

RESURFACING SHOULDER ARTHROPLASTY

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INTRODUCTION

It is generally accepted that anatomic reconstruction is preferred when performing conventional shoulder arthroplasty. Anatomic replacement of the articular surface using a stemmed humeral component requires an implant system that addresses variations in neck-shaft angle, humeral head height, radius of curvature, and humeral head offset. The currently available implant systems often fail to provide enough variability to allow anatomic reconstruction in all cases.

Over the last few decades, heightened interest has emerged in bone-preserving options for the management of arthritic conditions of the shoulder. Resurfacing arthroplasty of the shoulder has evolved as an alternative to conventional shoulder arthroplasty. Resurfacing differs from conventional shoulder arthroplasty primarily because of the absence of an intramedullary stem on the humeral component. This eliminates the need for the implant system to account for variations in neck-shaft angle and humeral head offset from the shaft. Preserving humeral head bone stock can compromise exposure of the glenoid, however, making implantation difficult, and has led some authors to advocate humeral

resurfacing without glenoid replacement or biologic resurfacing of the glenoid.¹

HISTORY OF SHOULDER RESURFACING

The initial experience with resurfacing arthroplasty of the humeral head used implants that either were poorly fixed to the humerus or were adapted hip resurfacing implants that did not replicate the anatomy of the proximal humerus.² The earliest implants designed specifically for humeral resurfacing had a radius of curvature that more closely approximated that of the native humerus. These implants possessed no stem and were fixed to the proximal humerus with polymethyl methacrylate.

Resurfacing implant systems have evolved over time. Currently available designs have a central humeral peg, and most achieve a press-fit with surface preparation of the peg and the undersurface of the implant. Various implant systems are available that offer different design features and surface preparations, but they all provide implants with different diameters and humeral head heights, allowing the implant to be adapted to the native geometry.

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Partial resurfacing of the humeral articular surface has been introduced as a new design philosophy. With partial resurfacing, only the diseased portion of the articular cartilage is resurfaced, leaving healthy cartilage adjacent to the implant at the margin. The implant is sized by referencing the normal articular surface adjacent to the diseased area.

DESIGN RATIONALE

The goal of humeral resurfacing arthroplasty is to position the metallic humeral component anatomically on the proximal humerus. The challenge with conventional arthroplasty implant design is to provide enough versatility in the implant system to achieve the goals of anatomic reconstruction. To achieve acceptable anatomic replacement of the articular surface with conventional arthroplasty using a stemmed implant, the humeral implant must accommodate at least 2 inclination (neck-shaft) angles, 3 head heights with 4 radii of curvature (12 head sizes), and 2 offset positions.³ Humeral resurfacing retains most of the humeral head and references surface landmarks about the articular surface to appropriately size and position the implant. Because osteotomy of the anatomic neck of the humerus is not performed and an intramedullary stem is not used, inclination angle and humeral offset do not need to be considered. The only anatomic parameters needed to anatomically resurface the humerus are the radius of curvature and the humeral head height.

More recently, partial resurfacing of the humeral head has been used to address focal chondral irregularities.⁴ These implants need to address only the radius of curvature of the articular surface because the joint surface is referenced during implantation and the other anatomic parameters are not germane.

INDICATIONS AND CONTRAINDICATIONS

The indications for humeral resurfacing are identical to those for conventional shoulder arthroplasty. Humeral resurfacing, however, provides a distinct advantage over stemmed humeral components in the setting of periarticular deformity or deformity between the articular segment and the humeral canal. In addition, if an intramedullary stem is contraindicated because of previous hardware or a history of osteomyelitis, humeral resurfacing is the preferred treatment.

The primary indication for partial resurfacing of the

humerus is progressive pain refractory to nonsurgical measures in the setting of a focal chondral lesion. The cartilage defect can be quite large, as the design of resurfacing implants can accommodate defects of various sizes. Additionally, these implants have been used to extend the arc of the articular surface in patients with humeral bone loss following instability (Hill-Sachs and reverse Hill-Sachs lesions).^{5,6}

Adequate humeral bone stock is required to support the implant for both partial and complete resurfacing of the humeral head. Levy and Copeland⁷ found that 60% of the native humeral head is required and 40% of the entire head may be grafted when considering a resurfacing arthroplasty.

SURGICAL TECHNIQUE

Preoperative Planning

A standard series of orthogonal radiographs is mandatory for preoperative planning. Radiographic views should include AP views of the shoulder in internal and external rotation, a lateral scapular view, and an axillary view. CT can provide valuable information on the degree of glenoid wear and subluxation of the joint, which can be difficult to assess on standard shoulder radiographs. MRI may provide information about the quality of the rotator cuff and glenoid bone stock. CT provides better bone detail, however, and is the preferred modality for assessing glenoid bone stock.

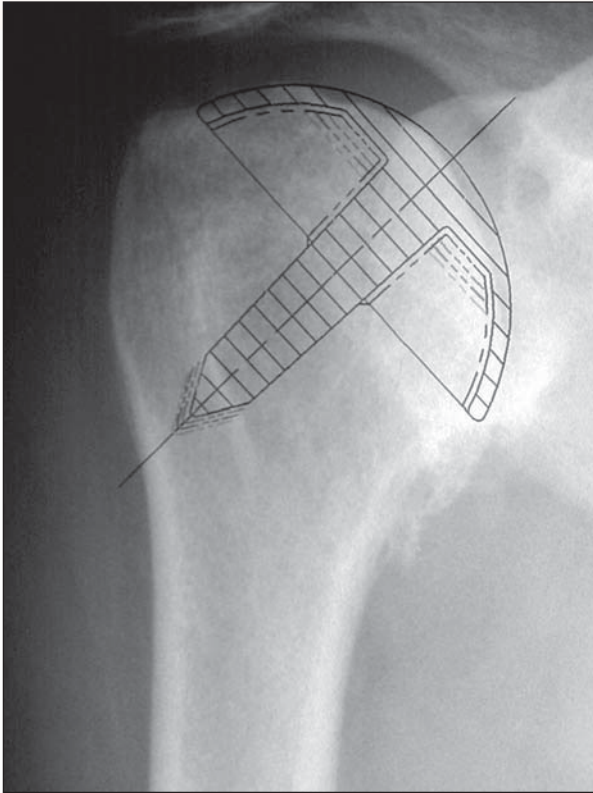
Preoperative templating on the radiographs provides an initial prediction of the size of the implant required at the time of surgery. The AP view of the shoulder in external rotation provides the best profile of the proximal humerus for templating (Figure 1).

Many patients undergoing partial resurfacing of the humeral head have already undergone an arthroscopic evaluation of the shoulder, during which the diagnosis of a focal chondral lesion was made. The size of the chondral lesion is determined arthroscopically and used to plan the size of the implant.

Patient Positioning

The patient is placed in the beach-chair position. The arm is draped free and is placed in a sterile arm positioner that allows the arm to be held in any position (Figure 2). A regional anesthetic can be used with or without general anesthesia.

FIGURE 1



External rotation AP view of a shoulder demonstrates preoperative templating for a resurfacing humeral head arthroplasty.

Surgical Approaches

Either a deltopectoral approach or an anterosuperior approach^{8,9} can be used for resurfacing arthroplasty. The deltopectoral approach is used more commonly for resurfacing arthroplasty and is more familiar to most surgeons. The anterosuperior approach has the advantage of allowing better exposure for glenoid replacement. One disadvantage of this approach is that it is more difficult to address contractures and inferior osteophytes because access to the inferior humeral head and capsule is limited, compared with the deltopectoral approach.

Anterosuperior Approach

The anterosuperior approach uses the interval between the anterior and middle deltoid muscles. The anterior

FIGURE 2



Photograph shows the beach-chair position for shoulder arthroplasty.

deltoid is elevated subperiosteally from the clavicle and the anterior acromion. The coracoacromial ligament is maintained in continuity with the deltoid fascia and included in the deltoid repair to reestablish the coracoacromial arch.

If the rotator cuff is intact, the anterior leading edge of the supraspinatus is identified, and the rotator interval is opened from the lesser tuberosity to the base of the coracoid. The coracohumeral ligament is released at the base of the coracoid during the process of developing the rotator interval. The biceps tendon sheath is opened, and the biceps is released from the superior glenoid. The long head of the biceps is tenodesed to the pectoralis major tendon. Either a subscapularis tenotomy 1 cm lateral to the musculotendinous junction or a subperiosteal release of the tendon from the lesser tuberosity is performed. The capsule is released from the surgical neck of the humerus using progressive external rotation. The humeral head is delivered into the surgical field with extension, external rotation, and adduction of the arm.

Deltopectoral Approach

Most surgeons are more familiar with the deltopectoral approach for arthroplasty. An oblique incision is made from the clavicle, just medial to the coracoid, along the deltopectoral groove toward the deltoid insertion (Figure 3, A). The cephalic vein defines the deltopectoral interval and is retracted medially with the pectoralis major or laterally with the deltoid. The deltopectoral interval is developed from the clavicle to the deltoid insertion. The upper border of the pectoralis major is released to assist with exposure (Figure 3, B). The subdeltoid and subacromial spaces are developed to allow deep retractors to be placed.

The lateral border of the conjoined tendon is developed from the coracoid distally. The axillary and musculocutaneous nerves are identified by digital palpation. The biceps tendon sheath is opened and extended proximally to the rotator interval. The long head of the biceps is released from the superior attachment to the glenoid and tenodesed to the pectoralis major tendon. Either a subscapularis tenotomy 1 cm lateral to the musculotendinous junction (Figure 3, C), or a subperiosteal release of the tendon from the lesser tuberosity is performed. The capsule is released from the surgical neck of the humerus using progressive external rotation. The humeral head, is delivered into the surgical field with extension and adduction of the arm.

Implantation

Humeral Head Resurfacing

The goals of humeral head resurfacing are to reestablish anatomic version, inclination, and offset. The key references to reestablishing normal anatomy are the native anatomic neck and the rotator cuff attachments. To reestablish the native anatomy, peripheral osteophytes are circumferentially removed around the humeral head, allowing identification of the anatomic neck and neck-shaft relationship (Figure 4, A).

The diameter and thickness of the native humeral head are determined with the guides provided and compared with the templated size determined preoperatively (Figure 4, B). Two measurements are critical when sizing a resurfacing implant: diameter and thickness. Thickness is critical because selecting an implant that is too thick can compromise the rotator cuff attachments during humeral preparation, or overstuff the joint, lead-

ing to stiffness or subscapularis failure.

Once the humeral component size is selected, a humeral guide pin matching the selected component size is placed using a humeral sizing guide. Humeral version and inclination are reestablished when the inferior margin of the guide is placed parallel to the anatomic neck, with an equal gap around the entire margin of the guide. The guide pin is placed so that the lateral cortex of the humerus is engaged. This avoids migration of the pin within the cancellous bone of the proximal humerus during bone preparation (Figure 4, C).

A reamer is used to shape the articular surface of the proximal humerus. The humeral head is reamed until bone debris is seen coming from the superiormost holes of the reamer. The posterior and superior attachments of the rotator cuff must be checked to ensure they are not being compromised by overaggressive reaming of the head. The stem hole is then prepared with a punch or a drill and punch.

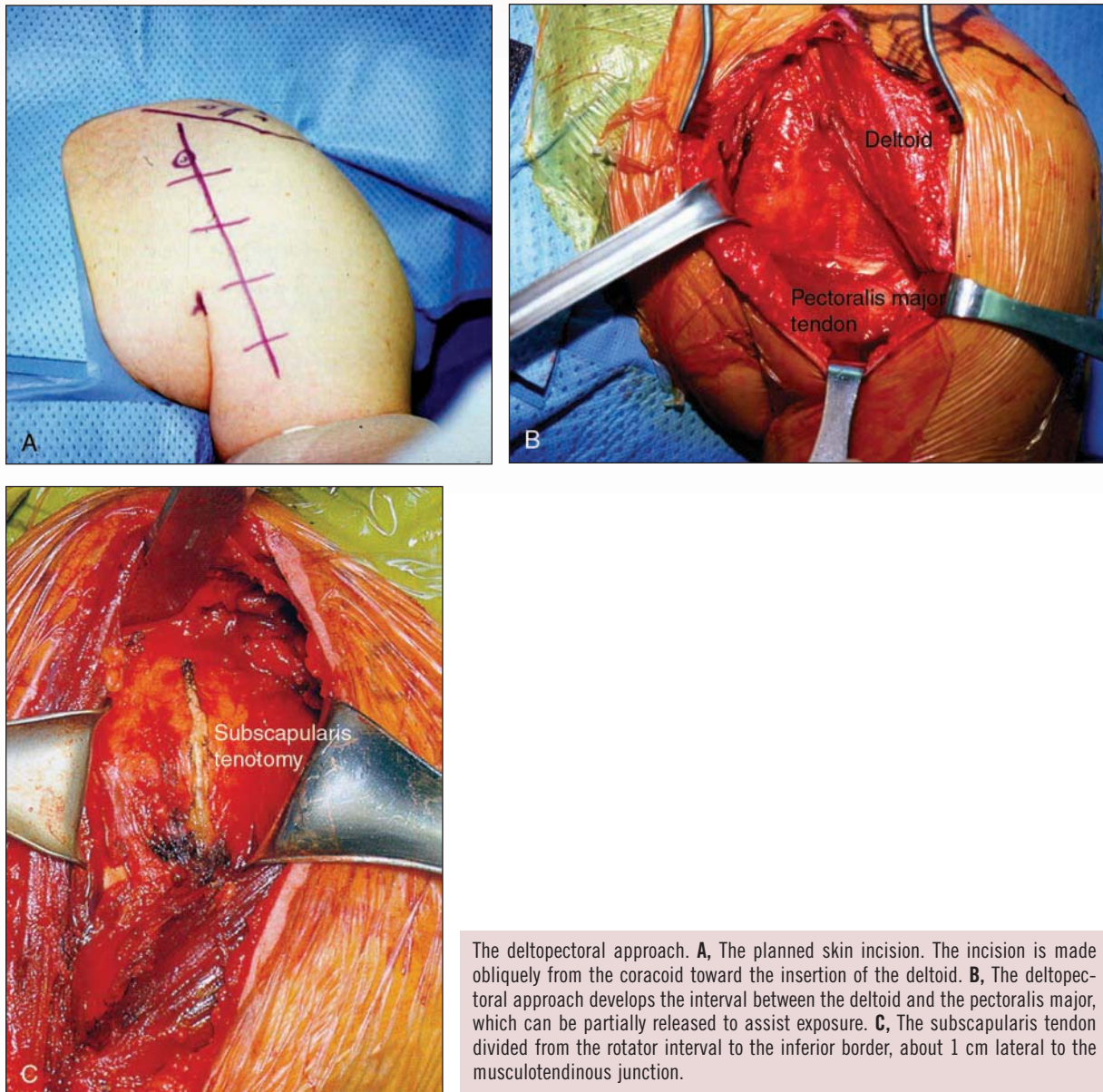
A trial reduction is performed to assess whether the implant will seat fully on the prepared humeral head. Uniform contact of the trial head must occur to provide proper support to the implant. If the glenoid is not being resurfaced, the final implant is impacted. Assessing the position of the implant relative to the rotator cuff attachment sites confirms proper seating of the final implant (Figure 4, D).

Partial Surface Replacement

The initial step in a partial resurfacing procedure is to place a guide pin perpendicular to the articular surface in the center of the area to be replaced. A drill guide is placed on the articular surface, making sure that all sides of the drill guide are flush with the articular surface. The entire lesion must be contained within the outline of the drill guide. A guide pin is then inserted through the drill guide. This step is critical because the remaining steps leading to final component implantation are based on accurate guide pin placement.

A cannulated drill is placed over the guide pin and drilled until the flange of the drill is flush with the articular surface. The drill hole is tapped and a tapered implant post is inserted using the driver and is seated to the appropriate height. A contact probe is inserted to obtain the superior-inferior and medial-lateral reference points needed to size the articular component.

FIGURE 3

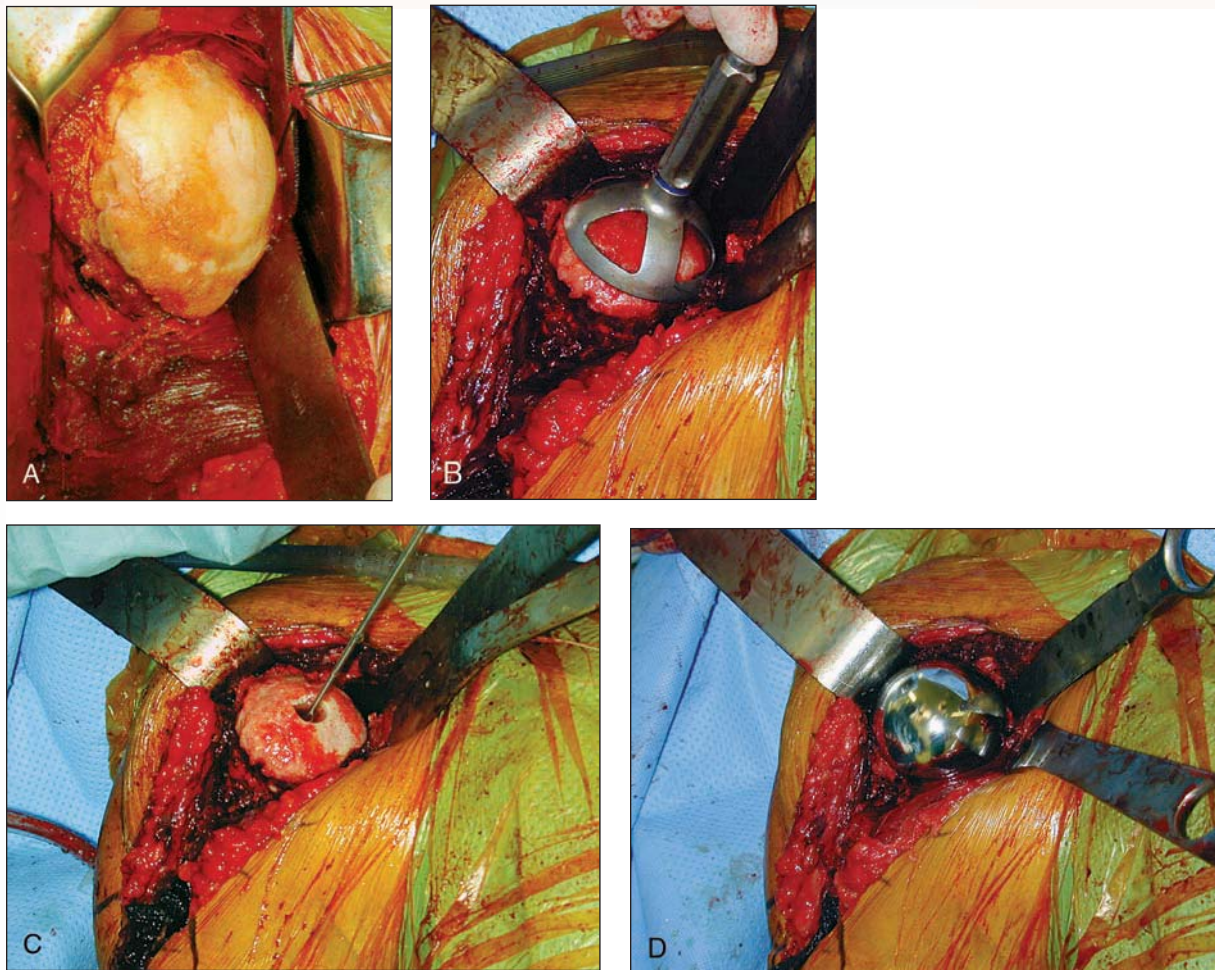


The deltopectoral approach. **A**, The planned skin incision. The incision is made obliquely from the coracoid toward the insertion of the deltoid. **B**, The deltopectoral approach develops the interval between the deltoid and the pectoralis major, which can be partially released to assist exposure. **C**, The subscapularis tendon divided from the rotator interval to the inferior border, about 1 cm lateral to the musculotendinous junction.

The articular surface and subchondral bone are prepared initially using a circular cutter to score the articular surface to the subchondral bone. The appropriate surface reamer for the selected articular component is passed over the guide pin and the surface is reamed. The trial cap is inserted to check the peak height of the

joint surface, which is the peak height of the implant (Figure 5). Once prepared, the defect and taper post are cleared of any debris. The final component is inserted in the appropriate alignment based on the superior-inferior and medial-lateral sizing used to select the final component.

FIGURE 4



Intraoperative photographs demonstrate humeral head resurfacing. **A**, Peripheral osteophytes are identified and removed to determine the normal anatomy of the joint. **B**, Humeral head guides assist with sizing of the implant and placement of the guide pin. **C**, The guide pin is placed to engage the lateral cortex of the humerus. **D**, The final resurfacing implant is in place. The margin of the implant abuts but does not encroach on the attachment of the rotator cuff.

Wound Closure and Postoperative Rehabilitation

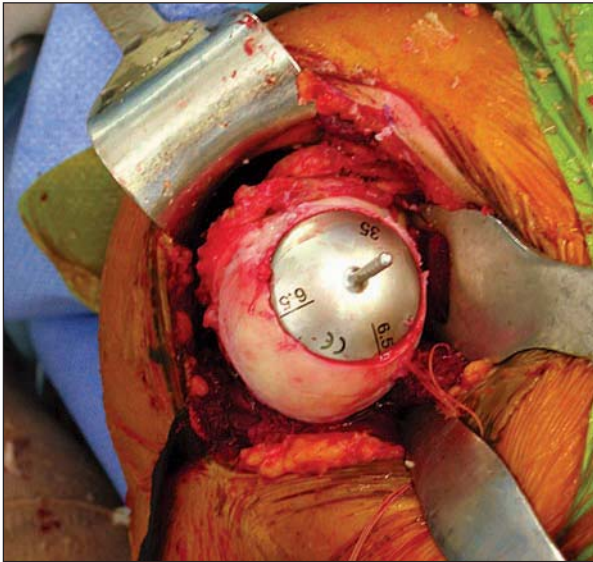
The subscapularis is meticulously repaired and wound closure is performed in standard fashion. Protected passive range of motion is started immediately postoperatively. The patient is permitted passive range of motion within a safe, limited range determined intraoperatively. Typically, passive elevation to 120° and external rotation to 30° is permitted. These safe arcs of motion are allowed

for the first 6 weeks, until the subscapularis tendon repair has healed. Active assisted range of motion and progressive strengthening are begun 6 weeks postoperatively.

GLENOID RESURFACING

Resurfacing the glenoid along with the humerus is somewhat controversial. Clearly, glenoid resurfacing is more difficult when performed concomitant with humeral resurfacing, compared with a conventional shoulder arthro-

FIGURE 5



Intraoperative photograph shows partial resurfacing of the humeral head. The trial cap has been inserted to confirm proper bone preparation in anticipation of final implant insertion.

plasty, in which the humeral head is resected. The factors influencing the decision whether to resurface the glenoid include the amount of articular damage (a glenoid component may not be required if articular damage is minimal) and the difficulty involved in gaining adequate glenoid exposure. If sufficient glenoid exposure cannot be obtained for resurfacing, the surgeon should abandon resurfacing arthroplasty in favor of conventional shoulder arthroplasty.

If glenoid replacement is required, the trial humeral component is left in place to protect the prepared surface of the proximal humerus. Glenoid exposure is the biggest problem when glenoid resurfacing is performed in association with humeral head resurfacing because obtaining good visualization is challenging.

RESULTS

Several clinical studies have reported the results of humeral head resurfacing. The early reports represent first-generation implants characterized by nonanatomic geometry (adapted femoral resurfacing implants), lack of a central stem to augment fixation, and no surface preparation to improve implant fixation to bone. Ryd-

holm and Sjogren¹⁰ reported on the implantation of a nonstemmed, cemented stainless steel resurfacing implant in a group of patients with rheumatoid arthritis. Most patients had improved pain and mobility. Among these patients, however, 25% demonstrated radiographic evidence of subsidence or a change in the inclination of the implant, which suggested loosening. A similarly high rate of radiographic loosening with the same implant was reported by Alund et al¹¹ in another group of patients with rheumatoid arthritis. These authors concluded that bone quality in this population was the cause for these failures. However, the lack of a central stem on the implant design and the absence of surface preparation likely contributed to the loosening.

Modern resurfacing designs have a central stem and bone ingrowth surface preparation on the central stem and concavity of the implant. The clinical outcomes with these modern humeral resurfacing implants are comparable with those of conventional stemmed humeral head arthroplasty.¹² Implant-specific and pathology-specific results of modern humeral head resurfacing, with or without glenoid replacement, have been reported by multiple authors.^{7,13-17} In general, patients with osteoarthritis and osteonecrosis had better functional results and improvement in pain than patients with rheumatoid arthritis, posttraumatic arthritis, or rotator cuff tear arthropathy. The improvement in the mean age-adjusted Constant score parallels that of conventional stemmed humeral head arthroplasty.

A few studies have compared humeral head resurfacing with and without glenoid resurfacing. Levy and Copeland¹² presented the 5- to 10-year results of cementless humeral head surface arthroplasty in patients with a variety of shoulder pathologies. In patients with primary osteoarthritis, the mean age-adjusted Constant score was 93.7% when the glenoid was replaced and 73.5% when it was not replaced. Buchner et al¹⁵ performed a matched-pair analysis comparing humeral head resurfacing with conventional total shoulder arthroplasty (TSA) in patients with osteoarthritis. There was no difference in the final mean Constant score at either 6- or 12-month follow-up. The relative improvement at 12 months compared with the baseline, however, was significantly better in patients undergoing TSA compared with humeral head resurfacing.

Partial resurfacing of the humeral head was devel-

oped in an attempt to treat focal chondral lesions. The indications for partial resurfacing have expanded to include more advanced degenerative arthritis and humeral head defects associated with instability.^{5,6} Uribe and Botto-van Bemden⁴ reported on 12 shoulders that underwent partial resurfacing for osteonecrosis of the humeral head. Postoperative pain and function significantly improved compared with the preoperative values.

COMPLICATIONS

Many of the complications encountered with humeral head resurfacing also are encountered with other forms of shoulder arthroplasty. Some that are specific to this type of implant are described here.

Loosening and subsidence of the humeral components was more common in the early generations of humeral resurfacing implants. These implants did not have a central stem or surface preparation. Loosening of these implants was reported predominantly in patients with rheumatoid arthritis who had destruction of the proximal humerus.¹¹ In both of these reports, loosening rates of 25% were noted. Loosening also has been noted in stemmed implants without a surface preparation,¹⁷ and less so with implants with an ingrowth surface.^{14,16}

Radiolucent lines around the glenoid component and frank loosening of the glenoid component have been recognized following humeral head resurfacing with glenoid replacement.^{7,17} Revision of a symptomatic loose glenoid component also requires revision of the humeral resurfacing arthroplasty to a conventional stemmed humeral component because of the need for wide exposure to the glenoid.

In patients who did not undergo glenoid replacement, progressive glenoid erosion that required subsequent revision has been reported, most commonly in patients with rheumatoid arthritis.^{14,15,17} However, the need for later glenoid arthroplasty has been reported in other pathologies as well. Other less common complications have been reported. These include surgical neck fractures in patients who were treated nonsurgically,^{14,16} glenoid rim fracture,^{7,12} and progressive pain and functional loss requiring revision to a reverse TSA.¹

CONCLUSIONS

Conceptually, humeral resurfacing has several advantages over conventional stemmed arthroplasty. The

absence of a humeral stem eliminates the need for the implant system to account for the variations in neck-shaft angle and humeral head offset. In addition, bone stock in the humeral head is preserved for possible future revision surgery. Removal of a stemmed humeral component during revision surgery is extremely difficult and may lead to intentional or unintentional fracture or osteotomy of the tuberosities or the humeral shaft.

One of the major disadvantages of humeral head resurfacing is the compromised glenoid exposure. This has led some authors to advocate humeral head resurfacing without glenoid replacement. Glenoid replacement as part of shoulder arthroplasty has well-known advantages, but the challenge remains to refine the surgical technique to provide improved glenoid exposure.

The indications for partial resurfacing of the humeral head continue to evolve. This chapter focused on partial resurfacing of the humeral head that is performed for isolated chondral defects in the absence of glenoid-based pathology. The early reports for this indication appear promising.

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