



Nonunion of the radial neck following operative treatment for displaced radial head and neck fractures

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Nonunion of the radial neck is uncommon after operative treatment of displaced radial head and neck fractures. Treatment of nonunion of the radial neck remains a subject of debate and various treatment options have been introduced. This study presents six patients with nonunion of the radial neck following operative treatment for displaced radial head and neck fractures and the long-term clinical outcomes of conservative treatment for nonunion of the radial neck.

Three hundred and twenty-six patients underwent operative treatment for displaced fractures of the radial head and neck from 1996 to 2008 ; six of these patients (1.8%) developed nonunion of the radial neck. No additional surgical treatment was undertaken after nonunion was confirmed. Time from primary operation to diagnosis of nonunion, clinical presentation, radial head-shaft angle, range of motion and residual angulations on plain radiographs were documented. Functional outcomes were evaluated using the Mayo elbow performance index (MEPI) at final follow-up visit.

Average time from primary operation to diagnosis of nonunion was 10.2 months. Five patients reported no functional deficits and no clinical discomfort when nonunions were confirmed. Another patient complained of mild elbow discomfort only when lifting heavy weights. All patients achieved satisfactory clinical outcomes after an average follow-up of 7.6 years. Regardless of radiological findings, no further surgical treatment is recommended for asymptomatic nonunion of the neck of the radius.

Keywords : radial neck fracture ; surgical treatment ; complications ; nonunion.

INTRODUCTION

Fractures of the radial head and neck account for 1.5-4% of all fractures and 25-33% of elbow fractures (1,10). Minimally displaced radial head and neck fractures consistently achieve satisfactory clinical outcomes, regardless of treatment methods (1). However, fractures of the radial head and neck are prone to displacement and comminution when associated with other injuries, such as elbow dislocation, collateral ligament disruption, and fracture of the coronoid process (11). Operative treatment is required to treat a mechanical block of elbow motion due to the fracture fragments and for unstable fractures combined with dislocations. The

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optimal operative method for displaced radial head and neck fractures is controversial, with conflicting evidence supporting open reduction and internal fixation, radial head excision, and radial head replacement (8,11). Furthermore, the traditional concept of: “resect the radial head if in doubt” has been set aside in favor of: “preserve the radial head if possible” (11). Despite good functional outcomes after operative treatment, fixation failures, malunion, nonunion, and avascular necrosis have been reported as complications (14). Nonunion of the radial neck following operative treatment is an uncommon complication (7,12,13); accordingly, the treatment of nonunion of the radial neck remains the subject of debate and various treatment options have been introduced (7,12,14). Furthermore, the prognosis and long-term results of nonunion of the radial neck cannot be explained with any certainty due to lack of literature (2,7,12-14).

In this study, we present six patients with nonunion of the radial neck following operative treatment for displaced radial head and neck fractures and the long-term clinical outcomes of conservative treatment for nonunion of the radial neck.

MATERIALS AND METHODS

Three hundred and thirty-one patients underwent operative treatment for displaced fractures of the radial head and neck from 1996 to 2008. Five patients were excluded because of follow-up loss before bone union and six of the remaining 326 patients (1.8%) were diagnosed with nonunion of the radial neck. There were three men and three women with an average age of 30.7 years

(range: 14-48 years) at the time of injury. The dominant extremity was involved in two of the six patients. Three patients had fractures resulting from a fall onto an outstretched hand, two patients were involved in a motor vehicle accident and another patient was injured in a bicycle accident. According to the Mason classification, four patients presented with type III fractures and two patients with type II (Table I). Three patients had combined injuries, such as an Essex-Lopresti fracture or a Monteggia fracture. There were no associated neurovascular injuries. Preoperative radial head-shaft angles were measured by plain radiography in the anteroposterior view. Radial head-shaft angle was defined as the angle between a line perpendicular to the articular surface of the radial head and a line drawn down the center of the radial shaft.

All patients underwent operative treatment within an average of 3.8 days after injury. Three patients were treated by open reduction and internal fixation with a plate and screws. One patient underwent open reduction and internal fixation with a Herbert screw and K-wires. Another patient was managed by open reduction and pinning, and the sixth was treated with a long arm cast with the elbow in 90° of flexion after open reduction without any fixation. Three days after surgery, the splint was replaced with a hinged brace to allow for elbow range of motion exercise, except for the patient with cast immobilization. Plain radiography was performed at 1, 6 and 12 months postoperatively. If union was confirmed and functional outcome showed good results, the follow-up was discontinued. However, in the case of nonunion a follow-up visit every six months was recommended.

Nonunion of the radial neck was diagnosed by plain radiography and CT (computerized tomography) when the diagnosis was equivocal by plain radiography. Time from primary operation to diagnosis of nonunion, clinical presentation, elbow range of motion, and residual

Table I. — Patient demography

Patients	Age (yrs)	Gender	Occupation	Injury mechanism	Fracture type*	Associated injury	Operation
1	47	F	Housewife	MVA	III	Essex-Lopresti Fx	Plate & screws
2	29	F	Telemarketer	Bicycle	III	Monteggia Fx	Screws & K-wires
3	24	M	Salesman	Fall	II	—	Pinning
4	14	M	Student	Fall	III	—	OR & cast
5	48	M	Bus driver	Fall	II	—	Plate & screws
6	23	F	Student	MVA	III	Monteggia Fx	Plate & screws

* Fracture type according to the Mason classification, MVA: Motor vehicle accident.



Fig. 1. — Postoperative 8 months plain radiograph showed nonunion with bony defect in a 47-year-old female patient (No. 1) who reported no functional deficit and no clinical discomfort.

angulation of the radial head and shaft on plain radiographs were evaluated. After confirming nonunion, no additional surgical treatment was administered to any of the six patients. Functional outcomes were assessed using the Mayo elbow performance index (MEPI) at the final follow-up visit, which took place on average 7.6 years (range : 2-14 years) after diagnosis of nonunion. Written informed consent was obtained from all patients. This study was approved by the ethics committee of our institution (ECT/12/05/05).

RESULTS

The average time from primary operation to diagnosis of nonunion was 10.2 months (range : 8-15 months). Five patients (Case 1, 3, 4, 5, and 6) reported no functional deficit and no clinical discomfort when nonunions were confirmed (Fig. 1). One patient (Case 2) complained of mild elbow discomfort only when lifting heavy weights (Fig. 2). Four patients were diagnosed with nonunion by plain radiography during follow-up, and in one patient (Case 3) suspected of having nonunion after plain radiography, this was confirmed by CT. Of the three patients who underwent concomitant operations due to associated injuries, two (Case 2 and 6) requested to have the hardware removed from the radial head and forearm and wrist simultaneously, despite no functional deficits. One (Case 6) of these two patients was diagnosed with nonunion of the radial neck at the time of hardware removal (Fig. 3).



Fig. 2. — This 29-year-old female patient (No. 2) underwent hardware removal upon her request. Residual radial head-shaft angle further changed by 10° from the time of hardware removal to final follow-up.

During the operation, fibrous tissue was found between the radial head and neck without any evidence of bony union. However, the distance between the radial head and capitellum was not changed and no instability of the radial head was observed. After hardware removal without any additional treatment, the patient demonstrated no functional deficit during daily activities. No subsequent complications, such as heterotopic ossification, early fixation failure, or infection were observed in any of the six patients. The average pre-operative radial head-shaft angle was 29.7° (range : $3-60^\circ$) and anatomical reduction was achieved in all six patients after the primary operation. However, the average radial head-shaft angle at the time of diagnosis of nonunion was 18° (range : $9-30^\circ$). Residual radial head-shaft angle further changed from the time of diagnosis of nonunion by an aver-



Fig. 3. — (A) Plain radiographs of a 23-year-old female patient (No. 6) one year after open reduction and plate fixation for displaced radial head and neck fracture. Nonunion of radial neck is suspected but not definitely shown. (B) Nonunion of radial neck was confirmed at the time of hardware removal.



Fig. 4. — This 14-year-old male patient (No. 4) developed a cubitus valgus deformity after radial neck nonunion.

age of 10° in two patients (Case 2 and 4) at final follow-up. During physical examination at final follow-up, both patients had cubitus valgus deformities with carrying angles of 18° and 23° , respectively. Nevertheless, the functional outcomes of these two patients were good; no functional deficit, instability, or weakness was apparent and the patients were satisfied with their outcomes. One patient (Case 4) completed 26 months of military service successfully, despite mild osteoarthritic change on plain radiography (Fig. 4).

At final follow-up visit, all patients demonstrated good functional range of elbow motion: average supination was 77° (range: $65-80^\circ$); pronation was 75° (range: $60-80^\circ$); flexion was 128.3° (range: $120-140^\circ$); and extension was 7.5° (range: $0-10^\circ$). Average Mayo elbow performance index at final follow-up was 96.7 (range: $85-100$) (Table II). No patients experienced a change of employment after operative treatment. One patient (Case 5) showed mild instability, however this did not affect every day activities.

DISCUSSION

Nonunion of a radial head and neck fracture is caused by many factors (2,7,14). Disruption of the vasculature to the radial head and neck at the time of injury is likely to be an important contributory

factor. Improper surgical technique causing devascularization or interfragmentary defect due to comminution may also lead to iatrogenic soft tissue and vascular damage. Early loss of fixation after inadequate internal fixation and early rehabilitation despite unstable fixation may also contribute. In this study, all fractures resulted from high-energy injuries and the patients all underwent surgical treatment utilizing various fixation methods, which may have compromised the vascularization of the radial head and neck.

In theory, the incidence of nonunion of the radial head and neck after fracture should be high due to the unique anatomical structure of the radial neck. The radial epiphysis is contained within the elbow joint capsule and the radial head has a tenuous blood supply with limited soft tissue attachments (15). Therefore, a high-energy injury can disrupt the vascular structure, and surgical manipulation can further increase the damage to soft tissue and blood supply. However, contrary to our expectations, nonunion of the radial neck is reportedly uncommon, although it should be noted that no study has determined the accurate incidence of radial neck nonunion following internal fixation (7, 12,13). In the present study, we found an incidence of 1.8%. Nonunion of the radial head and neck may be underestimated because radiographs are not taken until symptoms are evident. Furthermore, nonunion

Table II. — Clinical outcomes of radial neck nonunion at an average 7.6 years follow-up

Patients	Time for nonunion (months)	Follow-up (years)	Residual symptoms	ROM (sup/pro/flex/ext)	Radial H-S angle	MEPI
1	10	14	—	80°/60°/140°/5°	9°	100
2	15	9	Mild pain Cubitus valgus	80°/80°/120°/0°	30°	85
3	11	7	—	50°/80°/135°/5°	9°	100
4	8	7	Cubitus valgus	80°/80°/140°/10°	30°	100
5	9	6	—	80°/80°/120°/10°	10°	95
6	8	3	—	80°/70°/130°/0°	20°	100

Radial H-S angle : Radial head-shaft angle, MEPI : Mayo elbow performance index.

is often difficult to diagnose on plain radiographs because of the presence of small fragments of the radial head and hardware. Vague symptoms derived from radial neck nonunion are one of the contributing factors for delayed diagnosis ; more careful evaluation may have shown a higher incidence of nonunion.

Various treatments for nonunion of the radial neck have been introduced, including conservative management, radial head excision, internal fixation with bone graft and radial head replacement. The choice of treatment depends on the clinical symptoms and the patient's demands (7,13,14). Radial head excision is an appropriate treatment for radial neck nonunion, especially for older or low-demand patients. Ring *et al* reported five symptomatic patients treated by radial head excision ; none of these patients complained of elbow instability or pain after radial head excision (13). A bone graft with or without internal fixation is usually recommended for younger and high-demand patients. Most patients treated with an iliac bone graft in the nonunion area obtained solid union and normal strength without any functional disturbance (6). Waters and Stewart also demonstrated satisfactory clinical outcomes after bone grafting in children with radial neck nonunion (14). In cases of instability and severe bone loss, radial head replacement is considered a good treatment option for restoration of a mobile, stable and painless elbow (4,5,12). Ozcan *et al* reported good functional outcome for radial head replacement for the treatment of neglected nonunion (12).

However, when a patient has asymptomatic nonunion of the radial neck, no further treatment is recommended. Despite a scarcity of literature, asymptomatic patients with nonunion of the radial neck appear to demonstrate satisfactory clinical outcomes after conservative treatment (3,9). Five of our six patients with nonunion of the radial neck showed no functional deficit before radiological diagnosis of nonunion. No additional surgical treatment was necessary for the sixth patient, who underwent hardware removal, because the elbow was stable with good range of motion. Long-term observation of nonunion patients after conservative treatment demonstrated neither further symptomatic nor radiologic changes in four patients, such as distance between the radial head and capitellum or radial head-shaft angle in. In two patients who showed radiologic changes including nonunion gap between the radial head and neck, valgus deformity, and residual angulation of radial head-shaft, the clinical outcomes were excellent. Several studies have reported that most cases of nonunion of the radial neck are asymptomatic, but the reason for this has not been clearly established (7,12,13). The authors found fibrous tissue filling nonunion areas with stability noted during hardware removal. This fibrous tissue may have acted as a space-occupying structure contributing to elbow joint stability. Furthermore, the likelihood of this asymptomatic state is undoubtedly enhanced by the non-weight bearing status of the elbow joint.

The limitations of our study include the small number of patients as a result of the low incidence,

the different mechanisms of injury, types of fracture and surgical options which have an influence on nonunion.

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