# The Reverse Total Shoulder Arthroplasty

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*J Bone Joint Surg Am.* 2007;89:660-667.


# Selected Instructional Course Lectures

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# The Reverse Total Shoulder Arthroplasty

By Frederick A. Matsen III, MD, Pascal Boileau, MD, Gilles Walch, MD, Christian Gerber, MD, and Ryan T. Bicknell, MSc, MD

*An Instructional Course Lecture, American Academy of Orthopaedic Surgeons*

A reverse total shoulder arthroplasty is a procedure considered for patients whose shoulder problem cannot be effectively managed with a conventional total shoulder replacement. The reverse total shoulder prosthesis is based on a concept introduced by Professor Paul Grammont, in which a convex articular surface is fixed to the glenoid and a concave articular surface is fixed to the proximal part of the humerus[1] (Fig. 1). This prosthesis addresses some of the limitations of conventional arthroplasty. To understand the role of the reverse total shoulder arthroplasty, one must first understand the limitations of conventional arthroplasty.

## Limitations of Conventional Arthroplasty

A conventional or anatomic shoulder arthroplasty is the replacement of damaged joint surfaces with prosthetic components that approximate the normal joint surfaces and are stabilized by mechanisms similar to those stabilizing a native glenohumeral joint. In performing a conventional arthroplasty, the surgeon is faced with the following limitations.

### *Limited Ability to Manage Glenohumeral Translation*

The normal glenohumeral joint consists of a small, shallow concave glenoid with a compliant rim for articulation with a spherical humeral head. The small articular surface and minimal constraint of the glenoid allow a large range of rotational motion before the humeral neck abuts on the glenoid rim. They also allow small physiologic translations of the humeral head on the glenoid in response to loads that are applied tangential to the glenoid joint surface. Translation also occurs at the extremes of glenohumeral motion, permitting a greater range of motion than would be possible if the humeral head did not translate.

While the compliant rim of the normal glenoid enables full surface contact during small humeral translations, this attribute is not replicated by the much less compliant polyethylene joint surface of a conventional shoulder arthroplasty. If the prosthetic glenoid surface conforms exactly to the humeral head (i.e., if each has the same radius of curvature), no translation can occur without loading of the polyethylene glenoid rim. Rim loading is associated with markedly diminished contact area, increased contact pressure (load per unit contact area), and cold flow of the rim. Rim loading also challenges glenoid component fixation through the so-called rocking-horse mechanism. A prosthetic glenoid surface that does not conform exactly to the humeral head (i.e., has a radius of curvature that is larger than that of the humeral head) allows translation but also diminishes contact area, increases local contact pressure, and increases the risk of polyethylene failure.

### *Limited Fixation of the Glenoid Component to Bone*

The normal glenoid joint surface is well fixed to the subjacent glenoid bone. This fixation is critical for the management of tangential humeral loads that are directed off-center to the glenoid center line. In conventional arthroplasty, the polyethylene glenoid surface can be fixed to the bone with bone cement or with screws and tissue ingrowth through a metal back. With the repeated application of off-center loads, bone-cement fixation is at risk of failing as a result of cement fatigue and bone resorption. While metal backs can

**Disclosure:** The authors did not receive any outside funding or grants in support of their research for or preparation of this work. One or more of the authors or a member of his or her immediate family received, in any one year, payments or other benefits in excess of $10,000 or a commitment or agreement to provide such benefits from a commercial entity (Tornier [royalties]). Also, commercial entities (DePuy and Tornier) paid or directed in any one year, or agreed to pay or direct, benefits in excess of $10,000 (Tornier [royalties]) or of less than $10,000 (DePuy [endowment of a chair]) to a research fund, foundation, division, center, clinical practice, or other charitable or nonprofit organization with which the authors, or a member of their immediate families, are affiliated or associated.

be secured to bone, the fixation of the polyethylene to the metal back is also at risk of failing.

### *Limited Intrinsic Stability*

The normal glenohumeral joint is stabilized by the concavity compression mechanism, in which the joint forces compress the humeral head into the glenoid fossa. These compressive forces are due to the combined action of muscular and capsuloligamentous restraints. A loss of any of the normal osseous, capsuloligamentous, or muscular constraints leads to glenohumeral instability and a loss of normal shoulder function. Anterior instability results from defects in the subscapularis, anterior aspect of the capsule, glenoid labrum, anterior glenoid bone, rotator cuff, or posterior humeral articular surface. Posterior instability results from glenoid dysplasia; posterior glenoid erosion or fracture; and defects in the posterior aspect of the labrum, posterior aspect of the capsule, posterior aspect of the rotator cuff, or anterior humeral articular surface. Superior instability results from loss of the compression and spacer effect of the normal supraspinatus. Upward displacement of the humerus slackens the deltoid so that it is less effective in humeral elevation. If the deltoid cannot compensate for this slack, the humerus cannot be elevated, a situation known as *pseudoparalysis.* The coracoacromial arch serves as a backstop limiting upward translation of the humeral head with rotator cuff deficiency. Deficiency of the coracoacromial arch, from wear, fracture, or surgical acromioplasty, can allow the humeral head to slip out from underneath it, a condition known as *anterosuperior escape,* which compounds the pseudoparalysis.

Conventional arthroplasty can be used in some patients with arthritis and glenohumeral instability. When arthritis is coupled with instability resulting from deficiencies of the humeral head, the full articular surface can be restored by a humeral component. When the glenoid is deficient, its contour can be restored by a glenoid prosthesis as long as the bone beneath it offers sufficient support. When arthritis is coupled with instability resulting from acute reparable rotator cuff tears, stability may be restored by cuff repair in association with conventional shoulder arthroplasty. When arthritis is coupled with instability resulting from excessive capsular laxity, capsular tightening or the use of a larger humeral head component may restore the capsular tension needed for stability. When the cuff is deficient and the upwardly displaced humeral head is stabilized by an intact coracoacromial arch and the deltoid has not been slackened to the point where it is unable to raise the arm, a conventional or extended-articular-surface humeral hemiarthroplasty may enhance shoulder comfort and function.

Conventional arthroplasty usually cannot be used to manage instability resulting from unreconstructable soft-tissue or osseous deficiencies, such as severe posterior glenoid bone deficiency. If the posterior aspect of the capsule and rotator cuff have been lost as a result of trauma or previous surgery, conventional arthroplasty cannot restore posterior stability. Similarly, in the presence of anterosuperior escape and pseudoparalysis of the shoulder, resurfacing of the humeral head and glenoid cannot restore shoulder stability or deltoid function.

### *Limited Ability to Compensate for Deltoid Dysfunction*

Conventional shoulder arthroplasty can only minimally modify the tension and moment arm of the deltoid. Deltoid tension can be adjusted by raising and lowering the humeral component, but such changes may adversely affect the alignment of the humeral and glenoid articular surfaces. With a conventional arthroplasty, the center of rotation of the humeral head cannot be medialized to increase the deltoid moment arm.

### *Limitations of Any Type of Shoulder Reconstruction*

Conventional shoulder and reverse shoulder arthroplasty are limited by the same factors that limit any surgical reconstruction. Shoulders with skin, vascular, lymphatic, or osseous deficiency may be at excessive risk when treated with reconstructive surgery[1]. Patients who have fragile bone or general medical, emotional, motivational, or social health issues are usually not candidates for any type of shoulder arthroplasty. Deltoid deficiency, limited scapular mobility, and infection usually preclude effective reconstruction[2].

## Features of the Reverse Total Shoulder Arthroplasty

### *Glenohumeral Translation*

In reverse total shoulder arthroplasty, the deep, conforming concavity of the humeral articular surface does not permit glenohumeral translation. While this constraint reduces the range of mo-

Fig. 1

A reverse total shoulder prosthesis. From left to right: the humeral stem and metaphysis, the polyethylene humeral concavity insert, the glenosphere, and the metaglene.

tion before contact occurs between the humeral and glenoid elements, it eliminates the possibility of rim loading and the resulting problems of cold flow of the rim polyethylene and the creation of eccentric forces that can contribute to component loosening. Full surface contact is maintained during the allowed range of the articulation[3-6].

### *Fixation of the Glenoid Component*

In reverse total shoulder arthroplasty, a metal "metaglene," or base-plate, is fixed to a prepared glenoid with locking and nonlocking screws along with a press-fit hydroxyapatite-coated central peg. No bone cement is used. The spherically convex glenoid articular surface, the "glenosphere," is fitted to the metaglene and held in position with use of a Morse taper and screw. The glenoid component does not have a polyethylene element, therefore avoiding the challenges associated with securing a polyethylene surface to a metal-backed glenoid fixation system. The geometry of the glenoid prosthesis medializes the center of rotation of the glenoid prosthesis on the osseous surface of the glenoid, so that eccentrically applied loads have a small lever arm, reducing the moments that challenge glenoid fixation.

### *Intrinsic Stability*

One of the measures of the intrinsic stability of an articulation is the balance stability angle—i.e., the maximal angle that the net joint reaction force can form with the concavity before dislocation occurs. In most conventional shoulder arthroplasty systems, the net humeral joint-reaction force must be directed within ≤30° of the glenoid center line to avoid dislocation. In reverse total shoulder arthroplasty, the glenosphere is stabilized in the humeral socket as long as the net joint-reaction force exerted by the glenoid convexity is within 45° of the center of the humeral articular concavity. Because the center line of the humeral concavity forms an angle of 155° with the long axis of the humeral shaft, the joint is stable against forces applied to it by the deltoid, although these forces may be parallel to the surface of the osseous glenoid. This high degree of intrinsic stability frees the reverse total shoulder prosthesis from dependence on soft-tissue constraints and the coracoacromial arch for stability. It can also provide stability when there is glenoid osseous deficiency, as long as there is sufficient bone stock for glenoid fixation.

### *Compensation for Deltoid Dysfunction*

In contrast to conventional arthroplasty, reverse arthroplasty provides the opportunity to restore tension to the deltoid by moving the deltoid insertion distally and provides an increased deltoid lever arm by increasing the perpendicular distance from the center of rotation (on the osseous surface of the glenoid bone) to the deltoid muscle. Finally, the intrinsic stability of the reverse total shoulder prosthesis allows for humeral elevation by the lateral deltoid even in the presence of an anterior deltoid defect that may have resulted from injury or previous surgery.

## Possible Applications of the Reverse Total Shoulder Arthroplasty

Reverse total shoulder arthroplasty is considered when rehabilitation has not satisfactorily addressed, and conventional surgical reconstruction methods cannot satisfactorily manage, shoulder pain and loss of function. Because of the magnitude and potential risks of the reverse shoulder arthroplasty, nonoperative means of improving the patient's quality of life merit a dedicated trial prior to surgery. The patient should be treated initially with a specific exercise program and analgesics before any surgery is considered.

The reverse total shoulder arthroplasty may be considered for the management of a patient with refractory rotator cuff tear arthropathy, especially with anterosuperior escape and pseudoparalysis; a failed prosthetic reconstruction with superior, anterior, or posterior instability; or a failed reconstruction for a traumatic injury with pseudoparalysis and instability. As is the case with any major surgical procedure, the surgeon must consider the adequacy of the skin, bone, and deltoid muscle. When the procedure is being done as a revision of a previous operation, consideration must be given to the possibility of occult infection with organisms such as *Pseudomonas acnes* or *Staphylococcus epidermidis*. The surgeon needs to assess the patient's physical, emotional, and social situation to determine if those factors favor a successful outcome. Finally, the surgeon needs to be confident of his or her ability to manage the complex intraoperative decision-making and any complications that may arise with this procedure.

## One Technique for Reverse Total Shoulder Arthroplasty

There are now a number of different reverse total shoulder arthroplasty systems and many variations on the technique. The following is an example of a reverse total shoulder arthroplasty technique involving use of the Delta Reverse Shoulder Prosthesis (DePuy, Warsaw, Indiana). It is beyond the scope of this article to present each of these methods and perhaps too soon to understand their relative advantages and disadvantages. The presentation of this example provides the opportunity to describe some of the key principles and technical aspects of the procedure.

Preoperative planning is critical. The surgeon must consider the osseous anatomy, the reconstructability of the soft tissues, and the alterations resulting from previous injury and surgery. An anteroposterior radiograph made in the plane of the scapula and a transparent glenoid template are used to estimate the most inferior position of the glenoid that will result in the inferior screw being contained in the thick bone of the scapular axillary border. An anteroposterior humeral radiograph is used to estimate the size and fit of the diaphyseal and metaphyseal humeral components.

Although the deltopectoral approach may be associated with an increased prevalence of instability, it is often used because it is familiar, safe, and versatile. Any adhesions are lysed and bursal tissue is removed while the

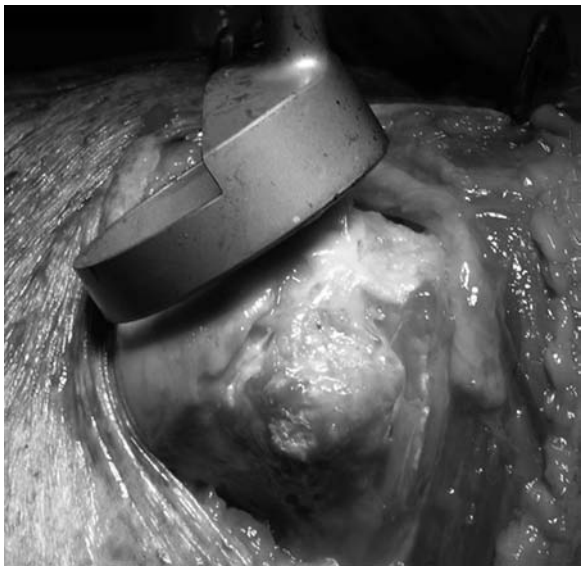

Fig. 2

The humeral resection guide is inserted into the humeral canal and placed in 0° of retroversion.

deltoid, the acromion, and any residual rotator cuff tissue are protected. The rotator cuff tear is examined to verify that it cannot be repaired, and, if it cannot, useless tendon tissue is resected. The glenohumeral joint is opened by incising the subscapularis and capsule from their insertion on the lesser tuberosity. The surgeon should preserve as much length of the subscapularis as possible. The inferior aspect of the capsule is released from the humerus, and the axillary nerve is identified. The subscapularis is dissected so that it is freed circumferentially. It will be repaired to the humerus later.

The humeral head is removed first to expose the glenoid. Final preparation of the humerus is deferred until the glenoid prosthesis is in place. The humeral resection guide stem is inserted into the medullary canal (Fig. 2), and the humeral head is resected in 0° of retroversion. When the arm is pulled distally, the plane of the humeral cut should pass just below the inferior aspect of the glenoid face.

Secure fixation of the all-metal glenoid component to the bone of the glenoid is one of the unique features of the reverse total shoulder arthroplasty. This secure fixation depends on proper preparation of the bone, positioning of the component, and screw placement. The surgeon should be sure to identify and protect the axillary nerve. First, the capsule is dissected from the anterior aspect of the glenoid down to and around the inferior pole so that the superior aspect of the axillary border of the scapula can be palpated and seen. The origin of the long head of the triceps is released as necessary. All abnormal glenoid anatomy is identified. The surgeon should note the amount of overhang of the inferior aspect of the glenoid with respect to the axillary border of the scapula. The labrum and cartilage are removed from the glenoid. A point is marked 13 mm anterior to the posterior rim of the glenoid and 19 mm superior to the inferior glenoid rim, and a guidewire is drilled into the glenoid at this point (Fig. 3). The metaglene is placed over this guidewire (with the peg laterally) to verify the appropriateness of this center point. If the metaglene rim is flush with the extrapolated axillary border, the metaglene is removed and the central hole is drilled with a step drill. The glenoid is reamed conservatively, with removal of only enough bone to make the surface relatively flat; and the surgeon makes sure that the reamer handle remains perpendicular to the face of the glenoid. Bone graft harvested from the humeral head is added to any defects in the osseous glenoid, and the metaglene peg is inserted into the central peg hole.

The anterior and posterior aspects of the axillary border of the scap-

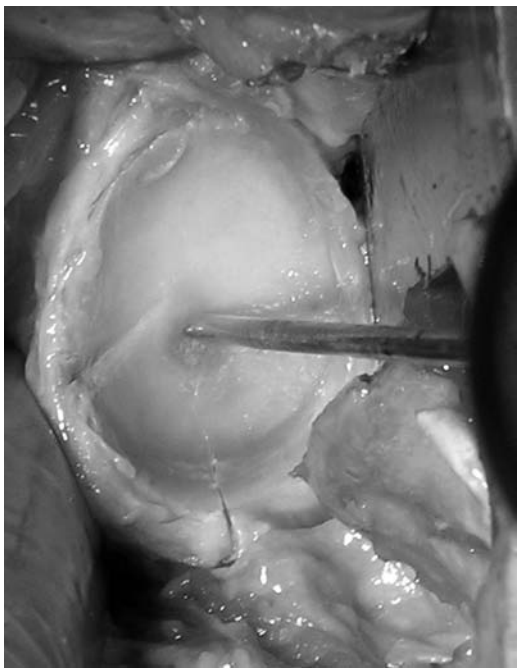

Fig. 3

A guidewire is drilled 13 mm anterior to the posterior glenoid lip and 19 mm superior to the inferior glenoid lip.

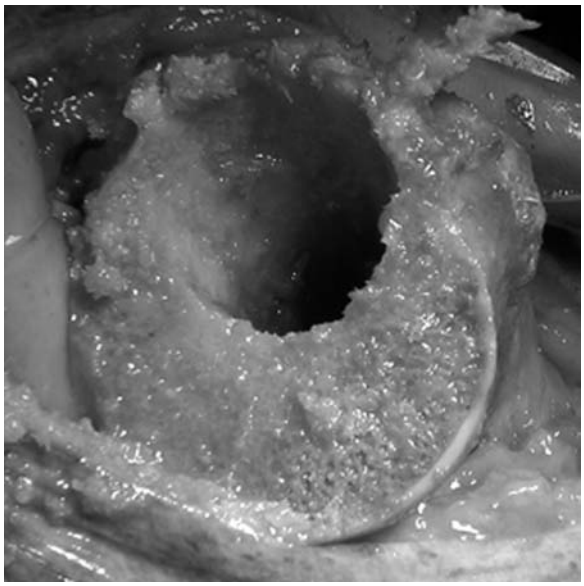

Fig. 4

Humeral reaming is stopped when cortical contact is first achieved.

ula are palpated, and the metaglene is rotated so that the inferior hole is centered over the axillary border. With use of a drill guide, the hole is drilled for the inferior locking screw. (The inferior locking screw makes a 16° angle with the central peg.) The surgeon should check frequently to ensure that the drill is in bone by pushing on the drill while it is not rotating. A 2-mm drill bit is used unless the bone is unusually hard. At least 36 mm of intraosseous drilling is recommended. If this is not achieved, the rotation of the metaglene with respect to the axillary border of the scapula should be reexamined. Once an adequate hole has been made, the inferior locking screw is inserted. A similar technique is used to drill the hole for and insert the superior locking screw. Then the hole for the anterior nonlocking screw is drilled and the screw is inserted into the best bone available, with the orientation guided by palpation of the anterior aspect of the glenoid neck. The posterior nonlocking screw is then inserted, again in the best bone accessible. A trial glenosphere is inserted into the metaglene and the inferior aspect of the glenoid is inspected, with removal of bone that may abut against the humeral polyethylene component. Any axillary glenoid bone is resected as necessary. The adequacy of the bone resection can be verified by placing a trial polyethylene component over the glenosphere and making sure that it can be adducted fully, while recalling that the humeral cup makes a 155° angle with the humeral shaft.

The final preparation of the humerus must preserve humeral bone stock while optimizing the height, version, and fixation of the humeral component. The humeral canal is prepared by inserting progressively larger reamers until cortical contact is first achieved (Fig. 4). The trial stem is inserted with the metaphyseal reamer guide in 0° of retroversion, and the metaphysis is reamed until bone purchase is achieved.

The trial humeral component is assembled and is inserted in 0° of retroversion. A 3-mm trial plastic cup is used, and the joint is reduced. The surgeon checks for medial abutment of the polyethylene against the axillary border of the glenoid, for stability, and for range of motion. There should be <2 mm of distraction when distal traction is applied to the arm. If the joint cannot be reduced, the surgeon should consider lowering the humeral component by sequentially resecting small amounts of humeral bone.

The glenosphere should be inserted before the humeral component. The glenosphere is inserted into the metaglene, with the surgeon making sure that there is no soft tissue interposed between them, that the glenosphere is aligned to avoid cross-threading, and that it is fully seated.

Positioning of the humeral component and selection of the humeral polyethylene cup are the definitive steps for adjusting the deltoid tension. The definitive humeral component is securely assembled with a strong crescent

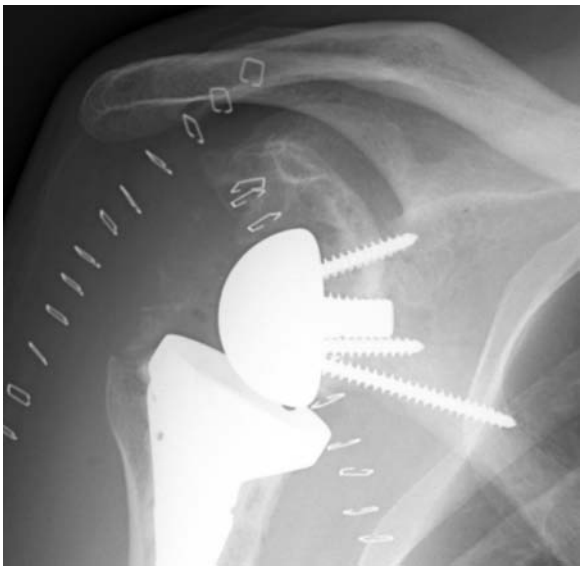

Fig. 5

Anteroposterior radiograph showing a low position of the glenoid component and the inferior screw in the thick bone of the axillary border of the scapula.

wrench on the stem and the component inserter on the metaphysis. The humeral medullary canal is brushed and irrigated. A cement restrictor is inserted 13 mm distal to the lateral aspect of the humeral cut. Six drill holes and number-2 nonabsorbable sutures are placed in the anterior neck cut for later attachment of the subscapularis. The assembled humeral component is cemented in 0° of retroversion without the polyethylene insert. Different heights of polyethylene liners, starting with 3 mm, are tried to discover the height that allows reduction of the shoulder but <2 mm of distraction with traction. The surgeon checks again for abutment of polyethylene against the lateral aspect of the glenoid inferiorly with the patient's arm adducted. Finally, the surgeon places the definitive polyethylene component, making sure that it is inserted straight. The subscapularis is repaired to the humerus with the sutures that had been previously placed at the anterior neck cut. A postoperative radiograph is recommended (Fig. 5).

This is a major operation on individuals who are usually older and less robust than those treated with conventional arthroplasty; thus, rehabilitation is gentle and gradual. The arm is rested in a sling for thirty-six hours. Hand-gripping exercises are started immediately. Hand-to-mouth exercises are started after thirty-six hours, and physical activity is limited to gentle activities of daily living, with a lifting limit of 1 lb (0.45 kg) until six weeks after the surgery. Activities are progressed from that point, with the range of motion limited to 0° of external rotation and 90° of elevation for three months.

## Results of the Reverse Total Shoulder Arthroplasty

A retrospective study including all reverse shoulder prostheses implanted over a ten-year period at three shoulder centers was conducted in France. Of the original group of 457 patients, 242 (53%) had a rotator cuff lesion: 149 had cuff tear arthropathy, forty-eight had a massive cuff tear, and forty-five had failed rotator cuff surgery. Ninety-nine patients (22%) had a revision of a previous prosthesis, sixty (13%) had fracture-related problems, twenty-six (6%) had osteoarthritis, and 2% each had rheumatoid arthritis, a tumor, or another condition. Three hundred and eighty-nine shoulders (85%) were available for follow-up more than two years postoperatively. The average age at the time of follow-up was 75.6 years (range, twenty-two to ninety-two years). The average duration of follow-up was 43.5 months (range, twenty-four to 142 months).

Significant improvement was noted in the mean Constant scores for pain (from 3.5 points preoperatively to 12.1 points at the time of follow-up), activity (from 5.8 to 15.1 points), mobility (from 12.1 to 24.5 points), and strength (from 1.3 to 6.1 points) ($p < 0.0001$). Active elevation improved, but active internal and external rotation did not. The operations for the treatment of cuff tear arthropathy had the best results, whereas the revision procedures had the worst outcomes. A young age, preoperative stiffness, teres minor deficiency, tuberosity nonunion, and pain rather than loss of function as the preoperative symptom tended to be associated with inferior results. The deltopectoral approach tended to result in greater active elevation but also a greater risk of instability. Survivorship to the end points of revision and loosening was better for patients with rotator cuff problems than for those with a failed prior hemiarthroplasty. The functional results were noted to deteriorate progressively after six years in the group treated for a cuff tear, after five years in the group treated with a revision of a prior hemiarthroplasty, after three years in the group with osteoarthritis, and after one year in the group managed with a revision of a total shoulder arthroplasty.

## Complications of the Reverse Total Shoulder Arthroplasty

Reverse total shoulder arthroplasty is a new, unconventional approach to the treatment of a variety of difficult shoulder conditions in older individuals. Thus, it is not surprising that it would be associated with frequent and substantial complications. Indeed complication rates as high as 60% with revision rates as high as 50% have been reported[2]. Complications are more frequent and more serious when reverse total shoulder arthroplasty is used to revise a failed prior arthroplasty.

Humeral cortical perforations, shaft fractures, or tuberosity fractures may occur during surgery. Intraoperative humeral fractures are most commonly associated with revision of a prior humeral arthroplasty, with a rate as high as one in four. Prevention requires careful removal of the prosthesis and respect for the thin bone that is often encountered in candidates for reverse shoulder arthroplasty. These fractures can often be treated at the time of the surgery with a longer stem and cerclage wires or tension band wire fixation. The surgeon performing a reverse total shoulder arthroplasty must be prepared and equipped for these eventualities. Furthermore, humeral fractures may increase the risk of subsequent humeral loosening.

Intraoperative glenoid fracture may involve the rim, major portions of the glenoid surface, or the glenoid neck. These fractures occur during glenoid reaming or during tightening of glenoid screws. Prevention requires respect for the osteopenic bone of older patients and gentle reaming of the glenoid by hand. Rim fractures can often be stabilized by the metaglene. If fixation is questionable, placement of the humeral component can be delayed until fracture consolidation is achieved. If the central peg of the metaglene cannot be secured to intact bone, a staged reconstruction with bone graft should be considered.

Postoperative hematomas are common and may be prevented by careful hemostasis, the use of drains, and delaying motion of the shoulder for several days after the surgery. Large hematomas may require surgical drainage.

A humeral shaft fracture is another relatively common postoperative complication. These fractures usually are due to a fall or to abrupt passive ele-

vation or rotation of the arm. They often occur at the tip of the prosthesis, probably because of the abrupt transition between the stiff cemented segment of the humerus containing the prosthesis and the osteopenic bone distal to it. Treatment may include bracing, additional fixation, or revision to a longer component.

Loosening of the humeral component is uncommon and usually is associatd with a fracture or infection. Unscrewing of the junction between the metaphyseal and diaphyseal portions of the humeral component can be avoided by vigorous tightening at the time of the surgery and by maintaining tuberosity support for the metaphysis.

Loosening of the glenoid component results when the component is insecurely anchored, because of either glenoid bone deficiency or suboptimal positioning, or it occurs secondary to trauma in which the force on the arm is transmitted directly to the glenoid fixation. The risk of glenoid loosening can be minimized by ensuring that (1) the glenoid component is positioned low on the glenoid bone so that upwardly directed forces on the glenosphere can be resisted by compression of the superior aspect of the metaglene against solid glenoid bone and (2) the fixation screws are securely anchored in the best scapular bone available. Secure anchoring is particularly important for the inferior screw, which must resist pull-out when inferiorly directed loads are applied to the glenosphere.

Infection is a relatively frequent and serious complication of reverse total shoulder arthroplasty. Contributing causes include hematoma formation, revision of a previous arthroplasty, the magnitude of the surgery, and the compromised general health of some patients. Infection with persistent low-virulence organisms, such as *Propionibacterium acnes* and *Staphylococcus epidermidis,* are particularly prevalent in patients treated with revision arthroplasty. Prevention is optimized by obtaining culture specimens in a thorough fashion at the time of the revision surgery and maintaining the cultures for several weeks to allow growth of these slow-growing organisms. Once a specific organism is identified, culture-specific treatment should be employed. The inclusion of appropriate antibiotics in the cement is recommended.

Dislocation is a relatively common complication, especially after the revision of a previous arthroplasty, when the osseous and soft-tissue anatomy has been distorted by prior trauma, when components are malpositioned, or when the humeral component levers against glenoid bone. Instability can be prevented by careful intraoperative examination to ensure full motion, proper version, absence of abutment, and no separation (pistoning) of the components when traction is applied to the humerus, combined with repairs of the subscapularis and other soft tissues. If there is any question about the intrinsic stability, delaying shoulder motion for six weeks after the surgery may allow healing of the soft-tissue envelope around the reconstruction. If the components have been properly positioned with adequate soft-tissue tension and without medial glenohumeral abutment in adduction, an early postoperative dislocation may be managed with closed reduction and immobilization with the arm at the side in a sling. If instability results from component malpositioning, osseous abutment, or inadequate soft-tissue tension, revision surgery may be required.

Fractures of the acromion occur commonly as a result of a preexisting acromial lesion, overtensioning of the deltoid, or osseous fatigue from loading of an osteopenic acromion. Distal acromial fractures with inferior angulation usually require only treatment of symptoms. However, fractures of the scapular spine may cause clinically relevant pain and loss of function. Anteroposterior, axillary and scapular Y radiographs as well as computed tomography scans may be used to evaluate patients with unexpected pain or poor function after a reverse total shoulder arthroplasty. Internal fixation should be considered for such patients, despite the difficulties presented by poor bone and substantial loads.

Neurological injuries include axillary nerve damage from surgical dissection or traction injuries from excessive tension resulting from lengthening of the arm. These injuries are most common in revisions with difficult surgical exposures.

## Socioeconomic Considerations

Reverse total shoulder prostheses and the support for their application tend to be expensive. Being that this prosthesis is generally recommended for individuals sixty-five years of age and older, the cost of its implantation may substantially exceed a medical center's reimbursement from Medicare and other insurance programs. However, there are many individuals whose comfort, function, and quality of life are compromised by severe rotator cuff lesions and failed surgical reconstructions who could potentially benefit from this procedure. Finally, the substantial risks of the procedure create the need for informed consent and assessment of the total context in which the patient will live after this reconstruction.

## Overview

Reverse total shoulder arthroplasty is a powerful and technically demanding tool for managing problems in relatively older, less active patients who previously had no solution for these problems. It is tempting to expand its application to an increasing number of conditions in younger and more active individuals, such as irreparable rotator cuff tears, severe proximal humeral fractures, and complex instability patterns. This temptation needs to be balanced by an awareness of the complications, cost, and potential for deteriorating function with time after this method of reconstruction.

NOTE: The authors thank Steven B. Lippitt, MD, for his artwork.

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