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Are Radiographic Abnormalities in Radial Head Prosthesis as Asymptomatic as we thought? A Mini-Review

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Abstract

Radial head fractures are the most common fractures around the elbow. A radial head arthroplasty is recommended if a radial head fracture occurs in conjunction with elbow or forearm instability and the radial head fracture is not repairable, and in cases of chronic complications after a radial head injury. Current radial head prosthesis designs may be either monopolar or bipolar and may have fixed or smooth stems. Radiographic abnormalities associated with radial head implants are common to both press-fit and loose-fitting stems, such as radiolucencies surrounding the stem of the implant, heterotopic ossification, secondary-radiocapitellar joint osteoarthritis, loosening, fracture, and implant dislocation. Whereas many complications related to RHA seem to have little clinical consequence, those that result in significant pain, stiffness or instability often end in revision surgery. In this review, we briefly summarize the complications and clinical outcomes after a radial head replacement.

Keywords: Radial head fracture; Prosthesis; Revision; Complication; Failure

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Introduction

Radial head and neck fractures are common lesions found in nearly 20% of elbow injuries [1]. The radial head is the main stabilizer of the elbow if the coronoid process is fractured, the medial collateral ligament is incompetent, or the lateral ulnar collateral ligament is disrupted [2]. Replacement has to be considered in the presence of radial head fractures with more than three displaced fragments and in chronic situations including nonunion, malunion, post-traumatic osteoarthritis, and in case of failure of the previous resection of the head [3]. Initially the radial head prosthesis was designed to prevent heterotopic ossification however, currently the main indication is elbow stabilization [4,5]. In recent years, detailed biomechanical studies and advances in the design of radial head implants and the materials used to construct them have led to a better understanding of the behavior of these implants and their possible complications.

The Radial Head as an Elbow Stabilizer

The proximal radius consists of the radial head and the neck, articular cartilage covers the concave surface as well as at least an arc of approximately 280 around the rim of the native radial head [6]. The main stabilizer of the elbow is the Medial Collateral Ligament (MCL), which resists valgus stress; therefore isolated radial head injuries with an intact ulnar collateral ligament do not cause valgus instability [7]. Combined injury of the medial collateral ligament and the radial head results in valgus instability. The standard treatment for this injury is radial head replacement, but not all types of implant have proven equally effective in terms of stability [5]. The concave surface of the radial head articulates with the convex surface of the humeral capitellum acting as a buttress, providing stability by the concavity/compression mechanism and tensioning of the Lateral Collateral Ligament (LCL) complex, avoiding external rotation at the ulnohumeral joint [8]. Congruity of the humeroulnar joint is also crucial, for both rotational and lateral stability. Resection of more than 50% of the olecranon or coronoid process causes instability [9]. In addition, the musculature that attaches around the elbow plays an important role as dynamic stabilizers of the elbow.

Classification

Several classifications of radial head fractures have been proposed ultimately aiming to guide treatment according to the pattern of the injury. The most widely accepted classification was Mason's, modified by Hotchkiss; Type I Fracture of the radial head or neck, with little or no displacement range of pronation/supination limited only by pain and edema, articular fracture <2 mm or marginal fracture of the radial head, Type II Displaced fracture (>2 mm) or fracture of the neck with angulation, motion range limitation due to mechanical impingements or loss of joint congruity, no severe comminution (internal fixation feasible), Type III severe comminuted fracture of the radial head or neck, reconstruction not feasible according to criteria assessed intra-operatively or radiologically, excision required to restore range of motion. Johnston added a fourth type to denote a fracture of the radial with associated dislocation (no matter the amount of displacement or comminution of the fragments) [10,11]. The modified Mason–Hotchkiss did not include associated lesions although they often determine the outcome of the treatment. A limitation of these classifications is their poor intra-observer and inter-observer reproducibility. There are other ratings such as that of the Mayo Clinic that do consider such concomitant injuries [12].

Treatment

The critical role played by the radial head in overall stability of the elbow and forearm has motivated many orthopedic surgeons to preserve the radial head during fracture treatment. Type I fractures are managed non-operatively and Type II fractures by reduction and stable internal fixation [9]. Mason type III radial head fractures include comminuted fractures that are considered unreconstructed, these types of fractures can be treated by excision or radial head arthroplasty. In cases where the radial head fracture is isolated, excision may be considered versus arthroplasty of the radial head, recent studies have revealed altered kinematics and stability of the elbow after radial head excision alone owing to adverse biomechanical, the resection arthroplasty is followed by proximal migration in nearly 50% of cases, cubitus valgus in 30% of cases, and medium-term humeroulnar osteoarthritis in 50% of cases, radial head replacement is thus the immediate solution when stable internal fixation is not feasible; radial head replacement, the kinematics, stability, and load transfer of the elbow are equal to those of a native radial head [13].

In cases of radial head fracture in the context of a terrible triad or in association with an ulnar fracture, radial spine reconstruction with radial head arthroplasty is required [9,14].

Implant Types

There are different types of implants depending on their material, morphology and type of integration with the bone. Is there one that has demonstrated better results? Depending on the material, there are two types of implants: silicone implants and metal implants. The first, silicone implants were popular in the 1970s, these semi-rigid cementless implants were sometimes used as temporary spacers to prevent ascension of the radius, however its prolonged use is associated to adverse effects like synovitis secondary to wear, and fragmentation [15,16]. In terms of stability, they are also not good implants compared to metal prostheses, silicone implants do not provide adequate biomechanical resistance on the other hand valgus stability after radial head replacement with a metal implant is similar to that provided by the native radial head [17]. Metallic implants are currently globally accepted, within these we can differentiate between unipolar (Figure 1) and bipolar implants (Figure 2), modularity implants and cemented, cementless, or floating in the intra-medullary canal implants. Most surgeons will choose unipolar implants for traumatic indications for the potential instability of a bipolar implant because *in vitro*, bipolar implants provide less stability than do unipolar implants, although this difference has not been demonstrated clinically [18,19]. Regarding modularity, modular implants offer two advantages: the optimal head size can be chosen

Figure 1: The Ascension Modular Radial Head system (Ascension Orthopedics, Austin, TX) is a unipolar modular prosthesis with a fixed stem.

Figure 2: Bipolar radial head prosthesis with short press-fit stem (rHEAD recon SBI/Stryker, Morrisville, PA, USA).

and the height of the head and neck can be adjusted to match the height of the resection, which is a crucial technical point which could facilitate insertion into the case of an intact LCL [20]. Implants can be fixed with the press-fit technique, cemented or left loose as a spacer. According to the fixation there are no differences in the outcome of radial head arthroplasty in most of the studies [21,22].

Operative Technique

Lateral approach is now preferred (Kocher or modified Kaplan approach), after LCL complex evaluation, the radial head fracture is assessed and the number of fragments and the size of the radial head is determined. If the radial head fragments cannot be fixed they are removed, and resection is completed, perpendicular to the neck. The removed fragments shall be used to assess the size of the radial head [23]. Trial implants are assembled, size and congruency of the radial head is assessed dynamically under direct vision and X-ray, over the full arc of elbow motion. Special care to avoid excessive elongation is critical the height of the radial head corresponds to the proximal edge of the lesser sigmoid notch [24,25]. Once the trial is satisfactory, the definitive implant is inserted.

Clinical Outcomes

It has been recognized that associated injury about the elbow, forearm, or wrist is very likely to affect the outcome after radial head arthroplasty. Reinstitution of appropriate length, motion, and stability for the radius and radiocapitellar joint is of paramount importance in radial head arthroplasty [26]. Because upward of 75% of comminuted radial head injuries occur with concomitant injury to collateral ligaments, arthroplasty is usually performed in conjunction with ligament repair [27]. Metallic implants are the most commonly used in today's radial head arthroplasty procedures. After radial

Figure 3: a) Lateral radiograph showing loosening of a unipolar implant. b) Press-fit radial head arthroplasty showing osteolysis, chondral generation and heterotopic ossification. c) AP view of a Painful loosening and the implant had to be removed two years after the initial arthroplasty.

head replacement for a recent fracture, the outcome is satisfactory in 60% to 80% of cases [29-34]. Of course, one of the most important clinical outcomes for patients after radial head arthroplasty is return to functional range of elbow motion. What constitutes functional, however, varies by patient and the patient's individual activities and requirements [35]. Morrey et al. in 1981 found that tasks for daily living generally required 100° of elbow flexion (30° to 130°) and 100° of rotation (50° pronation and 50° supination) [36]. Main case series studies of radial head replacement to treat recent fractures report outcomes with range of movement between 14° to 20° of elbow flex-extension and 87°/64° of prono-supination, which remained within functional limits.

Which design of radial head prosthesis results in better functional outcome is currently debated (16, 37), with the exception of silicone prostheses, which have been shown to be biologically and biomechanically insufficient [16,29-34,37].

Complications

Recent publications report variable complication rates for radial head arthroplasty (i.e., rate of surgical re-intervention with implant removal ranged from 0% to 29% among studies) without significant differences according to implant type [37,38]. Common complications of elbow trauma and subsequent radial head arthroplasty are heterotopic ossification, post-traumatic arthritis, nerve injury, and implant loosening or failure leading to revision or removal of the prosthesis. The majority of early removals seem to be related to heterotopic ossification, infection, joint stiffness, and persistent subluxation, whereas late removal, although less common, were mostly related to osteolysis, loosening, and capitellar cartilage wear [39,40]. Aseptic loosening (Figure 3) is a frequently encountered problem. Radiolucencies around the prosthesis are frequently reported and seem to occur mostly shortly after implantation. Whether these radiolucencies also mean that prosthesis is loose, is not always clear. Sub collar resorption is often reported with press-fit prostheses, but seems to be stationary after one to two years, without progression to loosening and without clinical symptoms [40]. In addition, management of progressive lucencies varies among authors. Van Riet et al. [39] reported loosening as the leading reason of removal in 29 out of 45 patients who underwent removal or revision surgery. In contrast, Popovic et al. reported no revision or removal after a cemented fixed-stem despite radiographic findings of periprosthetic lucencies in 27 patients [34]. Peri-hardware lucency less than 2 mm did not have clinical symptoms, however, "loosening" greater than 2 mm reflected pain (>7 on VAS) in the proximal radial forearm with load and movement and it was a statistically significant association [5]. Generally, in cases of progressive radiographic signs of loosening, a poor clinical outcome could be expected osteoarthritis of the elbow (Figure 3) following RHA can either involve the capitellum or the ulnohumeral joint. Erosion of the capitellum can be the result of cartilage damage during trauma but might also be provoked by over lengthening of the prosthesis, or due to the hard surface of the prosthesis against the cartilage [41]. When replacing the radial head, restoration of the length of the radius is important. Overstuffing may result in increased radio capitellar pressure, which may in turn lead to attrition of the capitellar articular cartilage and pain [42]. It has been proposed that the proximal edge of the lesser sigmoid notch of the ulna with the forearm in neutral rotation can be used as a reference for the articulating surface of the prosthesis [25]. Plain radiographs will only show over lengthening in severe cases [43]. In case of symptomatic overstuffing, it is sometimes necessary to revise the implant. Stiffness is a problem encountered early on after elbow trauma and/or surgery and could have different underlying problems in the case of RHAs: Over sizing of the head, stiffness because of the (surgically) injured soft tissues around the elbow joint or a loose stem followed by migration of the implant [44,45]. When restriction in range of motion is the result of capsular adhesions around the elbow and the prosthesis, they could lead to impingement. This can be managed by open or arthroscopic arthrolysis and, if necessary, removal of the implant [46,47]. Common complications of elbow trauma and subsequent radial head arthroplasty are heterotopic ossification (Figure 3). Ha et al. hypothesize that this may be related to the high rate of concomitant ligamentous injuries that occur with these complex radial head fractures, not necessarily to the implant surgery techniques [48]. Fuentes et al. found no relationship between the appearance of heterotopic ossification and the development of postoperative pain; however, these were related to the limitation of the range of motion after surgery in a significant way. Nevertheless, revision of the implant was not necessary [5]. Implant removal was often performed as part of a procedure to manage elbow stiffness and heterotopic ossification at the surgeon's preference and not necessarily because the implant was malfunctioning. The need for reintervention (revision or removal (Figure 3) of the implant) was statistically associated with heterotopic ossifications, radiocapitellar osteoarthritis and cortical resorption around radial neck, being periprosthetic osteolysis the most likely factor related to failure and radial pain the main symptom leading to surgical intervention [5]. Dissociation of the head component is more common in bipolar implants but can occur in modular rigid designs as well [39]. In case of dissociation of the head it is essential to critically evaluate the snap-on mechanism. The most probable cause would be a surgeon's error. Possible other causes for this mode of failure could be malalignment, malrotation and instability of both the radioulnar and the ulnohumeral joint, as these may increase forces on the snap-on mechanism [49]. A revision surgery may be needed with a new head component or a completely new prosthesis. Subluxation of the radial head prosthesis is sometimes seen in cases of instability or chronic malalignment of the radius on the capitellum. In acute cases a revision with a cemented implant may compensate for a mild malalignment [50]. In case of a chronic malalignment, with capitellar cartilage severely damaged, more extensive surgery could be necessary. Other complications are the elbow instability and the periprosthetic infection. Radial head fractures for which an RHA is indicated very often have associated ligamentous injuries or coronoid fractures that need to be addressed during primary surgery [41]. Failure to do so may lead to instability during follow-up and subsequent revision surgery is thus not necessarily a failure of the RHA, but rather a failure of primary management. The infection is the most important diagnoses to act on. The surgical plan for infection following RHA depends on numerous factors including the type of microorganism, comorbidity, soft tissue status and duration of the infection [41].

Conclusion

Comminuted radial head fractures with elbow instability can be treated well with a radial head prosthesis, which restores stability in acute treatment. There seems to be no evidence to support one type of radial head prosthesis over another, with the exception of silicone prostheses, which have been shown to be biologically and biomechanically insufficient. Failure of primary radial head replacement may be due to infection, implant loosening, dislocation, disassembly, heterotopic ossification or osteoarthritis of the elbow. Patients can present with persistent pain, stiffness, and symptoms of infection, instability of the radiocapitellar joint, ulnohumeral joint or both.

Authorship

All authors certified that they made contributions in design, data acquisition, data analysis/interpretation, and drafting/revising the article. The authors have given approval of the version to be published.

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