Determination of Correct Implant Size in Radial Head Arthroplasty to Avoid Overlengthening

Surgical Technique

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ABSTRACT FROM THE ORIGINAL ARTICLE

BACKGROUND: Insertion of a radial head implant that results in radial overlengthening has been associated with altered elbow kinematics, increased radiocapitellar joint forces, capitellar erosions, early-onset arthritis, and loss of elbow flexion. The purpose of this study was to identify clinical and radiographic features that may be used to diagnose overlengthening of the radius intraoperatively and on postoperative radiographs.

METHODS: Radial head implants of varying thicknesses were inserted into seven cadaver specimens, which were then assessed clinically and radiographically. Eight stages were examined: the intact specimen (stage 1); repair of the lateral collateral ligament (stage 2); radial head resection with repair of the lateral collateral ligament (stage 3); insertion of an implant of the correct thickness (stage 4); and insertion of an implant that resulted in radial overlengthening of 2 mm (stage 5), 4 mm (stage 6), 6 mm (stage 7), or 8 mm (stage 8). The specimens were tested with and without muscle loading to simulate resting muscle tone and surgical paralysis, respectively. At each stage, radiographs were made to measure the ulnohumeral joint space and the lateral ulnohumeral joint was visually assessed.

RESULTS: We identified no difference, with regard to medial ulnohumeral joint incongruity as seen radiographically, among stages 1 through 6 during the tests with muscle loading. A significant difference in medial ulnohumeral joint incongruity was found in stages 7 ($p = 0.003$) and 8 ($p < 0.001$). The clinical (visually assessed) lateral ulnohumeral joint space gap was negligible in stages 1 through 4 but increased significantly at all stages involving overlengthening (gross gap, 0.9 mm with 2 mm of erlengthening [$p = 0.005$], 2.3 mm with 4 mm of overlengthening [$p < 0.001$], 3.4 mm with 6 mm [$p < 0.001$], and 4.7 mm with 8 mm [$p < 0.001$]).

CONCLUSIONS: Incongruity of the medial ulnohumeral joint becomes apparent radiographically only after overlengthening of the radius by ≥6 mm. Intraoperative visualization of a gap in the lateral ulnohumeral joint is a reliable indicator of overlengthening following the insertion of a radial head prosthesis.

CLINICAL RELEVANCE: This in vitro study indicates that the clinical (visual) observation of a lateral ulnohumeral joint gap is a reliable indicator of overlengthening following implantation of a radial head prosthesis. In contrast, radiographic measurements are relatively insensitive and cannot reliably demonstrate overlengthening of <6 mm.

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INTRODUCTION

Comminuted, displaced unreconstructible radial head fractures are commonly managed by radial head arthroplasty in the setting of concomitant elbow and/or forearm ligament injuries. Implantation of a correctly sized metallic radial head prosthesis restores elbow stability and near normal elbow kinematics. Insertion of an implant that is too long results in overstuffing of the radiocapitellar joint and has been reported to cause limited elbow flexion, capitellar erosions, pain, and early posttraumatic arthritis. Several studies have been done to identify reliable clinical and radiographic landmarks to gauge correct radial head length intraoperatively. The techniques we use to correctly size a radial head implant will be reviewed.

SURGICAL TECHNIQUE

The patient is typically positioned supine with a bolster placed under the ipsilateral scapula. This allows slight rotation of the patient's torso so that the operatively treated arm can be placed across the patient's chest. A sterile tourniquet is used. We prefer the use of a posterior longitudinal skin incision, situated just lateral to the tip of the olecranon; however, a direct lateral skin incision may also be used. The selection of a deep approach to the radial head depends on the status of the lateral ulnar collateral ligament. When this ligament is found to be intact during the initial examination with the patient under anesthesia, we prefer to use an extensor digitorum communis-splitting approach. When the lateral ligament complex is found to be disrupted and in need of repair, we prefer to use the Kocher interval between the anconeus and the extensor carpi ulnaris. The Kocher approach allows good access to the radial head and neck and also to the lateral collateral

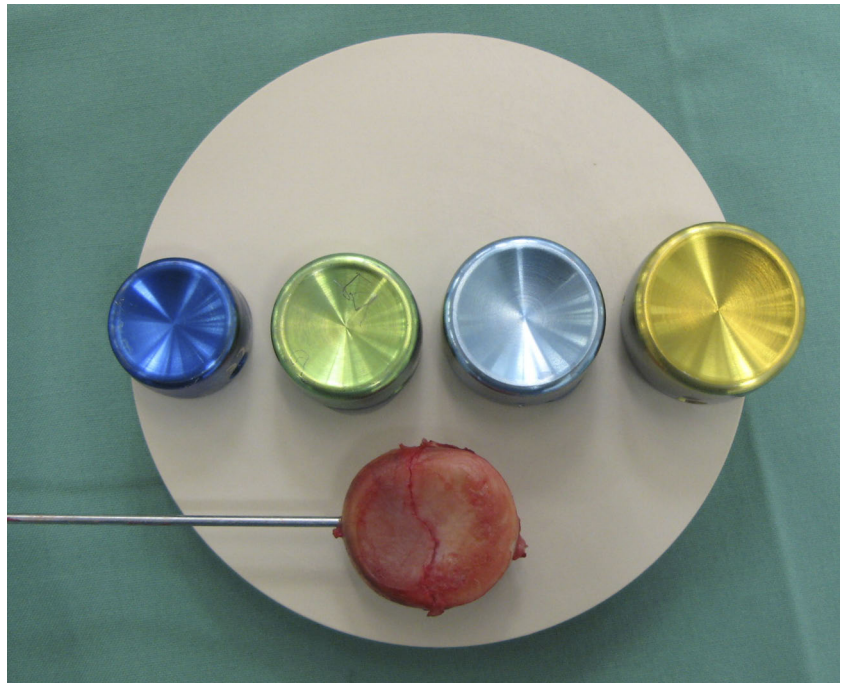

FIG. 1-A

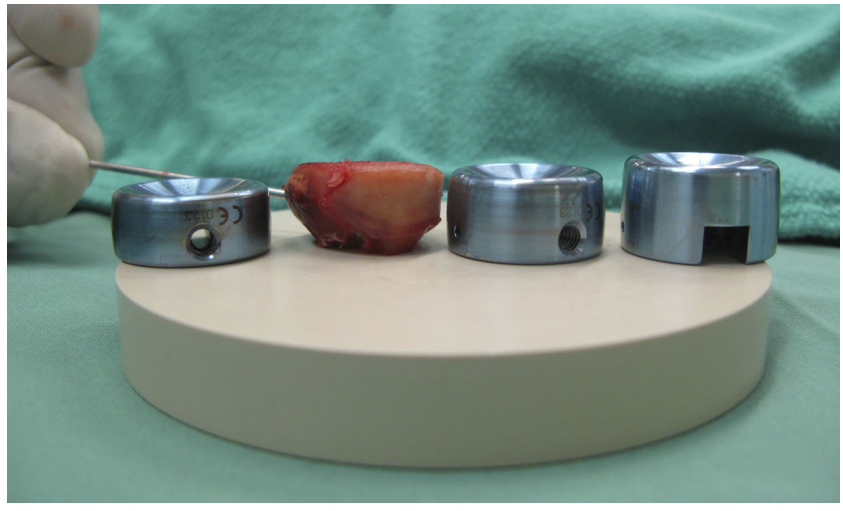

FIG. 1-B

Figs. 1-A and 1-B A clinical photograph demonstrating the piecing together of a fragmented radial head to determine the correct diameter (Fig. 1-A) and thickness (longitudinal length) (Fig. 1-B) of the implants.

ligament origin and insertion for the purpose of repair.

A lateral elbow arthrotomy is performed, and the radial head and/or neck fracture is assessed. When the fracture is deemed to be repairable, open reduction and internal fixation is performed. When the radial head fracture is highly comminuted, of poor bone quality, or otherwise considered unrepairable, a radial head replacement is performed.

A primary technical goal during radial head arthroplasty is the placement of an implant that closely replicates the dimensions of the native radial head. A reliable method to determine correct radial head implant size is to use the native head as a template. The fragmented pieces of the unreconstructible head can be pieced together to determine the height (thickness), the maximal diameter, and the minimal diameter (Figs. 1-A and 1-B). When measuring the thickness of the fractured head, it is best to measure from the articular margin to the fracture surface with the least amount of radial neck. This will determine the thinnest size of radial head implant that, when inserted into the radial canal, will rest on the most proximal segment of the remaining radial neck. An implant that is selected on the basis of the thickest portion of the fractured radial head will rest on the most proximal extent of the radial neck, leading to overlengthening of the radius[1].

A trial implant is selected on the basis of the dimensions of the native radial head and inserted into the radial neck. Once the trial implant is seated, local anatomic landmarks that have been correlated to correct radial length should be examined[2-4]. Doornberg et al.[2] conducted a computed tomography study examining the relationship between the radial head and the lateral edge of the coronoid or the most proximal extent of the lesser sigmoid notch in seventeen patients. They found that, on the average, the radial head was 0.9 mm more proximal than the lateral edge of the coronoid.

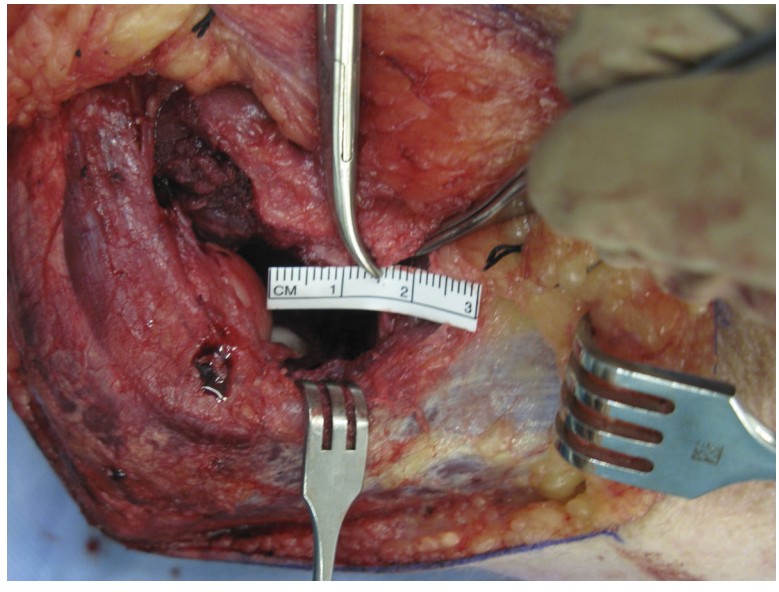

FIG. 2–A

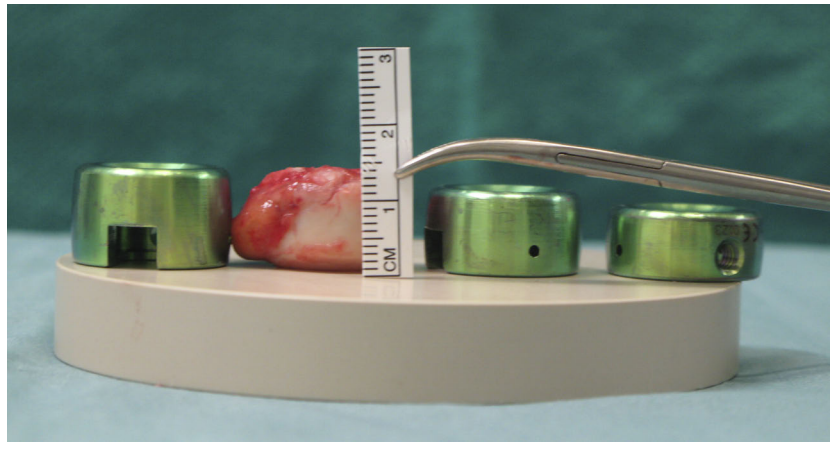

FIG. 2-B

Figs. 2-A and 2-B The technique of van Riet et al.[3] is used to check the selected trial implant to ensure that it is of the correct thickness. The distance from the fractured surface of the radial neck to the proximal edge of the lesser sigmoid notch is measured (Fig. 2-A). This distance reliably equates to the correct thickness of the radial head implant that should be used (Fig. 2-B).

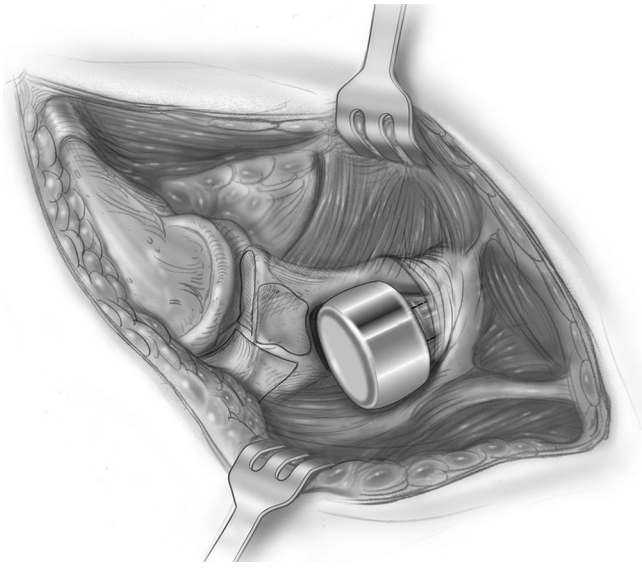

FIG. 3-A

Figs. 3-A, 3-B, and 3-C With the trial implant inserted, the proximal articular surface of the implant should be even with the proximal edge of the lesser sigmoid notch (Fig. 3-A). If the implant is overly proud (Fig. 3-B), overlengthening may occur. Conversely, if the implant is recessed (Fig. 3-C), it may be too short, resulting in underlengthening. (Blue facet = lesser sigmoid notch.)

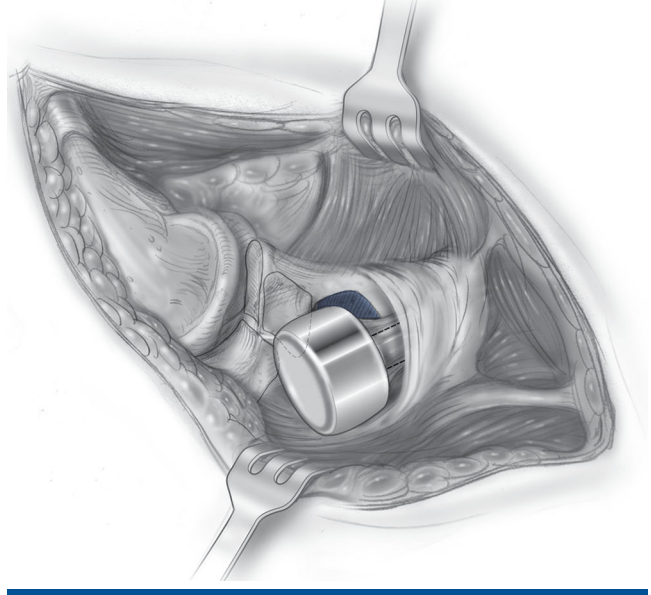

FIG. 3-B

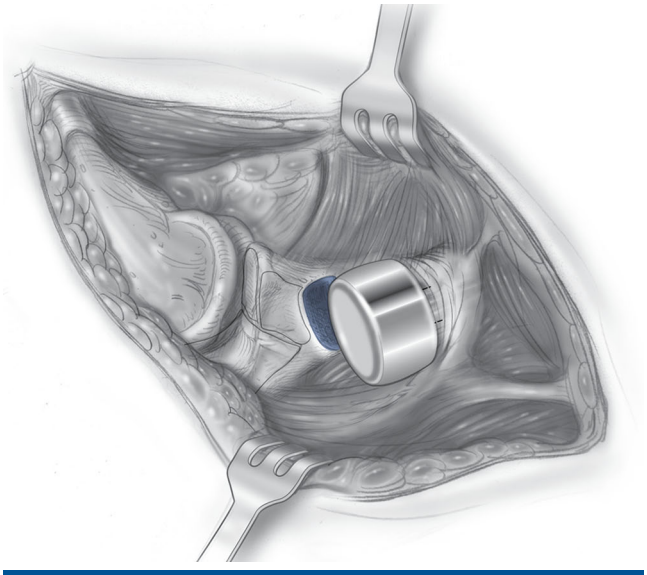

FIG. 3-C

Unfortunately, this measurement displayed a high degree of variability from patient to patient, with the values ranging from –2.7 mm to +0.4 mm. Along with this high degree of variability, the computed tomography method did not account for cartilage thickness, which may be significant. Doornberg et al. recommended that the implant height should be equal to or less than 1 mm proud when compared with the lesser sigmoid notch. Van Riet et al.[3] also examined the relationship of the radial head to the lateral edge of the coronoid (which they termed *the proximal edge of the lesser sigmoid notch*); however, they did so in eight cadaver specimens, thereby accounting for cartilage thickness. The authors measured the distance from the stump of the radial neck to the most proximal edge of the lesser sigmoid notch (Fig. 2-A) and found that it was essentially the same as the thickness of the radial head (Fig. 2-B). The mean difference in measures was –0.02 mm (range, –1.24 to +0.97 mm). They concluded that this measure could be used to reliably determine the correct thickness of the radial head.

Once the trial implant is inserted, the van Riet technique is used to confirm that the thickness of the selected implant is appropriate (Fig. 3-A). If the implant is overly proud when compared with the proximal edge of the lesser sigmoid notch, we become concerned about overlengthening (Fig. 3-B). Conversely, if the implant is recessed when compared with the proximal edge of the lesser sigmoid notch, we become concerned that the implant may be of insufficient length (Fig. 3-C).

Frank et al.[4] examined several intraoperative parameters to determine which correlated with correct implant length. The most sensitive intraoperative measurement was a direct visual assessment of the lateral ulnohumeral joint space. With the trial implant inserted and the elbow held reduced, the lateral ulnohumeral joint should be inspected visually. If a trial implant is as little as 2 mm too thick, resulting in overlengthening, there is visible gapping of the lateral ulnohumeral joint as the implant hinges the joint open (Fig. 4).

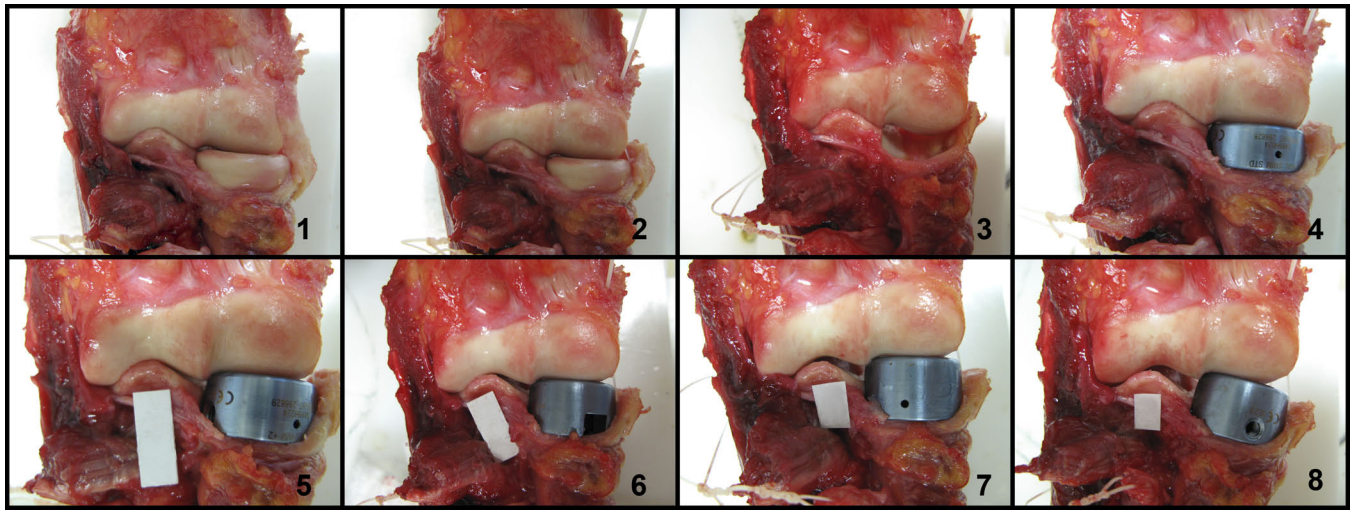

FIG. 4

The lateral ulnohumeral joint surfaces appose each other without a visual gap in the normal anatomic state and when the correct implant length is used (Panels 1-4). With as little as 2 mm of overlengthening (Panel 5), there is visible gapping of the lateral ulnohumeral joint as the implant hinges the joint open. Panel 1 shows an intact specimen; Panel 2, a lateral collateral ligament repair; Panel 3, a radial head resection; Panel 4, a radial head implant of the correct length; Panel 5, a radial head implant causing +2 mm of overlengthening; Panel 6, a radial head implant causing +4 mm of overlengthening; Panel 7, a radial head implant causing +6 mm of overlengthening; and Panel 8, a radial head implant causing +8 mm of overlengthening.

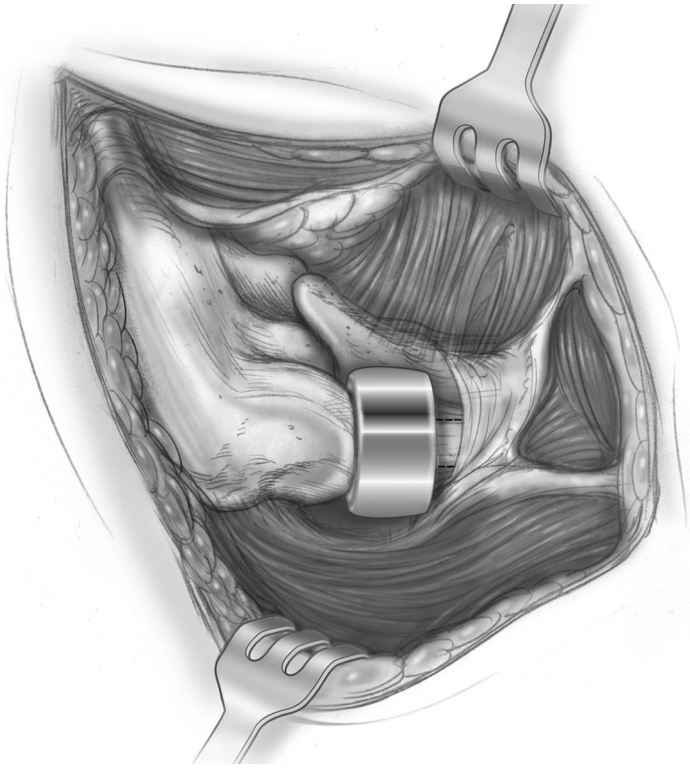

FIG. 5-A

Figs. 5-A and 5-B Visualization of the anterolateral aspect of the elbow joint can be achieved by releasing some of the extensor origin from the lateral supracondylar ridge to allow a line of sight to the lateral ulnohumeral joint. **Fig. 5-A** There is apposition of the surfaces of the lateral ulnohumeral joint, indicating that the implant is of the correct length. **Fig. 5-B** There is a visible gap in the joint (double-headed arrow), which is indicative of overlengthening caused by an implant that is too thick.

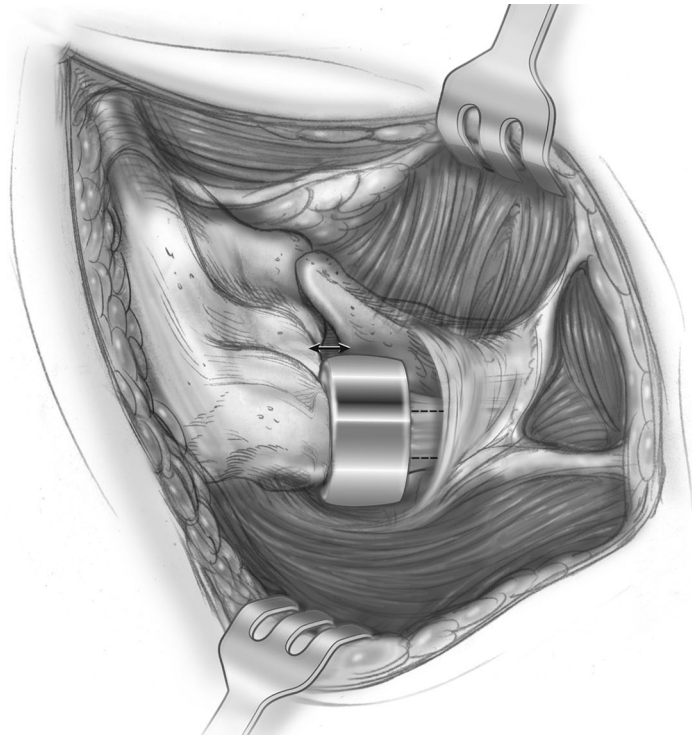

FIG. 5-B

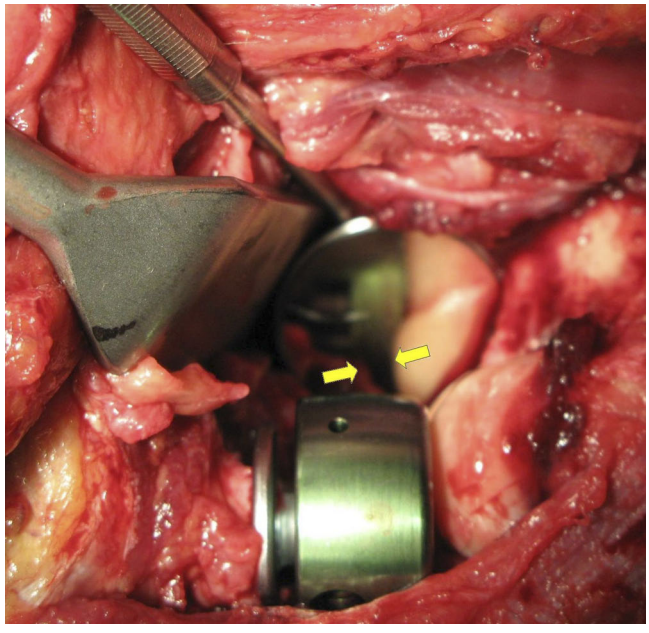

FIG. 6

Intraoperative photograph demonstrating how an angled dental mirror can be used to visualize the lateral ulnohumeral joint. If a gap is present with the elbow held reduced, the implant is too thick. This figure demonstrates overlengthening, as a gap is visible (between the arrows) at the lateral ulnohumeral joint.

If the trial implant is of correct length, the lateral ulnohumeral joint surfaces contact each other without a visible gap.

The lateral aspect of the ulnohumeral joint can be viewed from anterior or posterior. Visualization of the anterior aspect of the joint can be done in one of two ways: (1) through a release of some of the extensor origin from the lateral supracondylar ridge, which will create a line of sight to the lateral ulnohumeral joint (Figs. 5-A and 5-B), or (2) with use of an angled dental mirror, which can be inserted through the lateral arthrotomy to peer over the radial head and visualize the lateral ulnohumeral joint (Fig. 6). Apposition of the lateral ulnohumeral joint can also be assessed from posterior through the Boyd interval. Once visualization of the lateral aspect of the ulnohumeral joint has been obtained, it is assessed for a gap. On the basis of the results of our cadaver investigation, we have determined that the presence of any visible gapping of the lateral ulnohumeral joint is a true predictor of overlengthening. If a visible gap is present, a thinner trial implant should be tested; if a thinner trial implant does not exist, more bone should be removed incrementally from the radial neck until the lateral ulnohumeral joint surfaces appose each other.

Once the aforementioned checks are completed and the surgeon believes that the correct length of trial implant has been inserted, one final assessment is done with the aid of fluoroscopy. With the elbow held reduced, anteroposterior fluoroscopic images are obtained and assessed for the orientation of the medial ulnohumeral joint line[4,5]. With an implant of correct length, the medial ulnohumeral joint line should be congruent and parallel. Fluoroscopic evidence of medial joint gapping is highly suggestive of implant overlengthening. We have found that, during radial head arthroplasty, a systematic approach as described here should be undertaken to ensure proper sizing to replicate native radial head anatomy to optimize patient outcomes and lower the rate of complications.

CRITICAL CONCEPTS

INDICATIONS:

The techniques described in this article to determine a correct length radial head implant should be utilized in all cases of radial head arthroplasty.

continued

CRITICAL CONCEPTS (CONTINUED)

CONTRAINDICATIONS:

The parameters described were based on cadaver specimens without preexisting disease; therefore, they may not apply in patients with preexisting elbow disorders such as malunions or developmental deformities.

PITFALLS:

- In unreconstructible radial head fractures associated with medial and lateral collateral ligament injuries, the insertion of an overly long implant will cause the surgeon to have a subjective sensation of enhanced elbow stability prior to ligament repair; however, the surgeon must resist the urge to insert an overly long implant as a means of improving subjective stability. Once an implant of the correct diameter and length is inserted, elbow stability should be achieved through appropriate repairs to the collateral ligaments.
- The surgeon should use caution to ensure that the elbow is congruously reduced while evaluating radial head length because the presence of varus or valgus angulation as a result of lateral or medial collateral ligament injuries, respectively, will make the aforementioned techniques for confirming radial head length unreliable. Furthermore, concomitant disruption of the interosseous membrane may result in proximal migration of the radius and influence the determination of the optimal radial head implant size.
- Radiographic measurement of ulnar variance of the wrist should be performed routinely in all patients undergoing radial head arthroplasty.

AUTHOR UPDATE:

We have not made any changes to the technique.

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The line drawings in this article are the work of Jennifer Fairman (jfairman@fairmanstudios.com).

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