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A comparison of the open reduction-internal fixation and resection arthroplasty techniques in treatment of Mason Type 3 radial head fractures

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ABSTRACT

Objective: The aim of this study was to retrospectively compare a series of patients surgically treated with ORIF or early resection arthroplasty due to isolated comminuted radial head fractures.
Methods: Between the years 2009 and 2013, 34 patients with isolated comminuted fractures of the radial head (Mason Type 3) had been operated (ORIF in 19 patients, resection arthroplasty in 15 patients). The mean age of the patients in the ORIF group was 38.5 years and 54 years in the resection group. The carrying angle (CA) and ulnar variance were measured bilaterally, and radiographs were reviewed for degenerative elbow arthritis. The Mayo elbow performance score, Turkish version of the Disabilities of the Arm, Shoulder and Hand questionnaire (DASH-T) and visual analog scale (VAS) were used to evaluate the clinical results.
Results: The mean follow-up period in the ORIF group was 40.2 months and 44.4 months in the resection group. In the ORIF group, 11 patients were clinically rated excellent, six good, and two fair. In the resection group, seven patients had excellent, five had good, and two had fair scores. We did not find a statistically significant difference between the ORIF and resection groups regarding the clinical and radiological outcomes.
Conclusion: With these short-term results, resection arthroplasty may be considered an effective method in the treatment of isolated comminuted radial head fractures, as it is less technically demanding and it also allows for early postoperative motion. However, the patients should be evaluated in detail, regarding ligamentous injuries prior to resection arthroplasty.
Level of evidence: Level III, Therapeutic study.
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The surgical treatment of comminuted radial head fractures is challenging and controversial. Surgical treatment options include open reduction-internal fixation (ORIF), resection arthroplasty and radial head arthroplasty, with no clear advantage of one over the other.[1]

Recent studies have addressed the proper restoration of the radial head fractures in maintaining the stability of the elbow and the forearm[2–5]; and resection arthroplasty has been associated with complications, including postoperative pain, joint instability, decreased strength, proximal radial migration and osteoarthritis.[6–8] Therefore, instead of resection arthroplasty, performing ORIF or radial head arthroplasty is suggested to preserve the elbow function and forearm kinematics in cases of comminuted radial head fractures.[9–13] On the other hand, some authors believe that resection arthroplasty does not have an effect on stability and remains a valid option in the treatment of isolated comminuted radial head fractures.[7,14] Good long-term clinical outcomes have been reported with resection arthroplasty,[15–17] but the clinical relevance of the functional impairment related to the absence of the radial head is still very much in question.

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The aim of this study was to retrospectively compare a series of patients surgically treated with ORIF or resection arthroplasty due to isolated comminuted radial head fractures, and to report the clinical and radiological outcomes.

Patients and methods

Between 2009 and 2013, 55 patients with radial head fractures were surgically treated. After reviewing their medical records, 19 patients, in whom radial head fracture was accompanied by a complex elbow fracture–dislocation, who had undergone ORIF due to a Mason Type 2 radial head fracture, in whom radial head arthroplasty, delayed radial head resection or additional surgical procedures for ligamentous repair were performed and who were reported to have an obvious ligamentous injury detected by valgus/varus stress and/or radius pull tests,[18] were excluded from the study. Two patients were lost to follow-up. The remaining 34 patients (16 males, 18 females, mean age: 45.4 [range: 29–64] years) who were surgically treated due to isolated Mason Type 3 radial head fractures were included in the study.

The patients were operated by five different surgeons with no definitive surgical protocol, thus, the selection criteria for surgical indications for each case was not clear on the medical records.

Patients were divided into two groups. Group 1 consisted of 19 patients (9 males, 10 females; mean age: 38.5 [range: 29–56] years) who underwent ORIF, and Group 2 consisted of 15 patients (7 males, 8 females; mean age: 54 [range: 38–64] years) who underwent resection arthroplasty. Patient demographics are demonstrated in Table 1.

In Group 1, ORIF was performed using the lateral Kocher approach with anatomical titanium interlocking radial head plates and 2.7 mm screws (TST Tıbbi Aletler San., Istanbul, Turkey) on seven patients (37%), and only headless cannulated compression screws (TST Tıbbi Aletler San., Istanbul, Turkey) on the remaining 12 patients (63%). The mean follow-up period in this group was 40.2 (range: 27–58) months.

In Group 2, the Kocher approach was used on all patients, and the radial head was resected with a bone saw close to the surgical neck. The intraoperative notes in the medical records of the patients were reviewed, and only the cases in which radius pull test[18] was intraoperatively performed and a probable intraosseous ligament or triangular fibrocartilage complex injury was not diagnosed were included in the study. The mean follow-up period in this group was 44.4 (range: 38–72) months.

Due to the retrospective design of the study, there was no specific postoperative rehabilitation protocol. Generally, a molded posterior plaster long-arm splint at 90° of flexion was kept for two weeks in both groups. Then, passive and active range of motion (ROM) exercises were begun and gradually commenced.

Clinical outcomes were assessed with the Mayo Elbow Performance Score (MEPS)[19] and Turkish version of the Disabilities of the Arm, Shoulder and Hand questionnaire (DASH-T).[20] The MEPS rates pain, ROM, stability and function; and the results are graded as excellent (90–100 points), good (75–89 points), fair (60–74 points), or poor (<60 points). In DASH-T, 0 means 'no disability' and 100 means 'complete disability'. Pain was quantified using the visual analog scale (VAS). A goniometer was used to measure the range of flexion–extension and rotation of the elbow.

Bilateral anteroposterior and lateral radiographs of the elbows, including the forearms and wrists were used for the measurement of the carrying angle (CA), the evaluation of posttraumatic osteoarthritis and the presence of periarticular ossification. The CA was measured from the long axes of the humerus and forearm with the elbow at maximum extension. Degenerative changes were evaluated using the Broberg and Morrey classification.[21] The ulnar variance was measured on posteroanterior radiographs of bilateral wrists as the distance between a line drawn perpendicular to the longitudinal axis of the radius at the distal ulnar aspect of the radius and the end of the ulna.

Statistical analyses were performed using the SPSS v.20.0.0 (SPSS Inc., Chicago, IL, USA) software. The outcomes of the two groups were compared by the independent samples t-test and Pearson correlation test.

Results

In Group 1, the mean MEPS, DASH-T and VAS scores were 86.8 (range: 65–100), 3.9 (range: 0–15) and 1.5 (range: 0–6), respectively (Table 2). According to the MEPS, 11 patients were rated excellent, six good and two fair. Eleven elbows were completely pain-free. The mean postoperative CA was 9.2° (range: 913°) and the mean increase in the CA was 1.1° (range: 0–4°). This increase was statistically significant ($p = 0.015$) (Table 3). The mean ulnar variance was 0.4 (range: 0–1) mm on the injured side. The mean increase in the ulnar variance in comparison to the uninjured side was 0.1 (range: 0–1) mm. The average increase compared to the uninjured side was found statistically insignificant ($p = 0.165$) (Table 3). Degenerative changes were observed in six cases (Grade 1 in four patients and Grade 2 in two patients) (Fig. 1). Periarticular ossification was present in two elbows. The hardware was removed in three patients due to limited ROM.

In Group 2, the mean MEPS, DASH-T and VAS scores were 85 (range: 70–100), 3.7 (range: 0–18) and 1.8 (range: 0–6), respectively (Table 2). Clinically, seven patients were rated excellent, six good, and two fair. Six elbows were completely pain-free (Fig. 2). The mean CA was found 9.4° (range: 7–15°) and the mean increase in the CA was 2.4° (range: 0–7°). The increase was statistically significant ($p = 0.0001$) (Table 3). The mean ulnar variance was 0.5 (range: 0–1) mm on the injured side. The mean increase in the

Table 1
Patient demographics.

	ORIF (Group 1)	Radial head resection (Group 2)	Total
Number of cases	19	15	34
Mean age (range)	38.5 (29–56) years	54 (38–64) years	45.4 (29–64) years
Side	8 right, 11 left	7 right, 8 left	15 right, 19 left
Sex	9 males, 10 females	7 males, 8 females	16 males, 18 females
Mean follow-up period (range)	40.2 (27–58) months	44.4 (38–72) months	42 (27–72) months
Mechanism of injury	• Ground level fall on the outstretched arm in 15 (79%) • Sports injury in 3 (16%) • Motor vehicle accident in 1 (5%)	• Ground level fall on the outstretched arm in 13 (86%) • Motor vehicle accident in 1 (7%) • Work accident in 1 (7%)	• Ground level fall on the outstretched arm in 28 (82%) • Sports injury in 3 (9%) • Motor vehicle accident in 2 (6%) • Work accident in 1 (3%)

Table 2
Functional outcomes and statistical evaluation of the groups.

	ORIF (Group 1)	Radial head resection (Group 2)	p
MEPS (range)	86.8 (65–100)	85 (70–100)	0.583
DASH-T score (range)	3.9 (0–15)	3.7 (0–18)	0.903
VAS score (range)	1.5 (0–6)	1.8 (0–6)	0.696

Table 3
Radiological outcomes and statistical evaluation of the groups.

	ORIF (Group 1)	Radial head resection (Group 2)	p
Mean ulnar variance (range)	0.4 (0–1) mm	0.5 (0–1) mm	0.572
Mean increase in the ulnar variance (range)	0.1 (0–1) mm	0.4 (0–1) mm	0.119
Mean carrying angle (range)	9.2° (9–13°)	9.4° (7–15°)	0.768
Mean increase in the carrying angle (range)	1.1° (0–4°)	2.4 (0–7°)	0.008

ulnar variance in comparison to the uninjured side was 0.4 (range: 0–1) mm. There was no statistically significant average increase compared to the uninjured side ($p = 0.14$) (Table 3). Degenerative changes were observed in six cases (Grade 1 in three patients and Grade 2 in four patients) (Fig. 1). Periarticular ossification was present in three elbows (Fig. 1).

The clinical and radiological parameters and ROM in both groups were compared, and no statistically significant differences were found between Group 1 and Group 2 ($p > 0.05$) (Tables 2–4).

Discussion

The controversy over the treatment techniques in comminuted radial head fractures and the variety of the results are probably related to the fact that most of the studies had not evaluated the radial head fractures by classifying them as 'isolated' or 'with accompanying fractures' of the elbow. Besides, ligamentous injuries may be present in even seemingly uncomplicated radial head injuries.[22] These may all affect the overall radiological and clinical outcomes.

There are only two studies comparing resection arthroplasty and ORIF techniques in the treatment of isolated comminuted radial head fractures.[9,23] Ikeda et al[9] reported significantly higher functional scores in favor of ORIF in their prospective study comparing 15 patients who underwent resection arthroplasty to 13 who underwent ORIF. The authors did not mention whether the fractures were isolated or were accompanying a complex injury. In another study, Lindenhovius et al[23] compared resection arthroplasty with ORIF. Their patient groups were not homogenous regarding the fracture type, and some of the fractures were accompanying complex injuries and dislocations. The authors reported comparable clinical outcomes between the two groups, both in the early and the long-term. Arthrosis was more frequent in the resection group. Similar to their results, we also did not find a statistically significant difference between the groups in terms of functional outcomes.

Open reduction and internal fixation of the repairable comminuted fractures with reconstruction of the native radial head is conclusive.[14,24,25] However, there is conflicting evidence regarding the management of unrepairable fractures with radial head replacement or radial head excision.[26] Moreover, effective internal fixation may lead to suboptimal outcomes in cases of poor bone quality, impaired vascularity of the fragments and severe comminution.[27] In these cases, radial head excision may be considered if there is no associated fracture and ligament injury of the elbow and the forearm. However, it should be estimated that the incidence of concomitant injury to the collateral ligaments of the elbow or interosseous membrane of the forearm has been reported as high as 75% in most series of comminuted radial head fractures.[28,29]

There are several studies reporting outcomes in patients undergoing resection arthroplasty for comminuted radial head fractures.[6,7,15,16,30–33] All these researchers concluded that resection arthroplasty provided satisfactory pain relief and preservation of functional ROM in the long-term despite the presence of radiographic degenerative changes in a large number of the patients. Although moderate to severe degenerative changes of the elbow have been reported, this has no correlation with the functional outcome. In our study, osteoarthritic changes were more often in Group 2. Consistent with the literature, no relationship between the osteoarthritic changes and clinical outcome scores was observed in both groups. Short follow-up period may have an effect

Fig. 1. **(A)** Postoperative degenerative changes observed in a patient who had undergone resection arthroplasty and **(B)** postoperative periarticular ossification in a patient following ORIF.

Fig. 2. Postoperative **(A)** AP and **(B)** lateral radiographs and **(C, D)** photos demonstrating the ROM of a 53-years-old female patient who underwent resection arthroplasty and were followed up for a period of 72 months. The clinical result was rated excellent according to the MEPS and her DASH-T score was 4. Note the increased elbow valgus in Fig. 2C.

Table 4
Range of motion and statistical evaluation of the groups.

	ORIF (Group 1)	Radial head resection (Group 2)	p
Mean flexion (range)	135.2° (115–140°)	135.6° (120–150°)	0.864
Mean extension (range)	15.5° (0–40°)	13.6° (0–20°)	0.518
Mean arc of elbow motion (range)	119.7° (75–140°)	122° (105–135°)	0.615
Pronation (range)	76° (65–90°)	76° (70–90°)	0.770
Supination (range)	78.1° (60–90°)	77.3° (70–90°)	0.561
Pronation/supination arc (range)	154.2° (125–170°)	154.6° (145–170°)	0.913

on the outcomes regarding degenerative changes. We believe that, for a more precise conclusion, additional long-term studies with larger series of patients are required to detect statistical significance.

The common characteristic of the patients in our study was the presence of an isolated radial head fracture without ligamentous instability. In both groups, we had functional scores comparable with the data provided in the literature.[15,16,31,32] No statistically significant difference was found between the groups regarding clinical and radiological outcomes. We believe that this is related to the fact that the radial head fractures were all isolated and the patients were evaluated in the short term.

Stiffness is a common complication following fractures and surgeries of the elbow. Functional ROM may be achieved by allowing early mobilization.[33] Generally, in both groups, a long-arm molded plaster splint was kept for two weeks postoperatively and immediate rehabilitation was started after the removal of the splint. In both groups, the values of postoperative ROM degrees were found consistent with those previously reported in the literature. The functional outcomes were found slightly better in Group 1. However, there was no statistically significant difference. Short follow-up period may be a reason for better ROM degrees as degenerative changes, which may affect ROM, occur more often in the long-term.

After resection arthroplasty, proximal migration of the radius and increase in the CA should be considered.[7,11,30,34] However, there is no consensus regarding the correlation between proximal migration of the radius and poor clinical outcomes, especially in terms of pain and functional impairment of the wrist.[7,11,30] In our resection cohort, radius pull test[18] was performed preoperatively in all cases in order to exclude the possibility of an interosseous ligament injury. The radius pull test is a useful test performed intraoperatively. After the resection of the radial head, load to the proximal radius is applied with a bone reduction tenaculum. Then the ulnar variance is evaluated using fluoroscopy with the patient's shoulder positioned in 90° of abduction and 90° of internal rotation, and the wrist in neutral position. In case of a proximal radial

migration of 3 mm or more, the intraosseous ligament is likely disrupted. A migration of 6 mm or more occurs when both the intraosseous ligament complex and the triangular fibrocartilage complex are affected. Thus, a proximal radial migration of 3 mm or more should be considered as a warning for intraosseous ligament and the triangular fibrocartilage complex rupture, and in that case, a radial head replacement should be performed to avoid related further complications. Lindenhovius et al also suggested that resection arthroplasty should not be used unless the radius pull test failed to disclose injury to the interosseous ligament.[23] Evaluation of the longitudinal stability by performing the radius pull test intraoperatively could help identify the injury properly. In addition, because of the painful condition of the elbow, only physical examination findings may not be sufficient to determine ligamentous injuries. Therefore, a magnetic resonance imaging (MRI) of the elbow and the forearm revealing the findings of a probable injury in the collateral ligaments, the intraosseous membrane and the ulnocarpal ligament complex may warn the surgeon to not only focus on the fracture in the proximal radius but also on the soft tissue.[29] However, it should be also noted that MRI may have a limited contribution, due to the acute injury causing inflammation and edema in the affected extremity.

In our study, the limited number of patients, heterogeneity of the groups in terms of age, short follow-up periods, and the retrospective design are the main drawbacks and preclude reaching a more definite judgment. The heterogeneity of the groups in terms of age may have led to misinterpretation of the clinical outcomes as it may have an impact on clinical scores. Some of the complications of resection arthroplasty, such as degenerative changes and proximal radial migration occur in the long-term. Thus, short follow-up periods of the patients in Group 2 may have precluded observing these complications, which may effect on both clinical and radiological outcomes. Retrospective design of the study is a certain objection for the determination of the selection criteria of the patients regarding surgical indications. However, we believe that this is an important study as there is no sufficient data in the literature regarding the comparison of radial head resection and ORIF techniques in the treatment of isolated comminuted radial head fractures.

In conclusion, no statistically significant difference was found between the groups in terms of clinical and radiological evaluation parameters and ROM. With these short-term results, resection arthroplasty may be considered a surgical option for isolated comminuted radial head fractures as it is less technically demanding and also allows for early postoperative motion. However, the patients should be carefully evaluated regarding ligamentous injuries such as Essex-Lopresti lesions or collateral ligament ruptures before performing resection arthroplasty. Our results need to be interpreted with caution because of the retrospective nature and other limitations of the study. Long-term, prospective studies with larger patient groups are required for a definite judgment.

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