Reverse Shoulder Arthroplasty in the Management of Irreparable Rotator Cuff Tears without Arthritis

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Introduction

The ability to achieve reliable outcomes in treatment of patients with degenerative rotator cuff tears has become increasingly complicated, as a result of more advanced disease and the increased array of treatment choices. The number of patients with pain and functional deficits due to degenerative rotator cuff tears is expected to continue to grow as the global population ages¹⁻³. In this report, we will describe the application of reverse shoulder arthroplasty to patients who have a massive rotator cuff tear without substantial articular cartilage degeneration, as described in the recent publication by Mulieri et al.⁴. In addition, we will review the outcomes of other published series in which reverse shoulder arthroplasty was performed in a similar patient population, describe the indications for patient selection, outline potential pitfalls in patient selection, and provide questions to stimulate further thought and discussion regarding reverse shoulder arthroplasty.

The steps of the procedure include:

Step 1: Preoperative planning

Step 2: Patient positioning

Step 3: Surgical approach

Step 4: Humeral exposure and preparation

Step 5: Glenoid exposure and preparation; glenosphere insertion

Step 6: Final humeral preparation

Step 7: Trialing

Step 8: Component implantation and closure

Step 1: Preoperative Planning

Develop and communicate with a consistent team of interdisciplinary physicians both preoperatively and postoperatively; utilize advanced imaging modalities

to evaluate muscle atrophy as well as glenoid and humeral bone stock.

- Develop an interdisciplinary team, including internal medicine physicians, anesthesiologists, and other subspecialty consultants such as infectious disease experts, to provide expertise across the spectrum of care. Effective communication among a dedicated team optimizes the preoperative evaluation and maintains continuity of care throughout hospitalization. Strive to maintain a consistent operative team, including the circulating nurse, the scrub technician, product representative, and first assistant. Familiarity and consistency in the operative team are critical to ensure clear communication and anticipation in executing the surgical plan and to facilitate a consistent successful operative outcome.
- Obtain preoperative radiographs, including a standard four-view radiographic shoulder series (anteroposterior, Grashey, scapular Y, and axillary views). Appropriate imaging of any suspected rotator cuff tear is critical. You may use magnetic resonance imaging (MRI) arthrography in the setting of a prior rotator cuff repair. We also routinely perform preoperative computed tomography (CT) scans of the shoulder to assess glenoid version and bone stock.
- When a patient demonstrates extensive posterior rotator cuff deficiency on physical examination (i.e., cannot maintain the arm in 0° of external rotation with the elbow at the side), evaluate the infraspinatus and teres minor muscles on the CT scan. Determine the degree of muscle atrophy as described by Goutallier et al.⁵. Patients with advanced muscle loss may be candidates for a latissimus dorsi transfer to enhance postoperative external rotation, as described by Boileau et al.⁶. Make

the final decision to perform the transfer only after the subscapularis has been repaired. If passive external rotation motion is limited to $\leq 45^\circ$ by the repair, then the potential gains afforded by a transfer may not warrant the additional morbidity associated with the procedure. We currently perform this transfer infrequently, but one should consider it in the preoperative setting to allow for appropriate informed consent and adequate preparation of the surgical team.

Step 2: Patient Positioning

Place the patient in a beach-chair position, check the abdominal strap, and position yourself facing the axilla.

- Place the patient in the beach-chair position, flexing the hips to prevent the patient from sliding down the table and flexing the knees to relieve stress on the lumbar spine and hamstring muscles. Place TED (thromboembolic deterrent) hose and sequential compression devices over the lower extremities for prophylaxis against thromboembolic disease. Pad the heels or apply foam heel protectors and place protective goggles over the patient's eyes.
- Before you raise the patient from a supine to a seated position, communicate with the anesthesia team to ensure that the patient has sufficient blood pressure to provide ample cerebral perfusion pressure. Our anesthetic team prefers to monitor blood pressure with a properly zeroed arterial line, as opposed to pressure measurements with a pneumatic cuff on a lower extremity⁷.
- Check the chest and abdominal straps, particularly the abdominal strap, which may be tight if it was initially secured with the patient in the supine position. Generally, this strap should be lax with the patient supine and tensioned only after the patient is in the seated position.
- Perform a standard surgical preparation and drape the patient in a sterile fashion, leaving the operative extremity free. Position yourself facing the axilla with the operative extremity resting on a padded sterile Mayo stand. The surgical assistant stands posteriorly, opposite the Mayo stand, to assist with retraction and manipulation of the arm (Fig. 1-A). Before making the incision, verify the operative checklist, identifying that this is the correct patient and surgical site and confirming the delivery of preoperative antibiotics.

Step 3: Surgical Approach

Develop the subdeltoid and subacromial spaces and take care to avoid vigorous over-retraction of the deltoid.

- Perform a deltopectoral surgical approach to the shoulder. Begin the incision at a point on the inferior border of the clavicle approximately 5 cm medial to the acromioclavicular joint and extend it inferiorly and laterally toward the deltoid insertion on the humerus. End the incision just inferior and lateral to the axillary fold (Fig. 1-B). The deltopectoral interval is readily identifiable just inferior to the clavicle in the superior aspect of the wound and is demarcated by a triangle of fatty tissue.
- Identify the cephalic vein. We prefer to primarily mobilize the deltoid, leaving the cephalic vein overlying the pectoralis major surface (Fig. 2-A). Develop the deeper muscular planes only after the deltoid has been mobilized from origin to insertion.
- Incise the clavipectoral fascia and free the pectoralis major from any underlying adhesions to the conjoint tendon. You can expect to encounter extensive bursa formation in the subdeltoid and subcoracoid spaces. If there have been prior surgical attempts at repair or partial repair, adhesion formation is often increased. Extensive scarring of the deltoid to the humerus along prior suture lines may be present, making mobilization of the deltoid difficult. Early identification of the axillary nerve, by developing the planes between the subscapularis and the conjoint tendon, can be helpful. Confirmation of the nerve location can be facilitated by the "tug test."⁸
- Once the subdeltoid and subacromial spaces have been sufficiently developed, position a retractor specifically designed for the deltoid, such as a Browne retractor, in place underneath the deltoid. Avoid vigorous over-retraction of the deltoid by the assistant as this may damage or even avulse deltoid muscle fibers. If the long head of the biceps tendon remains intact, identify it at the superior border of the pectoralis major muscle. Incise the tendon sheath to expose the tendon proper. Continue opening the tendon sheath cephalad into the rotator interval. Using nonabsorbable suture, tenodesis the biceps tendon to the tendinous insertion of the pectoralis major. Excise the proximal extent of the biceps.

Step 4: Humeral Exposure and Preparation

Perform the head cut utilizing the 135° resection guide, broach the humerus, and ream the humeral socket.

- As in total shoulder arthroplasty, the goal of soft-tissue dissection is to allow easy visualization of the glenoid and humeral surfaces, ensuring that the implants are securely attached in their desired position. The soft-tissue envelope in patients who have a massive rotator cuff tear without articular cartilage degeneration has a great deal of variability. The capsule may be scarred and contracted from previous surgery, or it may appear thin and patulous from recurrent instability.
- To expose the humeral head, release the subscapularis or any remaining fibers and the anterior aspect of the capsule directly off bone (Fig. 2-B). Place a sharp Hohmann retractor between the humeral head and glenoid. Using this retractor, place tension on the superior margin of the subscapularis and capsule. Release the tissue inferiorly in one contiguous sleeve. External rotation and adduction of the humerus will place the tissues under tension, further facilitating the release. A more thorough capsular release is necessary in patients with scarring and stiffness; in unstable shoulders, with redundancy of the capsule, less effort is required to dislocate the humeral head.
- Place the humeral resection guide along the long axis of the humerus. As the distal end of the guide will lie beyond the surgical wound, take care that the guide is not in an inadvertently flexed or extended position. Align the humeral version rod with the forearm, and pin the guide in place. When the version rod is positioned parallel to the forearm, the humeral cut will be performed in 30° of retroversion. You can place a blunt Hohmann or equivalent retractor posteriorly on the humeral head as an additional measure to prevent injury to the conjoint tendon by the saw blade.
- Set the height of the head cut in patients without arthritis at a level slightly less than the anatomic head (neck-shaft angle of 135° and an inset humeral shell) (Fig. 3-A). This provides for nearly anatomic restoration of the position of the humerus, preserving lateral humeral offset (Fig. 3-B). Overly aggressive or inadequate head resection will alter the socket-to-tuberosity distance, resulting in increased or

decreased inferior translation of the humerus (Fig. 4). Maintaining the lateral position of the humerus preserves the normal length-tension relationship of the remaining rotator cuff musculature, which optimizes its strength and function. However, when the shoulder is excessively tight, a greater head cut can allow some adaptation of the scarred soft tissues. Alternatively, in excessively lax shoulders, a smaller head cut can provide additional tension on the soft tissues, improving stability of the glenohumeral articulation.

- Access the humeral canal with the starter or “canal finder” reamer (Fig. 5-A). Grasp the humeral condyles with your contralateral hand to determine the orientation of the humeral canal (Fig. 5-B). If you encounter substantial resistance, redirect the canal finder to avoid perforating the diaphyseal bone. Once the canal is identified, sequentially ream the proximal part of the humerus by hand. It is not necessary to ream to cortical bone. Broach the proximal part of the humerus and leave the last broach in place. Unless the canal is unusually capacious, the size-6 broach is generally sufficient. As this system utilizes an inset humeral socket, countersink the broach below the previous resection level (Fig. 6-A). Aligning the humeral version rod on the broach handle with the forearm will result in retroversion of the socket of 30°.
- Ream the proximal part of the humerus with the metaphyseal reamer on a powered reamer. Remove any remaining inferior and posterior humeral head osteophytes. A proper depth of reaming has been achieved when the reamer is flush with the level of the initial head cut (Fig. 6-B). This depth minimizes the difference between the tuberosity and socket heights, avoiding overlengthening of the humerus. If the reamer is countersunk below the initial head cut, the final socket will countersink as well, resulting in a prominent greater tuberosity, which may impinge on the undersurface of the acromion.

Step 5: Glenoid Exposure and Preparation; Glenosphere Insertion

Ream the inferior surface to bleeding subchondral bone; bleeding subchondral bone on the inferior 50% of the prepared glenoid surface indicates a sufficient depth.

- Leave the broach in place within the humeral canal to diminish the risk of humeral fracture

during glenoid exposure and preparation. Position a large spiked Hohmann retractor on the posterior aspect of the glenoid rim to translate the humerus posteriorly. Identify the subscapularis tendon and place a tagging suture in the superior-lateral corner for later repair (Fig. 7-A). Bluntly palpate and identify the course and proximity of the axillary nerve prior to further glenoid exposure. Identify the capsulolabral junction anterosuperiorly. Resect the labrum and release the capsule from the glenoid surface, extending inferiorly to the six o'clock position. Slide a Cobra retractor along the anterior aspect of the glenoid neck and resect any remaining inferior capsule. Place a sharp Hohmann retractor superiorly on the glenoid and resect the biceps stump.

- Prior to glenoid preparation, you may exchange the posterior Hohmann retractor for a Cofield or equivalent posterior glenoid retractor. Final placement of the retractors is shown in Figure 8. As during the humeral exposure, the amount of soft-tissue compliance will guide the extent of capsular release required. In addition to releasing the inferior aspect of the capsule, you may need to release the triceps from the inferior glenoid attachment in extremely stiff shoulders.
- Identify the center of the glenoid. Drill perpendicular to the face of the glenoid in the anterior-to-posterior plane, but with 10° of inferior tilt in the superior-to-inferior plane. The glenosphere in this particular system displaces the humeral shaft laterally, minimizing the potential for abutment of the humeral socket on the inferior aspect of the glenoid neck. Because the risk of adduction impingement is already reduced, it is not necessary to place the baseplate excessively low on the inferior quadrant of the glenoid. This prevents overlengthening of the humerus, which may occur with an inferior eccentric baseplate position (Fig. 7-B).
- The drill should exit the glenoid vault along the anterior surface of the scapula at approximately 30 mm. After confirming adequate depth with the depth gauge, insert the 6.5-mm guide tap under power (Fig. 8-A). Use the cannulated reamers over the tap to ream the face of the glenoid. Ream the inferior surface to bleeding subchondral bone. Generally, bleeding subchondral bone on the inferior 50% of the prepared glenoid surface indicates a sufficient depth (Fig. 8-B). Once adequate reaming is achieved, remove the tap using the manual tap handle. Take care to remember the inser-

tion angle of the tap. Insert the glenoid baseplate onto the prepared glenoid surface. The 6.5-mm center screw should achieve excellent purchase so that it will no longer advance on continued attempts to further insert the baseplate. When the baseplate is fully seated, attempts to further advance it will result in scapular rotation. Insert four peripheral locking screws into the baseplate for additional fixation (Fig. 9-A).

- Once the baseplate is securely attached, implant a glenosphere of the desired size (Fig. 9-B). If the desired size is unknown or uncertain, you can insert a trial glenosphere onto the baseplate. However, in the primary setting, we generally prefer to implant the final glenosphere without additional trialing. A patient with a massive cuff tear without arthritis has, by definition, no glenoid deformity. In this instance, we generally use a size-32, -4 glenosphere for female patients, and a size-32, neutral glenosphere for most male patients. Size-36 and larger glenospheres are generally employed in revision arthroplasty, shoulders with substantial glenoid bone loss, or very large individuals⁹.

Step 6: Final Humeral Preparation

At final reaming, the edge of the reamer should sit flush with the cut surface of the humerus.

- Deliver the humerus anteriorly around the glenosphere and back into the surgical field. Use the larger metaphyseal reamers to further prepare the humerus to accept the humeral socket. The edge of the reamer should sit flush with the cut surface of the humerus at final reaming. If the reamer will not seat to this level, re-broach the humerus to a greater depth and re-ream. If the proximal part of the humerus is not sufficiently reamed for the socket, it is likely that the humeral component will sit proud, overextending the remaining soft tissues.
- Place the humeral socket and trial liner onto the broach currently in the humeral canal. Reduce the glenohumeral articulation and trial the components to assess the stability and shoulder motion.

Step 7: Trialing

Proper soft-tissue balance is frequently achieved by positioning the humeral component so that the rim of

the socket lies just above the humeral osteotomy site at the anatomic neck.

- Since patients who have a massive rotator cuff tear without arthritis have no osseous deformity, the components often provide the needed stability by virtue of the reversed articulation. A large inferior humeral translation is neither required nor desirable. Instead, strive to reapproximate normal anatomy by preserving lateral humeral offset; this results in minimal alterations in the overall shoulder contour and humeral position. Overtightening the shoulder by markedly lengthening the humerus may produce an array of problems, such as brachial plexopathy, acromial fracture, and undue stiffness.
- Because of the semiconstrained nature of the implant, do not use the usual methods that are employed to assess stiffness in an anatomic shoulder arthroplasty, such as evaluating the amount of humeral translation. To ensure that there is minimal postoperative stiffness, assess the ease with which the articulation reduces. It should not take great force or manipulation of the arm to relocate the humerus for trialing. During trialing, the arm should easily forward elevate overhead without forceful effort or osseous impingement, yet the articulation should be stable on both internal and external rotation without the subscapularis in place. There should be sufficient laxity for you to slide your index finger over the lip of the socket and, by applying a laterally directed force to the socket and extending the humerus, easily dissociate the components.
- Proper soft-tissue balance is frequently achieved by positioning the humeral component so that the rim of the socket lies just above the humeral osteotomy site at the anatomic neck, in combination with a glenoid component centered on the face of the glenoid with slight inferior tilt. In cases of scarring, diminished soft-tissue compliance may limit glenohumeral motion and may even make reduction difficult. In these circumstances, you may have to use a smaller sphere with less offset or seat the socket to a greater depth within the humerus. Alternatively, if the articulation seems unstable, the use of a larger sphere or increased humeral offset are effective methods to enhance the stability of the glenohumeral joint.

Step 8: Component Implantation and Closure

When cementing the humeral component, the socket should match the reamed proximal part of the humerus.

- Place four drill holes along the lesser tuberosity and pass four number-2 nonabsorbable sutures for later subscapularis repair (Fig. 10-A).
- Prepare the humeral canal for cementation and assemble the humeral component. Place a cement restrictor in the humeral canal.
- Cement the humeral component in place, using antibiotic-impregnated cement (Fig. 10-B). The socket should match the reamed proximal part of the humerus to ensure that correct version of the final implant is obtained. Remove any excess cement and relocate the shoulder, allowing the cement to cure with the shoulder in the reduced position.
- Repair the subscapularis tendon to the lesser tuberosity using the four previously placed sutures. The subscapularis should be adequately released prior to reattachment to allow for the greatest maximal excursion. Close the deltopectoral interval with absorbable suture followed by skin closure. A suction drain is usually not required.

Results

Initially, reverse shoulder arthroplasty was primarily used to treat osteoarthritis of the glenohumeral joint resulting from chronic rotator cuff deficiency or for true rotator cuff tear arthropathy. However, it has been increasingly recognized that reverse shoulder arthroplasty can be used successfully in patients who have an irreparable rotator cuff tear without associated arthritis. Several investigators have reported outcomes of a direct comparison between these different patient populations.

Wall et al. reported their results of reverse shoulder arthroplasty, stratifying outcomes by etiology¹⁰. This series included thirty-four shoulders with a massive rotator cuff tear but no associated arthritis. There was no observed difference in outcome at the time of final follow-up between this group and a group that had undergone primary reverse shoulder arthroplasty for treatment of rotator cuff tear arthropathy. Subsequently, Boileau et al. reported the results of reverse shoulder arthroplasty following a failed rotator cuff repair¹¹. In their series, 61% of shoulders demonstrated radiographic evidence of associated osteoarthritis. Again, there was no difference in outcome

between the shoulders with and those without osteoarthritis. Lastly, Mulieri et al. reported the results of reverse shoulder arthroplasty in a patient population specifically without arthritis⁴. They reported an improvement in the American Shoulder and Elbow Surgeons (ASES) score from 33.3 preoperatively to 75.4 postoperatively as well as improvements in forward elevation (from 53° to 134°) and external rotation (from 27° to 51°).

These studies support the use of reverse shoulder arthroplasty for management of irreparable rotator cuff tears despite the absence of associated osteoarthritic change. However, it should be noted that, in the studies by Boileau et al.¹¹ and Mulieri et al.⁴, patients with preserved forward elevation of >90° preoperatively were at increased risk for a decrease in forward elevation and were generally more dissatisfied than were patients with pseudoparalysis. We have concerns about recommending the use of reverse shoulder arthroplasty in such patients even if they have a massive rotator cuff tear.

What to Watch For

Indications

Appropriate application of reverse shoulder arthroplasty to patients without obvious osteoarthritic changes is best demonstrated by considering three clinical scenarios. These are presented in order of increasing severity of disease, evidenced by increasing amounts of glenohumeral instability. All scenarios presume that a reasonable trial of nonoperative management was unsuccessful before surgical intervention was recommended.

Scenario 1: Massive Rotator Cuff Tear without Anterosuperior Escape of the Humeral Head

An elderly patient with multiple risk factors or comorbidities predictive of poor rotator cuff healing presents with painful pseudoparalysis (forward elevation of <90°) due to a massive rotator cuff tear, but she has no evidence of clinically apparent anterosuperior escape. These patients often present with an acute-on-chronic rotator cuff tear. It is clear that the acute extension of the tear was brought on by some event, which precipitated a sudden decline in shoulder function. Patients with multiple failed prior rotator cuff repairs may similarly fall into this category.

In this scenario, attempted rotator cuff repair has a limited likelihood of a successful outcome. Reverse shoulder arthroplasty provides more predictable pain relief and restoration of function.

Scenario 2: Massive Rotator Cuff Tear with Dynamic Anterosuperior Escape of the Humeral Head

In this scenario, there is clinically apparent anterosuperior escape of the humeral head on attempted forward elevation of the arm in a patient with multiple risk factors for poor rotator cuff healing. Radiographs may demonstrate normal findings, or they may reveal cephalad migration of the humeral head but no frank escape. However, radiographs made during attempted abduction may document humeral head escape resulting from a dynamic deltoid muscle contracture. Once the humeral head becomes unstable, soft-tissue repairs are unreliable with regard to restoring glenohumeral stability. Reverse shoulder arthroplasty is the preferred surgical option for this patient.

Scenario 3: Massive Rotator Cuff Tear with Static Anterosuperior Escape of the Humeral Head

Visible anterosuperior escape of the humeral head on radiographs denotes the presence of static anterosuperior escape. There is an obvious prominence of the humeral head on examination, and this may increase in severity on attempted elevation of the arm. Reverse shoulder arthroplasty is indicated.

Contraindications

- Reverse shoulder arthroplasty in the absence of glenohumeral arthritis is contraindicated in the presence of a repairable rotator cuff tear or a nonfunctional deltoid muscle. Deltoid dysfunction may result from previous open rotator cuff surgery, axillary nerve injury, brachial plexus injury, or C5-C6 cervical disc herniation. We frequently assess the adequacy of deltoid function by testing the ability of the patient to maintain the arm in 90° of forward elevation while in the supine position. It has been our experience that even those patients with severe pseudoparalysis are able to maintain the arm in this position once the arm has been passively elevated. If there is questionable deltoid muscle function, preoperative electromyography (EMG) should be performed.
- Active infection is a relative contraindication to surgery. In certain instances of advanced patient age and associated glenoid bone loss, reverse shoulder arthroplasty may be employed in a one-stage revision of an implant previously complicated by infection^{12,13}.

Pitfalls & Challenges

Reverse shoulder arthroplasty provides predictable pain relief and restoration of function in patients who

cannot elevate the arm because of a massive rotator cuff tear. However, it is not a panacea for all patients with “pseudoparalysis,” regardless of the underlying cause. Below we highlight pitfalls that we have observed in the use of reverse shoulder arthroplasty in patients without glenohumeral arthritis.

- Failure to obtain appropriate preoperative imaging. Clinical presentation of a pseudoparalytic upper extremity alone is not sufficient to warrant treatment with reverse shoulder arthroplasty, even with a correlative history suggestive of rotator cuff pathology. There are multiple pathologic states that may produce pseudoparalysis but may or may not be appropriately managed with reverse shoulder arthroplasty. Consequently, we recommend confirmatory imaging of all suspected rotator cuff tears prior to proceeding with surgery. Imaging also allows an assessment of reparability of any observed tear and more informed decision-making.
- Unappreciated preoperative neurologic injury.
 - Neurologic injury to either the C5 or the C6 nerve root, the upper trunk or posterior cord of the brachial plexus, the suprascapular nerve, or the axillary nerve may result in dysfunction of the rotator cuff or deltoid resulting in an inability to elevate the arm. Such a presentation may mimic pseudoparalysis due to a rotator cuff tear. It must be stressed that these neurologic conditions may exist concomitantly with a rotator cuff tear.
 - We have observed the most common scenario to be the coexistence of a rotator cuff tear and a cervical disc herniation. This may be suggested by weakness out of proportion to the size of the tear seen on MRI, such as an external rotation lag in the absence of an infraspinatus tear. Additionally, associated weakness on biceps flexion or wrist supination suggests a cervical nerve-root compression. These patients may lack classic radicular pain into the hand, manifesting symptoms primarily as weakness of more proximal muscles.
 - An acute shoulder dislocation in a more elderly patient may result in a massive rotator cuff rupture, but it may also cause an axillary nerve injury. Before one considers use of a reverse shoulder arthroplasty for management of the rotator cuff tear, axillary nerve function should be eval-

uated with EMG in the event that deltoid muscle function is difficult to ascertain on physical examination. Maintain a high index of suspicion for a neurologic source of weakness when evaluating a patient with pseudoparalysis. We frequently employ EMG when the results of the clinical examination are equivocal.

- Unappreciated preoperative deltoid injury. A loss of deltoid muscle function invariably affects, to some degree, the ability to elevate the affected extremity. This may be due to neurologic injury as described above, but it may also result from prior surgical intervention. Tumor resection around the proximal part of the humerus may necessitate sacrifice of a portion of the deltoid muscle, but more commonly dysfunction follows open rotator cuff repair. Take care to not erroneously assume that an inability to elevate the extremity after such a repair unequivocally indicates an isolated failure of the repair. You must carefully assess for deltoid dehiscence or detachment before considering reverse shoulder arthroplasty, as the pseudoparalysis may be due to deltoid detachment, as well as failure of the rotator cuff repair.
- Absence of pseudoparalysis. The success of reverse shoulder arthroplasty is predicated on eliminating pathologic instability of the glenohumeral joint due to a massive rotator cuff tear, or resurfacing areas of articular incongruity in those patients with associated arthritic change. The reversed articulation blocks cephalad migration of the humeral head, restoring stability and eliminating painful acromiohumeral contact. The prosthetic articulation itself provides a low-friction surface to eliminate the pain of articular cartilage disease. However, when neither of these conditions is present, reverse shoulder arthroplasty is unlikely to be effective for the management of a massive rotator cuff tear. The absence of pseudoparalysis generally indicates that there is sufficient remaining musculature to prevent glenohumeral instability and acromiohumeral contact. In such circumstances, the generator of the patient's clinical symptoms is often not clear. Other procedures for treatment of a painful rotator cuff tear, including biceps tenotomy, suprascapular nerve release, or biologic supplementation of a partial repair, should be considered in this setting¹⁴⁻¹⁶.

Clinical Comments

- How do the surgical technique and implant selection affect humeral translation following reverse shoulder arthroplasty?
- How do the degree and direction of humeral shift affect the function of the residual rotator cuff muscles?
- How often does a latissimus dorsi transfer need to be performed? What preoperative selection criteria should be used to define appropriate use of this transfer?
- What postoperative improvements and residual motion deficits should patients and surgeons expect?
- To what sports activities can patients safely return?

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Figures

Fig. 1

Fig. 1-A The surgeon is positioned anteriorly. The patient's arm rests laterally on a padded Mayo stand. The assistant is positioned posteriorly to assist with retraction. **Fig. 1-B** The surgical incision is planned by first locating the acromioclavicular (AC) joint. The most superior extent of the incision is identified 5 cm medial to the acromioclavicular joint on the inferior border of the clavicle. The incision extends inferiorly and laterally parallel to the arm, to end just lateral to the axillary fold.

Fig. 2

Fig. 2-A The cephalic vein (blue arrow) is readily identifiable in the deltopectoral interval. The deltoid is visible in the wound behind the retractor. The medial border of the deltoid is elevated in a superior-to-inferior direction, leaving the vein medial on the surface of the pectoralis major muscle. **Fig. 2-B** The subscapularis muscle is released directly off bone. The articular surface of the humeral head is visible following release of the superior attachment of the subscapularis muscle.

Fig. 3

Fig. 3-A Aligning the version rod with the patient's forearm results in a humeral head cut in 30° of retroversion. The head cut should be slightly less than that of a conventional total shoulder arthroplasty. Take care not to injure the conjoined tendon during the humeral head resection. **Fig. 3-B** The desired humeral head resection level necessitates a small inferior humeral translation but preserves the anatomic lateral position of the proximal part of the humerus.

Fig. 4

Fig. 4-A An overly cautious head resection results in a large inferior translation of the humerus due to the demonstrated discrepancy between the humeral socket height and greater tuberosity position. **Fig. 4-B** An overly aggressive head resection initially appears to result in the greatest reapproximation of normal proximal humeral anatomy. However, close inspection reveals substantial overhang of the greater tuberosity, placing the patient at risk for impingement and mechanical symptoms.

Fig. 5

Fig. 5-A The humeral canal finder enters the humerus at the superolateral edge of the cut surface, but is centered in the anterior-to-posterior plane. **Fig. 5-B** Grasp the humeral condyles with your contralateral hand (arrow) to determine the orientation of the humeral canal.

Fig. 6

Fig. 6-A The humeral broach is countersunk (arrow) below the cut surface of the proximal part of the humerus. **Fig. 6-B** The metaphyseal reamer should be seated flush with the cut surface of the proximal part of the humerus (arrow) to ensure that the socket does not sit proud, overlengthening the arm.

Fig. 7

Fig. 7-A The subscapularis (arrow) is identified, and a tagging stitch is placed in the superior-lateral corner for later repair. **Fig. 7-B** Inferior placement of the glenosphere increases inferior shift of the proximal part of the humerus.

Fig. 8

Fig. 8-A The tap is inserted along the drilled path and is left in place for cannulated reaming. **Fig. 8-B** Bleeding subchondral bone on the inferior half of the glenoid generally indicates that an adequate depth of reaming has been achieved.

Fig. 9

Fig. 9-A The baseplate is placed onto the reamed glenoid surfaced followed by four peripheral locking screws. **Fig. 9-B** The glenosphere is impacted onto the baseplate. The taper should be checked to ensure that it is adequately engaged by attaching the T-handle and pulling longitudinal traction on the sphere.

Fig. 10

Fig. 10-A Four sutures are placed into the lesser tuberosity for later repair of the subscapularis. **Fig. 10-B** The humeral component is cemented in place, and excess cement removed.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

Fig. 10