Comminuted radial head fractures treated with pyrocarbon prosthetic replacement

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Abstract

Purpose We had evaluated our experience in the treatment of displaced and comminuted radial head fractures with pyrocarbon radial head prosthesis.

Methods From May 2003 to July 2008, radial head prostheses were performed in 47 patients. There were 29 female and 18 male with mean age 51 (34–70 years). The follow-up was a mean of 48 (12–60 months). Fractures of the radial head have been classified by Hotchkiss. The indications for a radial head replacement were type III fractures in 27 cases, type IV fractures in ten cases, comminuted radial fracture associated with disruption of the medial collateral ligament in three cases, Monteggia variant in five cases, and Essex-Lopresti in two cases. Functional outcomes were assessed by visual analog scales (VAS) of pain, joint motion and stability, and using the Mayo Elbow Performance Index.

Results The mean VAS score for elbow pain was 1 (0.5–2.1). Patients showed an average arc of motion from 6° to 140°, with 75° of pronation and 67° of supination. By using the Mayo Elbow Performance Index, 42 patients had good/excellent results, with three fair and two poor outcomes. Complications were two implant dislocations, one elbow

stiffness, one dissociation of the implant, one stem rupture, and two posterior interosseous nerve palsy that recovered from 5 to 8 weeks. We had not seen persistent instability, infection, synostosis, severe degenerative changes, or impingement.

Conclusions The treatment of comminuted radial head fracture with pyrocarbon implant usually gives an optimal result depending on the severity of the initial injury and the presence of associated lesions. The size of the prosthesis is often overestimated, causing restriction in motion due to impingement, overstuffing, or dislocations.

Keywords Radial head arthroplasty · Radial head prosthesis · Pyrocarbon prosthesis · Comminuted radial head fractures

Introduction

The incidence of radial head fractures has been reported to be between 1.7% and 5.4% of all fractures and to represent 33% of all elbow fractures [5, 7, 14]. The most common injury mechanism is due to an axial load onto the pronated and extended forearm. In 1943, Mason and Shutkin [13] detailed the more favorable outcomes obtained with early range of motion of the elbow. Findings from these reports have developed into consistent recommendations for early motion of nondisplaced radial head fractures, open reduction internal fixation of displaced fractures, and excision with or without radial head prosthetic replacement when fixation is impossible [14].

The radial head provides stability about the elbow and forearm in two ways. First, it serves as a secondary stabilizer to valgus instability of the elbow, with the primary stabilizer being the medial collateral ligament (MCL). Second, the radial head also provides stability to

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the distal radial ulnar joint to assist the forearm in resisting axial forces and enhancing grip strength [11, 16]. In the presence of an intact MCL, radial head excision does not appear to result in cubitus valgus or late medial elbow instability [16]. Acute axial instability resulting from radial head fracture and disruption of the interosseous ligament and triangular fibrocartilage complex (TFCC) has been well described and defined as the Essex-Lopresti injury. Chronic axial instability after radial head excision without apparent interosseous ligament or TFCC instability and the resultant symptomatic proximal migration of the radius is less well understood but has been reported to range from 20% to 90% [11]. Radial head arthroplasty is indicated in unreconstructable head fractures and in cases of associated elbow instability for which excision of the radial head likely will produce late complications. The purpose of this study was to evaluate our experience in the treatment of displaced and comminuted radial head fractures with the Mopyc[®] pyrocarbon radial head prosthesis (Bioprofile-Tornier, Cedex, France).

Materials and Methods

From May 2003 to July 2008, 47 patients were operated in two institutions with Mopyc[®] pyrocarbon radial head prosthesis (Bioprofile-Tornier, Cedex, France). To be included in the study, a patient had to be skeletally mature and has presented with an unreconstructable radial head fracture associated or not with elbow instability (Fig. 1). There were 29 female and 18 male with mean age 51 (34–70 years). The mean follow-up was 48 months (12–60 months). Their dominant arm was involved in 32 (68%) of the 47 patients. The mean time between the injury and the surgery was 3 days (0–7 days). Radial head fractures were classified according to the system proposed by Hotchkiss [11]. Pain at rest and during activity was measured with a visual analog scale (VAS). Test of stability and neurological examination was done manually as well as measurement of the range of motion, using a goniometer. Stability in varus and valgus was manually tested in both the full extension and 30° and 60° of flexion. The indications for a radial head replacement were comminuted type III fractures in 27 cases, type IV (concurrent radial head fracture and an ulnohumeral dislocation) in ten cases, comminuted radial fracture associated with disruption of the MCL in three cases, Monteggia variant with olecranon and radial head fractures in five cases, and Essex-Lopresti in two cases. Functional outcomes were assessed using the Mayo Elbow Performance Index [17]. Anteroposterior (AP) and lateral radiographs of the elbow with the arm in pronation and supination were reviewed for congruity of the radial head with the capitellum, evidence of capitellar osteopenia, prosthetic sizing, periprosthetic lucency, het-

erotropic ossification, joint incongruity, and osteoarthritis. Roentgenograms should include quality AP and lateral views centered on the wrist. Accurate AP and lateral roentgenograms of the wrist were required in addition to those of the elbow to make the diagnosis of Essex-Lopresti injury. To accurately measure proximal migration of the radius (ulnar positive variance) on the AP projection of the wrist, the shoulder was abducted and the forearm was held in neutral rotation. Comparative views are helpful to determine the individual's normal ulnar variance. Lateral wrist roentgenograms are necessary to detect dorsal subluxation of the distal ulna.

Capitellar osteopenia was graded as none, mild, moderate, or severe. Prosthetic sizing and overstuffing were judged by comparing the medial ulnohumeral joint space of the operative treated and untreated elbows on follow-up anteroposterior radiographs. If the medial ulnohumeral joint surfaces were parallel and the joint space was equal to that of the contralateral elbow, it was deemed that there was no overstuffing of the joint. Periprosthetic lucency around the stem was graded as none, mild, moderate, or severe on the basis of the number of zones (adopted from Gruen classification for the hip, [9]) involved and the amount of lucency (in millimeters) observed. Lucency was rated as mild when one to two zones were involved by lucent lines of <2 mm in thickness, moderate when three to six zones were involved or the lucency was >2 mm in thickness, and severe when all zones were involved. Heterotopic ossification was graded as I, II, III, or IV according to the scoring system of Brooker et al. [4]. The degree of degenerative change was classified, with the system described by Broberg and Morrey [3], as grade 0 (a normal joint), grade 1 (slight joint space narrowing and minimum osteophyte formation), grade 2 (moderate joint space narrowing and moderate osteophyte formation), or grade 3 (severe degenerative changes with gross destruction of the joint).

Surgical Technique

With the patient placed in the supine position under axilar anesthesia, we used the extensile lateral approach, which was defined by Hotchkiss [11] through the lateral collateral ligament (LCL) and common extensor muscles to expose the radial head in all patients. After the arm was positioned, a long Kocher lateral approach was made beginning at the lateral epicondyle and ending distal to the radial neck. Then, the interval between the anconeus and the extensor carpi ulnaris (ECU) or between the posterior muscle fibers of the ECU was entered, and the LCL was exposed. A longitudinal incision was made in the anterior part of the LCL along its fibers extending from the lateral condyle to just distal to the radial neck through the annular ligament and capsule. We identified the head fracture, and we removed all fragments of

Figure 1 Comminuted radial head fracture treated with pyrocarbon prosthetic replacement. **a, b** Preoperative anteroposterior (AP) and lateral view. **c, d** AP and lateral view, 2 years after the implant.

the unreconstructable head. The annular ligament was partially opened. A cutting guide was used in order to achieve a good resection, which must be perpendicular to the axis of the radius. The parts of the broken head were reassembled on the table to ensure that the whole head had been resected and to choose the size of the prosthetic head. If a coronoid fracture or an anterior capsule tearing was present, the surgeon repaired it at this time. The pyrocarbon prosthetic replacement comes in four different sizes, and the surgeons estimated the size from the fractured pieces of the radial head. After resection of the radial head, the radial shaft was prepared. Then the trial stem was introduced and left temporarily in place. The positioning and height of the prosthesis are essential for the success of the implantation. Four sizes of the neck are available. The head had to reach the limit between the trochlear notch and the radial notch of the ulna. X-rays were performed to check to proper choice of the elements sizes, the positioning of the neck and the height of the prosthesis. The height of the implant must not exceed from 3 to 5 mm of over- or understuffing. After removal of trial

elements, the stem was inserted. The expansion screw was then applied with the expansion driver. After stem locking, the head and the neck were assembled together on the stem. At this stage, another X-ray control was done in order to check the good positioning of the prosthesis. Associated procedures included ulnar osteosynthesis in five cases of Monteggia fractures (Fig. 2), coronoid reconstruction in two cases, MCL reparation in three cases, temporal Kirschner wire in the radioulnar joint in two cases, and arthrolysis in two cases. The position of the prosthesis was estimated during implantation, and stability was tested. The average duration of immobilization was 12 days. After that, early active and passive motion of the elbow joint is allowed with a therapist.

Results

All patients with the prosthesis were stable. The mean VAS score at rest was 1 (0.5–2.1). The mean VAS during activity was 1.7 (0.5–2.4). Patients showed an average arc of

Figure 2 Monteggia fracture-dislocation. **a, b** Preoperative AP and lateral view. **c, d** AP and lateral view, 3 years after the treatment.

motion from 6° to 140° , with 81° of pronation and 76° of supination. By using the Mayo Elbow Performance Index, 42 patients had good/excellent results, with three fair and two poor outcomes. Complications were implant dislocation in two cases, needed to remove the implant. Postoperative stiffness in a type IV fracture with range of motion of flexion 90° , extension -30° , and supination 30° needed to remove the prosthesis with elbow arthrolysis. After the surgical procedure, the patient presented a posterior interosseous nerve (PIN) palsy that recovered in 6 weeks. Nowadays, the patient has an acceptable range of motion after physiotherapy. In the two cases with extracted prosthesis, the elbow was clinically stable. Transient neurologic symptoms developed in other two patients. We showed two postoperatively PIN palsy that recovered from 5 to 8 weeks. Radiological evaluation demonstrated that all

radial head implants articulated congruently with the capitellum. We did not have any evidence of capitellar osteopenia. There was no evidence of implant overstuffing, as there was parallelism of the ulnohumeral joint. Forty patients (85.1%) did not have any evidence of lucency around the stem of the prosthesis, 4 (8.5%) had minor lucencies (>2 mm in thickness in one or two zones), and 3 (6.4%) had moderate lucencies (>2 mm in thickness or involvement of three to six zones) around the stem. One patient presented pre-operative capitellar erosion. The patients did not have any arthritic changes. At the 4-year interval, one implant had fractured after an injury in the elbow, and other prosthesis required removal for dissociation between neck and stem components (Fig. 3). In four patients, we have also seen an axial migration of the stem without repercussions in the capitellum or in the mobility.

Figure 3 Radial head arthroplasty. Dissociation between the components, 6 months after the operation.

This may be was a loosening of the stem (Fig. 4). Three patients had heterotopic ossification which was stage I in two of them and stage II in one. We had not seen persistent instability, infection, radioulnar synostosis, severe degenerative changes, or impingement.

Discussion

Depending on the fracture pattern and associated soft-tissue injury, several types of treatment exist for fractured radial head [2, 17]. The radial head prosthesis used in this study for comminuted radial head fractures has an uncemented titanium stem, a 15° angulated neck, is modular, and has a pyrocarbon head [1]. We have chosen this prosthesis for its

hypothetical modularity, placement easiness, and the durability of pyrocarbon [1]. However, we have been able to appreciate that it is not a prosthesis of easy placement and that it can dissociate the components between the neck and the stem. Radial head replacement is a unilateral arthroplasty. Consequently, the contact between native cartilage and the prosthesis might lead to lesions of the capitellum and the radial notch [1, 18, 25]. Radial head fractures were classified according to the system proposed by Hotchkiss [11]. It is based more on predicted surgical treatment rather than radiographic findings. Type I fractures are nondisplaced and do not require surgical intervention, type II fractures are displaced (usually more than 2 mm) and believed to be amenable to surgical fixation, type III are displaced and severely comminuted and judged not amenable to surgical fixation. Type III fractures, in all likelihood, will require excision. The later addition to this classification was the Mason-Johnston type IV injury, which takes into account a radial head fracture in the presence of an ipsilateral ulnohumeral dislocation [11]. This classification system is helpful in communicating potential management strategies, but final treatment decision (between types II and III) is usually made intraoperatively [11]. Application of prosthesis is clearly indicated in cases of associated valgus or axial instability [23, 28]. The use of radial head prostheses is controversial in cases of radial head excision with no apparent valgus or axial instability noted acutely. However, some studies comparing simple excision versus prosthetic replacement have suggested a reasonable prophylaxis against chronic distal radial ulnar joint problems with the use of prosthesis [10, 12]. It is important to restore radiocapitellar contact through repair or replacement of the radial head when treating unstable fracture dislocations of the elbow, such as those associated with injury of the interosseous ligament of the forearm (an Essex-Lopresti lesion) or posterior dislocation of the elbow with fractures of the radial

Figure 4 a, b AP and lateral view. Three years follow-up. Axial migration of the stem without repercussions in the capitellum or in the mobility.

head and coronoid process (the so-called terrible triad of the elbow [20]. Biomechanical studies have demonstrated that metallic prostheses can reproduce the loads across the elbow more closely than silastic prostheses [2]. Acrylic, stainless steel, silastic, pyrocarbon, and articulating CoCr prostheses have been developed, and a variety of results have been reported. The complications associated with arthroplasty include subluxation or dislocation, painful loosening, implant impingement, and fracture of the prosthesis [12, 29]. Van Riet et al. [25] have showed capitellar erosion caused by metal radial head prosthesis. Bipolar radial head prosthesis can be effective as a solid monoblock prosthesis in restoring valgus stability in a MCL damage elbow [19, 24]. Arthroplasty with metal radial head implant was found to have been an effective treatment option for patients with unreconstructable radial head fracture [8, 10, 15]. However, pyrocarbon radial head replacement is not free from complications. In our study, we had showed two radial head dislocations associated by the overstuffing of the implant. We had also showed one case of understuffing of the implant with dissociation of the components, between the neck and the stem, that required removal of the prosthesis. Van Glabbeek et al. [24] suggests that accurate restoration of radial length is important and that axial understuffing or overstuffing of the radioulnar joint by >2.5 mm alters both elbow kinematics and radiocapitellar pressure. Shors et al. [22] concluded that radiographs could not be used to diagnose incorrect lengths in the range of -2 to +4 mm. These results agree with the findings of Frank et al. [7] with regard to the limitations of postoperative radiographs in the diagnosis of overlengthening. Rowland et al. [21] determined that lateral gapping was present in about one third of normal elbows. They also found that the medial ulnohumeral joint was normally parallel, and therefore they hypothesized that lateral gapping of the medial ulnohumeral joint may be useful indicator of overlengthening. In a cadaver model, Frank et al. [7] concluded that gapping or asymmetry of the medial ulnohumeral joint seen on AP radiographs, in tests that included muscle loading, is a reliable indicator only when the radial head is overlengthened by >6 mm; it cannot detect smaller degrees of overlengthening. The test without muscle loading, which mimicked the intraoperative environment with muscle paralysis, showed that asymmetry of the medial ulnohumeral joint was a reliable indicator of overlengthening of >4 mm. We have showed one stem fracture and four patients with axial migration of the stem without repercussions in the capitellum or in the mobility. This may be a loosening of the stem. Radiological assessment had showed heterotopic ossification in elbow in three cases and bone lucencies in seven cases. The osteolysis was found in four cases under the neck, and in three cases, peri-prosthesis stem lucency without clinical signs was found. Minor radiolucencies around the neck of the prosthesis and mild

radiographic changes in the capitellum are common but, to date, have not been associated with pain or elbow dysfunction [6]. We had not seen instability, infection, radioulnar synostosis, severe degenerative changes, or impingement. We had showed two postoperatively PIN palsy that recovered from 5 to 8 weeks. We attribute this to the retractor located in the proximal radius when we place the stem. Witt et al. [27] dissected 21 cadaver elbows to determine the relationship of the PIN to the posterolateral approach to the elbow and head of the radius. When using the posterolateral approach, it is important that interval between ECU and anconeus is clearly identified with the forearm fully pronated. The supinator should be released close to its ulnar border. It is safe to expose the proximal radius as far as the distal aspect to the bicipital tuberosity [27]. One patient had presented pre-operative capitellar erosion. The capitellar cartilage lesions were frequently concomitant with Mason type II and III radial head fractures [18]. The incidence of capitellum injury was 1% with all radial head fractures, but with more severe injuries, the incidence rose to 24% [26].

The treatment of comminuted radial head fracture with pyrocarbon radial head implant usually gives an optimal result depending on the severity of the initial injury and the presence of associated lesions. According to Morrey [16, 17] and the result of this study, type IV fractures are classified as complicated injuries. Our experience is that the size of the prosthesis is often overestimated, causing restriction in motion due to impingement, overstuffing, or dislocations. Additional studies are required to identify better tests to diagnose overlengthening postoperatively. According to Doornberg et al. [6] and the results of this study, a longer-term follow-up is needed to fully understand the effect of the articulation of an appropriately sized metal prosthesis on the capitellar cartilage over time.

Conflict of Interest The authors declare that they have no conflict of interest.

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