Long-Term Results of Radial Head Resection Following Isolated Radial Head Fractures in Patients Younger Than Forty Years Old

By Samuel A. Antu˜na, MD, PhD, FEBOT, Jos´e M. S´anchez-M´arquez, MD, and Ra ´ ul Barco, MD, FEBOT
Investigation performed at the Shoulder and Elbow Unit, Hospital Universitario La Paz, Madrid, Spain

Background: In the past, radial head resection was the surgical treatment of choice for radial head fractures that could not be internally fixed. More recently, radial head implant arthroplasty has gained popularity for the treatment of isolated radial head fractures. The purpose of the present study was to review the long-term results of radial head resection after radial head fractures not associated with elbow instability in patients younger than forty years of age.

Methods: Twenty-six patients younger than forty years of age who had sustained an isolated fracture of the radial head (including six patients who had sustained a Mason type-II fracture and twenty who had sustained a Mason type-III fracture) that had been treated with primary radial head resection were reviewed retrospectively at a minimum of fifteen years (mean, twenty-five years). Outcomes were evaluated according to the Mayo Elbow Performance Score and the Disabilities of the Arm, Shoulder and Hand score. Radiographic assessment of osteoarthritic changes and the carrying angle was also performed.

Results: Twenty-one patients (81%) had no elbow pain, three had mild pain, and two had moderate pain. The mean arc of motion was from 9_ to 139_ of flexion. All but one patient had a functional arc of motion. The mean pronation was 84_, and the mean supination was 85_. Nineteen elbows had normal strength in comparison with the unaffected side.

The mean Mayo Elbow Performance Score was 95 points; the score was classified as good or excellent for twenty-four elbows (92%) and as fair for two. The mean Disabilities of the Arm, Shoulder and Hand score was 6 points. Three patients complained of wrist pain, which was mild in two patients and moderate in one. In four patients, some degree of elbow instability could be detected on physical examination. The mean carrying angle of the involved elbow was significantly greater than that of the uninjured elbow (21_ compared with 10_). Radiographic changes of arthritis were considered mild in seventeen elbows and moderate in nine. We could not detect significant differences in functional

outcome on the basis of the degree of radiographic change.
Conclusions: Radial head resection in young patients with isolated fractures without instability yields long-term
satisfactory results in >90% of cases. Osteoarthritic changes are uniformly present but typically are not associated with
functional impairment.
Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

The treatment of comminuted radial head fractures remains controversial.While it is well established that these fractures should be fixed or the radial head should be replaced when there is an associated elbow dislocation or longitudinal forearm instability, the best therapeutic option for an isolated fracture is unclear.

Open reduction and internal fixation for patients who have a complex fracture pattern has resulted in a high number

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of complications1. Radial head excision is widely used when anatomical osteosynthesis is not possible. The long-term results of this procedure have been described by several authors, with some of them reporting excellent elbow motion2-9 and others reporting a high proportion of complications such as valgus instability, stiffness, or proximal migration of the radius 10,11. However, all of the reports describing the functional outcomes of radial head resection at a minimum of ten years have included a heterogeneous group of patients in terms of the fracture pattern, concomitant instability, and age.

Excision of the radial head alters the kinematics of the elbow, creating increased varus-valgus laxity, even when the ligaments are intact12-15. In addition, comminuted radial head fractures may be associated with occult ligamentous injuries or intra-articular damage, which may lead to early degenerative arthritis of the ulnohumeral joint, increased valgus angulation

of the elbow joint, and secondary ulnar nerve symptoms16. For these reasons, some authors have proposed that radial head arthroplasty be used routinely after an isolated, comminuted, closed fracture of the radial head in order to prevent additional deterioration of the elbow joint, especially in a young active patient who performs heavy work17,18.

The purpose of the present study was to review the longterm results of radial head resection after comminuted radial head fractures with no documented associated instability in patients who were younger than forty years of age at the time of the fracture.

Materials and Methods

Patient Data

Between August 1968 and January 1992, we identified seventytwo patients younger than forty years of age from our surgical database who had sustained a radial head fracture that was treated with primary radial head resection. None of the patients had a documented elbow dislocation or longitudinal forearm instability. After the chart review, we excluded thirty-three patients who had associated fractures in the elbow, an obvious injury of the medial collateral ligament, or a failure of nonoperative or operative treatment and had undergone delayed radial head resection. Of the remaining thirty-nine patients, two had died of unrelated causes, three refused to return for clinical evaluation, and eight patients had been lost to follow-up. The remaining twenty-six patients had a complete preoperative clinical evaluation, operative records, and a minimum duration of follow-up of fifteen years (average, twenty-four years and nine months; range, fifteen to thirtynine years) and were included in the study (see Appendix).

The study group included six female and twenty male patients who had a mean age of twenty-nine years (range, fifteen to thirty-nine years) at the time of the injury. The dominant extremity was involved in thirteen of the twentysix patients. The mechanism of the initial injury was a fall from standing height for twenty patients, a bicycle accident for four, and a motorcycle accident for two. The fractures were retrospectively defined according to the Mason system for the classification of radial head fractures19. Five patients did not have adequate preoperative radiographs, and the fracture was defined according to the surgeon's description in the operative records. Six fractures were classified as Mason type II, and twenty were classified as Mason type III. During the review of the charts and radiographs, special attention was

paid to exclude patients who had other fractures or indirect signs of instability that could have been missed at the time of the injury.

The average time from the initial injury to the time of radial head resection was seven days (range, one to twelve days). Two patients had an additional fracture involving the ankle (one patient) or the contralateral radial shaft (one patient). All patients reported that they had had normal elbow function prior to the injury. No patient had undergone any previous surgical procedure or reported previous trauma to the ipsilateral elbow.

Clinical Review

Our institutional review board approved a review of the medical records and an invitation to patients to return for evaluation. Many of the patients had relocated since the time of the injury and were located through the National Health Service registry. All of those patients were contacted and returned to our hospital for an interview, physical examination, and radiographic evaluation. Clinical and radiographic evaluations were performed by one of the authors (S.A.A.) who had not been involved in the treatment of the patients.

The outcome assessment included the Disabilities of the Arm, Shoulder and Hand questionnaire (DASH), which is a validated thirty-item self-reported outcome instrument that assesses symptoms and physical function in patients with upper extremity musculoskeletal disorders. The score is scaled between 0 and 100, with higher scores indicating worse upperextremity disability.

Elbow pain was graded as none, mild (pain only during activity, with no need for medication), moderate (pain during and after any activity), or severe (pain at rest, with the need for constant medication). Additional information was collected regarding the presence of wrist pain or ulnar nerve symptoms. Avisual analog scale was used for the assessment of patient satisfaction. Patients were also asked to give a verbal categorical rating of their degree of satisfaction as very satisfied, satisfied, or unsatisfied.

Physical examination included measurement of the range of motion of the elbow and forearm. Flexion and extension were measured with the forearm in neutral rotation, and pronation and supination were measured with the elbow at 90_. The difference between the injured and uninjured sides with regard to the strength of elbow flexion and extension against resistance was estimated on the basis of subjective comparison between the elbows. Strength was categorized as normal, mild loss (loss that was appreciable but

not limiting, with the strength measuring 80% of that on the contralateral side), moderate loss (loss that limited some activities, with the strength measuring 50% of that on the contralateral side), or severe loss (loss that limited everyday

tasks)6. Valgus laxity was assessed with the elbow in 20_ of flexion and with the forearm in pronation. Posterolateral rotatory stability was assessed with the pivot-shift test20 and the posterolateral drawer test21. Grip strength was measured with a Jamar dynamometer (Sammons Preston, Bolingbrook, Illinois). Twenty normal subjects were studied to determine the normal variation in grip strength between dominant and nondominant sides, as described byMorrey et al.12. The ratio of the nondominant to the dominant side was 0.87. This value was used to calculate and normalize the loss of strength according to hand dominance. The changes in strength on the operatively treated side were expressed as the percentage of reduction from the strength on the normal side.

With the information collected from the interview and the physical examination, a physician-based scoring system was used to define the results. The elbows were evaluated with the Mayo Elbow Performance Score (MEPS)22 for pain (maximum score, 45 points), motion (maximum score, 20 points), stability (maximum score, 10 points), and daily functional activities (maximum score, 25 points). The result was classified, on the basis of the MEPS score, as excellent (90 to 100 points), good (75 to 89 points), fair (60 to 74 points), or poor (<60 points). The result was considered to be satisfactory if an excellent or good rating was attained.

Radiographic Review

Radiographic evaluation was performed for all patients. Plain anteroposterior and lateral radiographs of both elbows, with inclusion of the forearm and wrist in supination, were used to evaluate the degree of elbow arthritis and the presence of periarticular ossifications and to measure the carrying angle. Elbow arthritis was rated according to the system of Broberg and Morrey6 as grade 0 (normal joint), grade 1 (slight jointspace 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). Posteroanterior and lateral zerorotation radiographs of both wrists were used to evaluate

radial shortening. Ulnar variance was measured as the distance between a line drawn perpendicular to the long axis of the radius at the distal ulnar aspect of the radius and the end of the ulna. Proximal migration of the radius was expressed as the difference in ulnar variance between the normal and involved sides.

Fig. 1-A

Figs. 1-A, 1-B, and 1-C Case 23. Fig. 1-A Anteroposterior radiograph of both forearms, made twenty-one years after radial head resection in the left elbow, showing narrowing of the lateral aspect of the ulnohumeral joint and an increased carrying angle. At the time of long-term followup, the patient had a flexion-extension arc of 145_ to 5_ with full pronation and supination.

Statistical Analysis

The Wilcoxon rank-sum test was used to compare the differences in values between the injured and uninjured sides. A significant difference was defined as $p < 0.05$.

Source of Funding

There was no external funding source for this study.

Results

Subjective Outcome

No postoperative complications were mentioned in the medical records. No patient underwent additional surgery of the elbow or wrist.

At the most recent follow-up, twenty-one patients (81%) had no pain, three had mild pain only after unusual activities, and two had moderate pain. Both patients with moderate pain (Cases 4 and 11) had sustained a Mason type-III fracture, both showed some instability on the most recent clinical examination (one posterolaterally and one medially), and both showed moderate osteoarthritic changes on elbow radiographs.

Three patients complained of wrist pain; it was considered mild in two patients and moderate in one patient who also had moderate elbow pain. All three patients showed proximal migration of the radius on radiographs of the wrist (Figs. 1-A, 1-B, and 1-C), and one of them had distal radioulnar instability on clinical examination.

Three patients complained of ulnar nerve irritation; this finding was transient in one patient and was only occasional

and mild in the other two. None of the twentysix patients sought additional treatment for neurological problems.

The mean satisfaction score on the visual analog scale was 9 (range, 4 to 10). Eighteen patients (69%) stated that they were very satisfied with the result of the operation, six (23%) were satisfied, and two (8%) were not satisfied. Both of the

Fig. 1-B Fig. 1-C

Posteroanterior zero-rotation radiographs of the elbow and wrist on the injured side (Fig. 1-B) and the uninjured side (Fig. 1-C), showing an increased ulnar variance of 9 mm on the injured side. The patient had mild wrist pain with strenuous activities and had demonstrable distal radioulnar joint instability.

Fig. 2-A

Fig. 2-B

Figs. 2-A through 2-D Case 1. Figs. 2-A and 2-B Anteroposterior and lateral radiographs, made thirty-nine years after radial head resection, showing moderate osteoarthritic changes in the elbow and wrist with medial heterotopic ossification. The active flexion-extension arc was from 140_ to 5_, without elbow pain; the patient had a MEPS of 100.

patients who were dissatisfied with the function of the elbow had a visual analog scale satisfaction score of <5, moderate elbow pain, and demonstrable instability. The average DASH score at the time of the latest examination was 6 points (range, 0 to 38 points). The DASH scores for the two patients who were not satisfied were 28 and 38.

Objective Outcome

At the time of the latest follow-up examination, the mean range of motion was from 9_ (range, 0_ to 30_) of extension to 139_ (range, 100_ to 145_) of flexion, with a mean total arc of 130_ (range, 70_ to 145_). Twenty-five elbows (96%) had a functional arc of flexion-extension (£30_ to ‡130_) at the time of the latest follow-up evaluation23. At the time of the latest follow-up evaluation, all elbows had a mean of 84_ of pronation (range,

40_ to 90_) and 85_ of supination (range, 60_ to 90_).
In four patients, some degree of elbow instability could be detected on the latest clinical examination. Two patients had moderate posterolateral rotatory instability with a positive lateral pivot shift apprehension test 20 and had considerable functional impairment with the elbow in extension and supination. However, neither patient complained of a subjective sense of instability. Both were symptomatic following radial head excision but did not seek additional treatment. In both patients, the scar from the operation was perpendicular to the axis of the lateral collateral ligament. Two other patients had increased valgus laxity that did not cause any functional limitation. Another patient had instability of the distal radioulnar joint associated with proximal migration of the radius (Figs. 1-A, 1-B, and 1-C). That patient had mild wrist pain and recognized that the symptoms had developed gradually years after the injury.
Nineteen elbows had normal flexion and extension strength against resistance when compared with the contralateral side. The average grip strength was 39 kg (range, 29 to 59 kg) on the injured side and 45 kg (range, 22 to 72 kg) on the
Fig. 2-C Fig. 2-D
Posteroanterior zero-rotation radiographs of the elbow and wrist on the injured side (Fig. 2-C) and the uninjured side (Fig. 2-D). Despite an increased ulnar variance of 4 mm on the injured side, the patient had no wrist pain with 85_ of pronation and 70_ of supination.

unaffected side ($p < 0.05$). The average loss of grip strength with the data normalized was 16%.
The mean MEPS was 95 points (range, 60 to 100 points). The result was excellent for twenty-one elbows, good for three, and fair for two. Thus, on the basis of the objective score, twenty-four elbows (92%) had a satisfactory result and two (8%) had an unsatisfactory result.
Sixteen of the twenty-six patients were manual workers at the time of the injury. Thirteen of these sixteen patients continued with manual work activities with no limitations. Three patients, all of whom had Workers' Compensation issues, had to change to a job that did not involve heavy lifting.

Radiographic Analysis

The average carrying angle was 21_ (range, 10_ to 32_) on the

injured side and 10_ (range, 5_ to 16_) on the uninjured side ($p < 0.05$). Osteoarthritic changes were considered to be mild in seventeen elbows and moderate in nine; however, none of the twenty-six elbows showed complete loss of the ulnohumeral joint space. Only two patients had mild signs of primary degenerative osteoarthritis in the uninjured elbow, with small osteophytes of the coronoid and irregular subchondral bone. We could not detect any significant difference in the MEPS between patients with mild osteoarthritic changes and those with moderate osteoarthritic changes (97 compared with 91). However, because of the small sample size in each group, this study was likely underpowered to detect a significant difference (Figs. 2-A through 2-D).

Seven elbows had heterotopic ossification on the medial (five) or lateral (two) aspect, and one elbow had severe heterotopic ossification all around the joint. The average arc of flexion-extension in this group of patients was not reduced in comparison with that in the group of patients without periarticular ossifications (126_ compared with 132_).

Twenty-two patients had an increased ulnar variance in the injured wrist as compared with the uninjured wrist. Radial shortening averaged 3.1 mm (range, 0 to 9 mm). Only three patients showed >5 mm of proximal migration of the radius.

Discussion

Fractures of the radial head are frequently associated with dislocation of the elbow, injury to the medial or lateral collateral ligaments, or forearm instability. The radial head has been considered to be expendable in the past24, but it is now recognized as an important stabilizer of the elbow and forearm. When treating unstable elbow fracture-dislocations and radial head fractures associated with injury to the forearm interosseous ligament, it is crucial to restore radiocapitellar contact through internal fixation or repair of the radial head25,26. Some authors have suggested that internal fixation or arthroplasty, rather than excision, should be considered for the healthy, active patient in the presence of a stable elbow or forearm articulation10. The main reason to consider this approach is the reported association of radial head resection with delayed complications such as pain, instability, proximal radial translation, decreased strength, osteoarthritis, or cubitus valgus. Moreover, biomechanical studies have demonstrated that the kinematics of the elbow joint are considerably altered after radial head excision, even in elbows with intact ligaments, suggesting the need for additional clinical studies in order to determine the long-term effects of this instability13.

There have been conflicting reports regarding the longterm outcome of radial head resection for the treatment of radial head fractures.While some authors have reported a high proportion of good results and minimum functional limitations 2-9, others have reported a high proportion of unfavorable outcomes11,12,27. However, all of those studies included patients of all ages, some of whom had associated elbow or forearm instability, making the analysis of outcome difficult. Conversely, the present study evaluated the functional outcome of radial head resection in patients less than forty years of age who had an isolated radial head fracture. In the future, our results could be compared with those of other surgical options, such as radial head replacement, in this specific group of patients.

In the present series, twenty-four patients (92%) had no pain or slight pain with strenuous activities after a mean duration of follow-up of twenty-five years. The same number of patients could performall daily activities without restriction and were satisfied with the result of the operation. Range of motion was slightly reduced, especially in extension, but this finding did not correlate with any clinically important functional impairment. In the series of Herbertsson et al.9 only two of the fortynine patients with a Mason type-II or III fracture had severe pain at a mean of eighteen years after radial head excision. Janssen and Vegter8 reported that four of eighteen patients who underwent a radial head resection for the treatment of a Mason type-II or III fracture had slight pain after strenuous work at a minimum duration of follow-up of sixteen years, but only one had to change his job. Faldini et al.2 reported a good or excellent result for all twenty-two patients with a Mason type-III radial head fracture at a mean duration of follow-up of fifteen years after resection. All sixteen patients in the report by Coleman et al.4 with type-III fractures had a good result after resection at a minimum duration of follow-up of eight years.

Two patients in our group showed posterolateral instability on clinical examination and had functional complaints consistent with this finding. The concurrence of radial head resection and posterolateral instability was recognized recently by Hall and McKee28 in their report of seven cases. Those authors attributed the ligament insufficiency to unrecognized acute damage at the time of the injury. This also could have been the case in our two patients, but both of them had a very suspicious scar crossing the axis of the ulnar part of the lateral collateral ligament, which might indicate iatrogenic sectioning of this structure at the time of surgery. Clinically, both patients complained of weakness and discomfort when the arm was placed in extension and supination. Two additional patients

had increased valgus laxity that did not cause any functional impairment. It is possible that these patients had an injury of the medial collateral ligament that was not recognized at the time of the index operation. However, because both patients denied any problems related to elbow function postoperatively

and because no mention of any form of instability was found in their charts, we believe that this increased laxity was due to progressive stretching of the ligament over time.

The present study supports the findings of previous authors who have noted that osteoarthritis is almost uniformly present after radial head resection2-4,12. This very high rate of degenerative changes could be attributed to the absence of radiocapitellar contact; however, this is only speculative in the absence of a control group. In our series, as in previous reports2-5,8,9, there apparently was no correlation between the degree of degenerative changes and functional impairment.

Our patients had an average radial shortening of 3.1 mm on the involved side. Three patients had >5 mm of shortening, all with radiographic evidence of distal radioulnar arthritis and wrist pain, and one demonstrated instability on clinical examination. Mild radial shortening has been reported in most series to have very little clinical importance, and it has been attributed to progressive stretching of the interosseous membrane after repeated loading of the forearm with daily activities 8. The three patients with shortening of >5 mm constitute a different group and probably had a mild form of Essex-Lopresti injury with disruption of both the interosseous membrane and the triangular fibrocartilage complex when they sustained the fracture of the radial head, which was not identified intraoperatively and progressed clinically over time29,30. An adequate assessment of longitudinal stability with the aid of the radius pull test and fluoroscopic confirmation could help to prevent this complication31.

The strengths of the present study are that, to our knowledge, it is the longest follow-up series of radial head resection for the treatment of isolated acute fractures to date and is the only study that has specifically analyzed the results in young patients. However, it suffers from the typical problems of retrospective reviews covering a long period of time; specifically, some patients were lost to follow-up, and adequate preoperative

radiographs were not available for every patient. In addition, most of the patients were managed by general orthopaedic surgeons with no specific training in elbow surgery during a time period when the pathology and kinematics of radial head fractures were not completely understood. It is quite possible that some associated ligamentous or articular injuries were missed, as we know today that, according to van Riet and Morrey16, 50% to 75% of patients with type-II and III fractures have concomitant pathology.

Appendix

A table showing the details on all study subjects is available with the electronic version of this article on our web site at jbjs.org (go to the article citation and click on ‘‘Supporting Data’’). n

Samuel A. Antu˜na, MD, PhD, FEBOT
Jos´e M. S´anchez-M´arquez, MD
Ra ´ ul Barco, MD, FEBOT
Shoulder and Elbow Unit,
Hospital Universitario La Paz,
Paseo de la Castellana 261,
28046 Madrid, Spain.
E-mail address for S.A. Antu˜na: santuna@asturias.com

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