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Radial Head Arthroplasty with a Modular Metal Spacer to Treat Acute Traumatic Elbow Instability

Surgical Technique

By David Ring, MD, PhD, and Graham King, MD, MSc, FRCSC

Investigation performed at the Orthopaedic Hand and Upper Extremity Service, Massachusetts General Hospital, Boston, Massachusetts, and St. Joseph’s Health Centre, London, Ontario, Canada

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ABSTRACT FROM THE ORIGINAL ARTICLE

BACKGROUND: The use of a metal radial head prosthesis to help stabilize an elbow with traumatic instability is appealing because internal fixation of multifragment, displaced fractures of the radial head is susceptible to either early or late failure. The newer modular prostheses are easier to size and implant, but their effectiveness has not been investigated, to our knowledge.

METHODS: Twenty-seven patients in whom a radial head replacement with a modular metal spacer prosthesis had been performed to treat traumatic elbow instability were evaluated with use of the Mayo Elbow Performance Index (MEPI), the American Shoulder and Elbow Surgeons Elbow Evaluation Instrument (ASES), and the Disabilities of the Arm, Shoulder and Hand questionnaire (DASH). Radiographs were evaluated for osteoarthrosis, periprosthetic radiolucency, and heterotopic ossification.

RESULTS: Seven patients underwent one or more subsequent operations to treat residual instability, heterotopic ossification and elbow contracture, ulnar neuropathy, or a misplaced screw. In two of these patients, the prosthesis was removed as part of an elbow contracture release or to treat infection. At an average of forty months postoperatively, elbow motion in the entire group of twenty-seven patients averaged 131° of flexion with a 20° flexion contracture, 73° of pronation, and 57° of supination. Stability was restored to all twenty-seven elbows, and twenty-two patients had a good or excellent result according to the MEPI. Seventeen patients had radiographic evidence of lucency around the neck of the prosthesis that was not associated with increased pain, thirteen patients had clinically inconsequential heterotopic ossification anterior to the radial neck, and nine patients had radiographic changes in the capitellum.

CONCLUSIONS: An intentionally loosely placed modular metal radial head prosthesis can help to restore stability in conjunction with repair of other fractures and reattachment of the lateral collateral ligament to the epicondyle in the setting of traumatic elbow instability with a comminuted fracture of the radial head. While a prosthesis that is too large can cause problems, lucencies around the stem of the intentionally loose prosthesis and most changes in the capitellum do not appear to cause problems, at least in the short term.

LEVEL OF EVIDENCE: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

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INTRODUCTION
A metal radial head prosthesis can help to restore stability to the elbow and forearm after a complex fracture-dislocation. Several short and long-term studies have confirmed the safety and effectiveness of metal radial head prostheses. A slightly undersized unipolar (monoblock) prosthesis with a straight smooth stem acts as an internal splint and can accommodate for our inability to precisely reconstruct the variable and complex anatomy of the proximal end of the radius. Two original research studies with data regarding this particular technique of radial head arthroplasty were published in The Journal within the last two years. The present article is a collaboration of the senior authors of those two studies and is intended to capture some of the variations as well as the similarities in our operative techniques. This report describes surgical techniques for implanting a modular metal radial head prosthesis with a straight smooth stem.

SURGICAL TECHNIQUE
When the olecranon is fractured (typically a posterior olecranon fracture-dislocation or a posterior Monteggia variant), it is usually preferable to place the patient in the lateral decubitus position with the arm supported on a pillow bolster or some other type of support. For elbow and forearm dislocations, it is usually preferable to place the patient supine with the arm supported across the chest or on a hand table. In both situations, a sterile tourniquet is used to facilitate exposure.

A lateral skin incision can be used if the surgeon does not anticipate fixation of the olecranon or coronoid or repair of the medial collateral ligament; otherwise a dorsal incision with a lateral skin flap may be preferable (Fig. 1). In patients with...
Most radial head fractures that are treated with prosthetic replacement occur in the setting of an elbow dislocation, in which case the origins of the lateral collateral ligament and extensor digitorum communis are typically avulsed from the lateral epicondyle. When necessary to increase exposure, in particular for access to the coronoid, the origins of the extensor carpi radialis brevis and longus can be incised and elevated off the supracondylar ridge of the distal part of the humerus as seen in this illustration. The scalpel is detaching the origin of the extensor carpi radialis longus. (Reprinted with permission of David Ring.)

Any remaining radial head is resected just distal to the flare of the head-neck junction with use of an osteotome or saw. (Reprinted with permission of David Ring.)
a posterior olecranon fracture-dislocation, reproduction of the apex posterior deformity of the ulna and slight extension of the interval of associated muscle injury with or without proximal mobilization of the olecranon (as one will do when performing an osteotomy for fixation of a fracture of the distal part of the humerus) usually result in sufficient exposure of the proximal end of the radius for insertion of the prosthesis.

In most patients with an elbow dislocation, there is at least a small rent in the fascia overlying the common extensor musculature, which belies a more extensive avulsion of the underlying origin of the lateral collateral ligament and common wrist and digital extensors. In these cases, it is easiest simply to develop and extend the traumatic rent or interval. If the extensor musculature is intact, the fascia over the supracondylar ridge is incised and the origins of the extensor carpi radialis longus and brevis are elevated off the anterior aspect of the humerus (Fig. 2). The capsule is entered, and dissection proceeds distally until the interval between the anterior and posterior halves of the capitellum is encountered (preferred by D.R.). Alternatively, a standard Kocher interval between the anconeus and extensor carpi ulnaris can be developed (preferred by G.K.).

In all patients who have dislocated the elbow and in at least half of the patients with a posterior olecranon fracture-dislocation, the avulsion of the origin of the lateral collateral ligament from the lateral epicondyle greatly facilitates exposure of the proximal end of the radius and insertion of the prosthesis (Fig. 2). Consequently, in the vast majority of patients who require prosthetic replacement of the radial head for a comminuted unreconstructible fracture, the exposure
is facilitated by the injury and little additional surgical exposure is required. Likewise, exposure of the proximal end of the radius and insertion of the prosthesis are more difficult in patients with a complex fracture of the radial head and injury to the medial, but not to the lateral, collateral ligament; in patients with an Essex-Lopresti injury or variant; and in patients in whom the prosthesis is considered as part of a reconstructive procedure. In these situations, detachment of the lateral collateral ligament and the overlying common extensor muscles facilitates access to the proximal end of the radius, but detachment is only infrequently utilized.

Any portion of the radial head that remains attached to the radial neck is removed with an osteotome or microsagittal saw.
at the head–neck junction (Fig. 3). The radial head fragments are retrieved and assembled; the larger ones are used to assist in selecting prosthesis size (Figs. 4-A through 4-E). The thickness (longitudinal height) of the prosthetic head is selected on the basis of the height of the radial head fracture fragments with use of trial prostheses for comparison (Figs. 4-D and 4-E). In general, it is preferable for both the diameter and the thickness of the prosthesis to be slightly undersized. If the neck is not planed flat, it is important to measure from the thinnest portion of the head (the area where the prosthesis will rest on the neck of the radius) in order avoid placing a prosthesis that is too thick. Likewise, the diameter chosen for the prosthetic head should be slightly smaller than the diameter of the native radial head as judged by the fracture fragments.

Newer modular prostheses are available in 2-mm increments of both thickness and diameter, making it relatively easy to choose an appropriately sized prosthesis. An attempt should be made to retrieve all of the fragments of the radial head so that one of them does not end up in the elbow joint, but in practice this is not always possible, even with the assistance of an image intensifier.

One of us (D.R.) makes no attempt to plane down slight irregularities in the neck of the radius, provided that there are no residual radial neck defects large enough to allow escape or dislocation of the prosthesis. The other one (G.K.) uses a neck planer to ensure that at least two-thirds of the diameter of the radial neck is smooth and will contact the implant (Fig. 5). The radial neck is reamed to remove cancellous bone, but little or no cortical bone is reamed from the...
radial neck. The stem size selected is one size smaller than the size of the final reamer—the one that began to ream cortical bone (Fig. 6). In this manner, the fit between the neck and the prosthesis is intentionally slightly loose. The rationale is that toggle of the stem of the prosthesis within the radius is well tolerated, and it allows for the articular surface of the radial head to articulate congruently with the capitellum as guided by the annular ligament rather than by the position of the radial neck. This is a means of compensating for the shortcomings of an axisymmetric prosthesis substituting for the anatomy of the native proximal end of the radius. Studies have demonstrated that the anatomy of the native radial head is variable and complex, with an elliptical head and an offset neck, which is difficult to replicate with an off-the-shelf prosthesis. In patients with an intact lateral collateral ligament,

**FIG. 6**
The medullary canal of the radial neck is reamed just until cortical bone is scratched, and a stem one size smaller than the reamer that removes a small amount of cortical bone is selected. (Reprinted with permission of David Ring.)

**FIG. 7**
Prosthesis insertion can be facilitated by placing a retractor posterior to the radial neck and levering the neck anteriorly and laterally with respect to the ulna and the distal aspect of the humerus. One should never put a retractor over the anterior part of the radial neck as this risks injury to the posterior interosseous nerve. (Reprinted with permission of David Ring.)
Figs. 8-A through 8-H An Essex-Lopresti lesion in a twenty-six-year-old man who fell from a height, sustaining a radial head fracture with an interosseous ligament injury (Essex-Lopresti) and a trans-scaphoid perilunate fracture-dislocation. (Reprinted with permission of David Ring.) Fig. 8-A A radiograph shows both injuries. Fig. 8-B A lateral radiograph of the wrist in a plaster splint shows the dislocation of the lunate. Fig. 8-C The excised radial head was too fragmented to repair.
making prosthetic insertion difficult, it may be advisable to downsize two full stem sizes to facilitate insertion of the prosthesis or use an in situ assembly tool which allows for the independent and sequential insertion of the modular stem and then the head with coupling of the implant and locking of the Morse taper in the elbow. An effective way to facilitate prosthesis insertion in the setting of an intact lateral collateral ligament is to place a retractor under the radial neck (posteriorly, between the radius and the ulna) and lever the proximal part of the radius anteriorly and laterally away from the capitellum (Fig. 7). A retractor should never be placed over the anterior aspect of the proximal end of the radius as this risks injury to the posterior interosseous nerve.

The lateral edge of the radial head prosthesis should be no more than 1 mm proud of the lateral edge of the lesser sigmoid notch of the ulna. Alternatively, the center of the proximal face of the prosthesis should be even with this landmark, although that can be more difficult to judge. If the prosthesis is too thick proximal to distal, the radial neck can be shortened with a saw or a thinner prosthesis can be selected. The position of the prosthesis with respect to the ulna can also be evaluated with use of image intensification, as can the ulnohumeral joint whose articular surfaces should be parallel on the medial side. In general, as previously stated, determining the correct thickness of the prosthesis is best done with use of the excised fragments as a template because imaging is relatively insensitive to quantify the optimal prosthesis size. It is important to note that, in the common setting of a coexistent lateral collateral ligament injury, overstuffing of the radial head space with a prosthesis that is too large is a common error and should be carefully avoided.
**Fig. 8-F** A radiograph of the forearm after prosthetic replacement of the radial head, repair of the scaphoid fracture, and stabilization of the carpal ligaments with screws. **Fig. 8-G** An anteroposterior radiograph of the elbow shows the loose, smooth-stemmed prosthesis. **Fig. 8-H** A lateral radiograph of the elbow.
CRITICAL CONCEPTS

INDICATIONS:
Replacement of the radial head with a metal prosthesis is indicated when the radial head is fractured into more than three articular pieces or when the fracture fragments are either too small or of inadequate quality to repair (impaction-deformation, insufficient subchondral bone, or osteoporosis) in the setting of either an elbow or forearm (Essex-Lopresti) dislocation, injury to the medial collateral ligament, and in most posterior olecranon fracture-dislocations (Figs. 8-A through 8-H). The indications for use of a radial head prosthesis when the forearm and elbow are stable (in either the acute or reconstructive setting) remain incompletely defined. The concept that a prosthesis provides load-sharing and more normal stability to the elbow, and may thereby limit and delay elbow arthrosis, must be balanced with the potential for long-term problems related to the prosthesis itself.

CONTRAINDICATIONS:
A prosthesis should not be inserted in the setting of an active infection or an excessively contaminated open wound. It may not be possible to use a prosthesis when the fracture extends distally to the level of the bicipital tuberosity, although fixation of the radial neck with use of cerclage wires or small plates with unicortical screws allows a standard prosthesis to be inserted.

PITFALLS:
The primary pitfall in the use of a metal radial head prosthesis is insertion of a prosthesis that is too large in diameter or thickness (vertical height). A prosthesis that is too large in diameter can lead to trochlear wear. A prosthesis that is too thick can lead to wear of the capitellum and subluxation of the ulnohumeral joint.

AUTHOR UPDATE:
Neither author has made any changes to the technique. To date, no prostheses have been removed for symptoms or infection.