Resection Arthroplasty for Mason Type III Radial Head Fractures Yield Good Clinical but Poor Radiological Results in the Long Term

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Long-term clinical and radiographic outcomes of primary resection for Mason type III radial head fractures were evaluated in 13 patients (14 elbows) with a mean age of 38.8 years (range, 20-67 years) at the time of surgery. All patients had isolated radial head fractures without associated injuries. Mean follow-up was 14.7 years (range, 9-26 years). Proximal migration of the radius and the carrying angle were measured, and radiographs were reviewed for degenerative elbow and wrist arthritis and periartricular ossification. Five results were excellent and 9 were good. In 8 cases, the radii had migrated proximally and the carrying angle had increased an average 6.3°; the increases in both ulnar variance and the carrying angle were significant, and a significant negative correlation was found between the carrying angles and the clinical scores. Degenerative changes occurred in 8 elbows and 4 wrists, and periartricular heterotopic ossification was present in 3 elbows. Despite the satisfactory long-term outcomes, radial head resection resulted in proximal migration of the radius and an increase in the carrying angle; in addition, osteoarthritic changes in both elbows and wrists as well as periartricular heterotopic ossification were frequent findings without pronounced functional impairment.

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Figure: Lateral radiograph showing heterotopic ossification on the lateral aspect of the elbow after 19 years of follow-up.
Radial head fractures are common injuries, accounting for one-third of all fractures about the elbow. Radial head fractures were classified by Mason. Type I fractures are fissure or marginal sector fractures without displacement, type II fractures are marginal sector fractures with displacement, and type III fractures are comminuted fractures involving the whole head.

Options for the treatment of radial head fractures are nonoperative management, fragment excision, open reduction and internal fixation (ORIF), resection arthroplasty, and radial head arthroplasty. Fragment number of the fracture, amount of displacement, impaction, bone quality, and associated fractures and ligament injuries must be considered when formulating a treatment strategy. As fractures become more comminuted and displaced, the method of treatment also becomes more challenging. Open reduction and internal fixation, resection arthroplasty, or radial head implant arthroplasty are the most advocated treatment options for Mason type III fractures, yet the ideal method continues to be a subject of debate.

Resection arthroplasty has been recommended by numerous studies for Mason type III radial head fractures, especially fractures with no concurrent ligament insufficiency or when stable osteosynthesis cannot be achieved. Many studies do not advocate radial head excision because of its high rate of complication, including pain, varus-valgus and postero-lateral rotatory instability, heterotopic ossification, proximal radial migration, cubitus valgus and associated ulnar nerve symptoms, and elbow and wrist arthritis; instead, these studies suggest radial head preservation if possible or replacement when necessary.

The purpose of this study was to evaluate the long-term clinical, radiographic, and functional results of resection arthroplasty for Mason type III radial head fractures.

**Materials and Methods**

**Patient Population**

Outcomes of 14 elbows in 13 patients (8 women and 5 men) who had been treated with primary radial head resection arthroplasty for Mason type III fractures were evaluated retrospectively. Mean patient age at the time of injury was 38.8 years (range, 20-67 years). The mechanism of injury in all the patients was a fall from standing. All the patients had isolated radial head fractures without associated injuries such as lateral or medial collateral ligament injuries, other fractures around the elbow, or fracture-dislocation. Seven of the fractures were on the right side and 7 were on the left side. Average time from injury to surgery was 6 days (range, 1-15 days). Postoperative treatment consisted of immobilization in a molded posterior plaster splint at 90° of flexion for 2 weeks, followed by passive and active range of motion exercises. Clinical and radiographic evaluations were performed at a mean of 14.7 years (range, 9-26 years) postoperatively.

**Clinical Assessment**

Clinical outcomes were assessed using the Mayo Elbow Performance Score (MEPS), which is a physician-based elbow scoring system (Table 1), the Turkish version of the Disabilities of the Arm, Shoulder, and Hand questionnaire (DASH-T), in which 0 means no disability and 100 means complete disability; and the visual analog scale (VAS), a scale ranging from 0 to 100, with 0 being pain free and 100 being horrible pain. Range of motion of the elbow and forearm were measured according to the neutral zero method. Elbow flexion-extension was measured with the forearm in neutral rotation, and pronation-supination was measured with the elbow at 90° flexion using a standard goniometric scale.

**Radiographic Assessment**

Bilateral elbows, forearms, and wrists were evaluated radiographically. Bilateral anteroposterior and lateral radiographs of the elbows, with inclusion of the forearm and the wrist in supination, were reviewed to evaluate joint congruity, degree of elbow arthritis, presence of periarticular ossification, and carrying angle. Posteroanterior and lateral zero rotation radiographs of bilateral wrists were reviewed to evaluate degenerative changes and to measure proximal migration of the radius (ulnar variance).

Elbow arthritis was evaluated according to the Broberg and Morrey classification system as grade 0 (normal joint), grade 1 (slight joint space narrowing with minimum osteophyte formation), grade 2 (moderate joint space narrowing with moderate osteophyte formation), or grade 3 (severe degenerative changes with gross destruction of the joint).
Ulnar variance was measured from 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. The carrying angle was measured from the long axes of the humerus and forearm with the elbow at maximum extension.

Statistical Analysis
Data were analyzed using SPSS version 11.5.0 software (SPSS Inc, Chicago, Illinois). Statistical analyses were performed using the Mann-Whitney U test, Pearson correlation test, and Spearman’s nonparametric correlation test.

RESULTS
At last follow-up, all patients were able to continue their activities of daily living with no restriction. Mean MEPS was 88.6 (range, 75-100), and results were rated as excellent in 5 elbows and good in 9. Mean DASH-T score was 6.6 (range, 0-15). Mean VAS score was 4.6 (range, 0-10), and 5 elbows in 4 patients were completely pain free.

Average elbow motion ranged from 6.9° (extension deficit range, 0°-20°) to 133.9° (flexion range, 120°-145°), with a mean total arc of 127° (range, 100°-145°). Mean pronation was 83.2° (range, 70°-90°), and mean supination was 84.6° (range, 75°-90°). Flexion, extension, pronation, and supination all correlated significantly with MEPS, DASH-T, and VAS scores (flexion, \( r = 0.509, -0.810, \) and \(-0.862, \) respectively; extension, \( r = -0.697, 0.866, \) and 0.933, respectively; pronation, \( r = 0.643, -0.758, \) and \(-0.791, \) respectively; supination, \( r = 0.569, -0.902, \) and \(-0.786, \) respectively). Elbow strength was evaluated subjectively with regard to elbow flexion and extension against resistance and was reduced in 5 elbows compared with that of the uninjured extremity; however, this reduction did not affect patients’ ability to continue their activities of daily living.

Radiographs revealed degenerative changes in 8 elbows (Figure 1) and 4 wrists on the injured side. Grade 1 degenerative changes occurred in 3 elbows, and grade 2 degenerative changes occurred in 5 elbows. Periarticular heterotopic ossification was evident in 3 elbows (Figure 2). The ossification was located on the medial, posteromedial, and lateral aspects of the joint in 1 patient each. Degenerative changes in all 4 wrists were mild. None of the patients had degenerative osteoarthritis of the elbow or the wrist on the uninjured side.
In 8 cases, the radii had migrated proximally. Mean ulnar variance was 1.7 mm (range, 0-4 mm) on the injured side, with a statistically significant average increase of 1.6 mm compared with the uninjured side ($P=.007$) (Figure 3).

Mean carrying angle was 11.2° (range, 5°-29°) on the injured side and 4.9° (range, 3°-7°) on the uninjured side. Mean increase was 6.3° (range, 0°-22°); this increase was statistically significant ($P=.0001$) (Figure 4).

Correlation between carrying angles and clinical scores was statistically significant: as the carrying angle increased, MEPS decreased, whereas DASH-T and VAS scores increased ($P=.05$; $r=-0.347$, 0.340, and 0.226, respectively). A strong correlation existed between the ulnar variance and degenerative changes in both wrists and elbows ($P=.05$; $r=0.621$ and 0.522, respectively); however, no significant correlation existed between MEPS, DASH-T, VAS, and degenerative changes (wrists, $P=.05$; $r=-0.083$, 0.138, and 0.062, respectively; elbows, $P=.05$; $r=-0.035$, 0.133, and 0.107, respectively).

**DISCUSSION**

Biomechanical studies have demonstrated that the radial head is an important stabilizer in forced varus and forced external rotation, as well as a secondary valgus constraint.\textsuperscript{27,29} The radial head also contributes to posterolateral elbow stability via proper tensioning of the lateral ulnar collateral ligament.\textsuperscript{25} It has been shown that radial head resection modifies the elbow kinematics, even in elbows with intact ligaments, finally resulting in increased elbow laxity.\textsuperscript{28} One magnetic resonance imaging (MRI) study showed that proximal radial drifting occurred following radial head resection in the presence of an intact medial collateral ligament and significant posterior drifting occurred in the presence of an intact lateral ulnar collateral ligament.\textsuperscript{25} These studies indicate that radial head resection may possibly cause catastrophic results in elbows with ligamentous injury. Van Riet and Morrey\textsuperscript{33} reported that 48 (75%) of 64 patients with Mason type III fractures had associated ligamentous or articular injuries, including lateral and medial collateral ligament lesions, elbow dislocation, fractures at the elbow (coronoid or olecranon fracture), and distal radioulnar joint injury.

In the current study, patients with associated injury records were excluded, and at last follow-up, valgus-varus elbow laxity or posterolateral instability were not noted in the patient records. However, the 8 cases with proximally migrated radii led the current authors to speculate that these patients may have had a subtle disruption of the interosseous membrane (the so-called Essex-Lopresti injury\textsuperscript{34}) at the time of the radial head fracture that was missed during evaluation. A high index of suspicion and MRI at the time of injury would have revealed this lesion.

Essex-Lopresti injury is the combination of radial head fracture and interosseous membrane rupture.\textsuperscript{34} A failure to diagnose the lesion followed by a radial head resection causes proximal migration of the radius, a well-described phenomenon. Many studies have reported 1 to 3 mm of proximal migration without clinical importance.\textsuperscript{4,8,11,12,14,16,22,23}
such as distal radioulnar arthritis, ulnar wrist pain, and marked reduction of wrist strength have been observed as the amount of migration increases.11 In the current study, ulnar variance was increased significantly compared with the uninjured side; however, no correlation existed between the amount of proximal migration and the clinical scores, probably due to the limited amount of increase in the ulnar variance, which was a mean of 1.6 mm. Similar to findings reported by Mikic and Vukadinovic,26 a strong correlation was detected in the current study between the ulnar variance and radiographic degenerative changes with no clinical evidence in both wrists and elbows. This correlation between positive ulnar variances and degenerative changes in wrists may be a result of increased distal ulnar loading as shown in a cadaveric study.35

The absence of radiocapitellar contact after radial head resection results in 2 radiographic consequences about the elbow: an increase in the carrying angle and degenerative changes in the ulnohumeral joint.11,17,21,26 A mean increase of up to 25° in carrying angles has been reported in many studies.4,6,8,12,14,16,17,23 Although cubitus valgus deformity may trigger ulnar nerve symptoms, this does not occur in all cases;8 for instance, a patient with normal elbow alignment may report ulnar nerve symptoms, whereas a patient with a valgus deformity of 45° may have no complaints.26 In the current study, a statistically significant mean increase of 6.3° in the carrying angle was also noted on the injured side compared with the uninjured side. Clinically, none of the patients in the current study had ulnar nerve symptoms. However, statistical analysis revealed a significant correlation between the carrying angle and clinical scores: as the angle increased, MEPS decreased, whereas DASH-T and VAS scores increased. Keeping in mind the underpowered statistical analysis as a limitation of the current study because of the small patient group, the authors believe preserving the radial head may be one of the logical options to overcome cubitus valgus deformity and therefore help in obtaining higher clinical scores.

Controversy about the correlation between the degenerative changes in the elbow following radial head resection and clinical outcome continues because most authors4,11,12,17,23,24 have reported that the outcomes are irrelevant from the presence of osteoarthritis, despite few articles that address a relationship.16,26 Two possible causes for osteoarthritis following radial head resection, which occurs more often in the elbow than in the wrist,12,16,22 are the initial injury itself causing a simultaneous articular injury and altered elbow biomechanical features and stability.5 In the current series, degenerative changes were more common in elbows than in wrists, and no relationship between the osteoarthritic changes and the clinical outcome scores was detected. With the statistical evidence of a strong correlation between ulnar variance and radiographic degenerative changes, it is rational to advocate altered elbow biomechanical features following the absence of radiocapitellar contact as the main reason for degenerative changes.

The main cause for periarticular heterotopic ossification is still unknown, although Mikic and Vukadinovic26 addressed the severity of soft tissue damage caused by the original trauma. In the current study, 3 of the patients with periarticular heterotopic ossification had no significant restriction in elbow motion, in contrast to the findings of Janssen and Vegter,14 who reported some correlation between radial overgrowth or periarticular ossification and loss of mobility, especially forearm rotation. Meticulous closing of the periostium and soft tissues over the radial stump at surgery or indomethacin use has been recommended to obviate this complication.14,17

Restriction in elbow and forearm motion following radial head resection can occur in all directions, but elbow extension and forearm supination appear to be affected the most.8,12,16,22,23,26 In previous studies, cartilage damage of the humeral trochlea and ulnar trochlear notch, soft tissue damage from the original trauma followed by additional surgery, radial overgrowth or periarticular ossification, and disordered biomechanics of the forearm following excision have been suggested as possible causes for limited elbow and forearm motions.14,26 An obvious relationship between proximal migration of the radius, cubitus valgus, and loss of pronation and supination has been reported.26 Coleman et al16 reported that patients with loss of supination greater than 30° had pain, increased arthritis, increased cubitus valgus, and decreased supination strength. In the current study, patients’ elbow and forearm motion were within reasonable limits with no remarkable restrictions and correlated significantly with the clinical scores and pain levels.

The clinical scores in the current study are satisfying and compatible with those reported in studies advocating radial head resection,4,6,11,14,17 but previously mentioned objective complications and subjective discomfort, such as elbow pain, cannot be ignored. Elbow and wrist pain affecting clinical scores directly have often been reported in previous studies that both defend and oppose radial head resection.8,11,12,14,16,17,22,23,26 The debate on the relationship of elbow pain to the degree of osteoarthritis continues; Mikic and Vukadinovic26 suggested a correlation, whereas Ikeda and Okas12 reported no relationship between pain and osteoarthritis or length of follow-up. Coleman et al16 noted that patients with elbow pain had decreased supination, pronation, and grip strength; they stated that patients with pain tend to have more advanced arthritis and decreased strength. In the current study, mild pain in 9 elbows correlated significantly with joint motion. Patients should be made aware that mild and occasional elbow pain is one of the potential outcomes after resection arthroplasty that may decrease patients’ satisfaction.
The current study has several limitations. The study is retrospective in nature and lacks a control group. The number of patients is limited, which reduces the power of the statistics, and the patient group was heterogeneous in terms of age. However, it is one of the longest follow-up series on radial head resection arthroplasty with a homogenous patient group in terms of fracture pattern. The findings revealed that focusing on satisfactory clinical outcomes can be misleading and that possible complications must be taken into account.

**Conclusion**

Advantages to resection arthroplasty for Mason type III radial head fracture are that it is not as technically demanding as ORIF or radial head replacement and that early postoperative motion can be permitted. However, the authors believe it is the orthopedic surgeon’s responsibility to use surgical procedures that attempt to restore or retain the original anatomy. Despite achieving satisfactory clinical outcomes, performing radial head resection arthroplasty as the initial method for treating Mason type III radial head fractures is no longer acceptable, especially in view of the latest encouraging studies on ORIF and radial head arthroplasty for this type of fracture. The possibility of proximal migration of the radius and an increase in the carrying angle also must be considered. Osteoarthritic changes in both the elbow and wrist are frequent radiographic consequences of the excision procedure; however, these complications often are without functional impairment.

**References**


