extrem Surg 2017; 21: 2-7.
[18] Babst R, Schraner C and Beeres FJ. Operative treatment of terrible triad injury of the elbow: open reduction and internal fixation. Oper Orthop Traumatol 2017; 29: 125-137.
[19] Al-Burdeni S, Abuodeh Y, Ibrahim T and Ahmed G. 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). Int Orthop 2015; 39: 1659-1664.
[20] Zwingmann J, Welzel M, Dovi-Akue D, Schmal H, Sudkamp NP and Strohm PC. Clinical results after different operative treatment methods of radial head and neck fractures: a systematic review and meta-analysis of clinical outcome. Injury 2013; 44: 1540-1550.