Eighty-six reverse shoulder arthroplasty (RSA) cases performed through a deltopectoral (DP) approach were reviewed at an average of 17.2 months after surgery. All procedures were performed by 2 fellowship-trained shoulder surgeons who perform a high volume of shoulder arthroplasty. We describe the surgical technique for the DP approach for primary and revision RSA, preliminary results, intraoperative complications, and early postoperative complications. We did not encounter instability in this series of patients. The DP approach affords an extensile view of the humerus during primary and revision RSA and can have a low incidence of instability contrary to recent reports.

Reverse shoulder arthroplasty (RSA) is an effective operative treatment for rotator cuff tear arthropathy and other complex shoulder disorders. When selecting a surgical approach for RSA, the surgeon should consider that the deltoid muscle is the primary source of shoulder movement after RSA. Any surgical approach used for RSA either should preserve the deltoid entirely or should leave the deltoid in excellent condition. Surgical approaches described for this procedure range from transacromial to superior/deltoid splitting/MacKenzie and to deltoid sparing/deltopectoral approaches. We present a series of patients who had RSA through a deltoid sparing/deltopectoral approach and describe the surgical techniques for primary and revision RSAs, including implant revision surgery. We also discuss the benefits of a deltoid sparing/deltopectoral approach and the short-term results in these patients.

PATIENTS AND METHODS

We retrospectively studied 86 patients who underwent RSA from January 2007 to June 2009 at our hospitals. All procedures were performed by the authors. A deltopectoral surgical approach was used in all cases. Fifty-one patients had a primary RSA with no previous surgery (Group 1), and 35 patients had undergone one or more surgical procedures on the involved shoulder before the RSA (Group 2).

Preoperative diagnoses in Group 1 included rotator cuff tear arthropathy as described by Neer (31 patients); secondary osteoarthritis and a massive rotator cuff deficiency shoulder (10 patients); and sequelae from a proximal humerus fracture, including malunion, traumatic arthropathy, avascular necrosis, and cuff deficiency (10 patients) (Table 1). All patients who had RSA for an acute proximal humerus fracture or had died for reasons unrelated to RSA were excluded from the study.

Preoperative diagnoses in Group 2 included failed open reduction and internal fixation for proximal humerus fractures (2 patients), failed humeral head replacement for complex proximal humerus fractures (9 patients), failed humeral head replacement for osteoarthritis (4 patients), failed total shoulder replacement...
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for osteoarthritis (6 patients), and one or more failed attempts to repair the rotator cuff (14 patients) (Table 1). Fifteen patients had undergone 1 previous procedure on the involved shoulder; 12 patients had undergone 2; 4 patients had undergone 3; 3 patients had undergone 4; and 1 patient had undergone 5, including a resection arthroplasty for infection.

The average age of the 16 male and 35 female patients in Group 1 was 74 years (range, 56-85 years), and the average follow-up was 18 months (range, 6-37 months). In Group 2, the average age of the 17 male and 18 female patients was 70 years (range, 43-88 years), and the average follow-up was 16.1 months (range, 6-36 months).

Pain scores were derived from a visual analog scale, with a grade of 0 indicating no pain and 10 indicating worst possible pain. Preoperatively, the average pain score for Group 1 was 9.09 (range, 8-10) and for Group 2 was 9.02 (range, 7-10).

Additional information obtained from the retrospective review of the medical records for each patient included preoperative active forward elevation in the scapular plane and active external rotation with the arm at the side; surgical findings of the status of the subscapularis, including its reparability at the end of the surgical procedure; the size of the glenosphere implanted; the presence of glenoid and humeral bone deficiency; and intraoperative and postoperative complications that occurred during our study. Seventy-nine patients returned to our clinic between December 1, 2009, and March 15, 2010, for a chart review; physical examination; and radiographs, including true anteroposterior and axillary lateral views of the involved shoulder. Seven patients were unable to return for follow-up during that time, so we interviewed them via telephone to confirm the status of the operatively treated shoulder. In these 7 patients, the most recent radiograph was used for analysis. The Nerot classification was used to grade any scapular notching that was present. Radiographic assessment of component loosening or migration and any problems related to bone grafts or hardware also were recorded.

The early results were graded based on patient satisfaction; visual analog pain scale score; use of pain medication; shoulder motion; subjective shoulder function; and the ability to perform activities of daily living, work, and recreation. Patients with excellent results had visual analog scale pain scores equal to or less than 2, only occasionally took over-the-counter medication for pain, and had subjective improvement in pain and function that warranted an excellent subjective rating of their early results. Patients noted that they would have the procedure again.

Patients with satisfactory results required over-the-counter pain medication at least once per week and had subjective functional impairment with activities of daily living, work, and recreational activities. However, these patients were satisfied with their surgical results overall and would have the procedure again.

Patients with unsatisfactory results had visual analog scale pain scores equal to or greater than 3 and generally had stiff shoulders. They needed daily medication, including occasional narcotic medication, for their shoulder pain. Patients in this group indicated that they would not have the procedure performed again.

**TECHNIQUE**

**Primary Reverse Shoulder Arthroplasty for Cuff Tear Arthropathy**

The surgical technique that we describe is a routine deltopectoral approach in a patient who has cuff

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**Table 1. Indications for Reverse Shoulder Arthroplasty**

<table>
<thead>
<tr>
<th>Type of Indication by Group</th>
<th>No. of Indications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1</strong></td>
<td></td>
</tr>
<tr>
<td>Cuff tear arthropathy</td>
<td>31</td>
</tr>
<tr>
<td>Secondary osteoarthritis and massive rotator cuff tear</td>
<td>10</td>
</tr>
<tr>
<td>Fracture sequelae</td>
<td>10</td>
</tr>
<tr>
<td><strong>Group 2</strong></td>
<td></td>
</tr>
<tr>
<td>Failed rotator cuff repair syndrome</td>
<td>14</td>
</tr>
<tr>
<td>Failed open reduction and internal fixation for fracture</td>
<td>2</td>
</tr>
<tr>
<td>Failed humeral head replacement for fracture</td>
<td>9</td>
</tr>
<tr>
<td>Failed humeral head replacement for osteoarthritis</td>
<td>4</td>
</tr>
<tr>
<td>Failed total shoulder replacement for osteoarthritis</td>
<td>6</td>
</tr>
</tbody>
</table>
tear arthropathy and is receiving a primary RSA. In the preoperative holding area, each patient receives intravenous prophylactic antibiotics, which should be completed before the surgical incision. If appropriate for the patient, the anesthesiologist performs a scalene block that is used in conjunction with general anesthesia during the surgical procedure. Next, the patient is taken to the surgical suite, and the general anesthetic is administered. The patient is placed in the beach chair position with the head and neck safely positioned and secured to a headrest device. All pressure points in the lower extremities and the opposite upper extremity are padded. Perforated protective goggles are placed over the eyes to prevent a suction-cup effect, and a device is placed on the forehead to monitor cerebral oxygen saturation during the procedure while the patient is in the beach chair position (Figure 1).

The patient’s arm is draped free to ensure adequate exposure of the anterior, superior, and posterior shoulder regions and to allow unrestricted positioning of the arm in the adducted, extended, and internally rotated position.

The deltopectoral incision begins inferior to the clavicle and extends 1 cm lateral to the coracoid tip, angling toward the deltoid insertion on the humerus (Figure 2A). A needle-tipped cautery is used to deepen the incision through subcutaneous fat to the deltopectoral fascia. The cephalic vein is exposed and retracted laterally with the deltoid as the deltopectoral fascia is released along the entire length of the skin incision (Figure 2B). Blunt dissection of the subdeltoid space is accomplished while protecting the anterior axillary nerve, which is located along the deep surface of the deltoid muscle about 3 cm below the lateral acromial edge (Figure 3A). The deltoid origin and insertion are maintained intact and are never compromised during the procedure.

The subacromial space also is released from scar and bursal tissue, and a portion of the coracoacromial ligament is released in its midportion after the thoracoacromial artery is cauterized (Figure 3B). The acromiohumeral distance is narrowed because the supraspinatus and infraspinatus tendons are generally absent in patients with cuff tear arthropathy. The deltoid and the cephalic vein are retracted laterally with a Richardson or Browne deltoid retractor, and the superior half of the pectoralis insertion is released to facilitate exposure (Figure 4). Medially, blunt dissection is performed between the pectoralis major and the conjoined tendon and between the conjoined tendon and the subscapularis. Identification of the musculocutaneous nerve deep to the conjoined tendon is important, and sharp dissection medial to the coracoid process is avoided to protect vulnerable neurovascular structures.

Anterior humeral circumflex vessels along the inferior-third of the subscapularis tendon are coagulated or ligated (Figure 5). With the patient’s arm in adduction and external rotation, a vertical incision is
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made through the subscapularis tendon (if present) and capsule 1 cm medial to its insertion on the proximal humerus if the subscapularis tissue quality is adequate for mobilization for repair and if passive external rotation preoperatively is equal to or greater than 20° (Figure 5). If the subscapularis is thin and of poor quality and/or preoperative external rotation is less than 20° with anterior capsular contracture, the tendon is dissected off the lesser tuberosity as lateral as possible to maximize tendon length for attempted repair at the completion of the procedure. A coronal Z-lengthening of the subscapularis tendon is not recommended in these patients. Traction sutures are placed in the subscapularis tendon to assist with medial retraction. The axillary nerve always should be palpated along the inferior and medial subscapularis tendon and muscle, but dissection of the nerve for identification is not advised.

Figure 3A. Subdeltoid blunt dissection.

Figure 3B. Subacromial blunt dissection.

Figure 4. Release of the superior half of pectoralis major.

Figure 5. The subscapularis tendon and capsule incision is made 1 cm medial to its insertion on the lesser tuberosity with tagging sutures placed.
Adduction and gentle progressive external rotation and extension of the arm at the side of the operating table allow for sharp release of the capsule from the anterior, inferior, and posterior humeral neck under direct vision. A small Darrach retractor is placed inside the joint inferiorly and gently pulled inferiorly and medially to place the capsule under some tension to make dissecting off the humeral neck easier and to protect the axillary nerve (Figure 6). Adequate anterior, inferior, and posterior capsular release is critical to optimize glenoid exposure later in the procedure. Two large Darrach retractors are placed into the joint and posterior to the humeral head, and, with adduction, internal rotation, and extension of the arm, the humeral head is dislocated anteriorly. If the biceps tendon is partially or completely intact, it is released near the proximal bicipital groove at the level of the humeral neck cut. Tenodesis of the biceps tendon is not recommended.

The humeral head of the patient with cuff tear arthropathy generally is rounded or “femoralized,” softened, and void of additional soft tissue attachment except for the teres minor tendon posteriorly (Figure 7). The humeral head resection guide and the humeral preparation instrumentation for the selected shoulder system are used to remove the humeral head and prepare the humeral canal to receive the humeral stem trial component. The humeral neck cut usually is performed at 10° to 20° of retroversion. Osteophytes around the humeral neck are removed with a rongeur or osteotome. Placement of the humeral trial component protects the proximal humeral bone from injury during glenoid preparation and implantation.

Adequate surgical exposure and access to the glenoid is critical for glenoid preparation and implantation. A Fukuda retractor is used to retract the proximal humerus posteriorly, and a global intra-articular and extra-articular mobilization of the subscapularis tendon is performed if the tendon is to be repaired later in the procedure.

Circumferential capsular release and excision of any remaining degenerative labrum and osteophytes around the glenoid rim expose the true glenoid surface (Figure 8). Inferiorly, the long head of the triceps is bluntly elevated off the glenoid neck, and the lateral border of the scapula is exposed to allow digital palpation of its anterior and posterior surfaces. The inferior edge of the glenoid drill guide is placed along the inferior edge of the glenoid (Figure 9A), and the centering hole is drilled with a 0° to 15° inferior tilt to minimize the risk of scapular notching and to minimize shear forces across the bone-baseplate interface (Figure 9B). Superior tilt of the glenoid face is avoided when preparing the native glenoid for implantation.
Glenoid reamers are used to prepare the glenoid surface for the baseplate, which is secured to the glenoid with locking screws. All soft tissue must be cleared completely around the glenoid to allow for a secure fixation of the glenoshere to the baseplate. The size of the glenosphere chosen is predicated on the amount of soft tissue contracture, dead space, patient size, glenoid bone quality, availability and quality of the subscapularis tendon for repair, and potential for prosthetic instability.13 After the glenosphere has been implanted, the proximal humerus is dislocated anteriorly into the wound; various humeral polyethylene inserts are placed on the humeral stem; and the joint is reduced and tested for stability, range of motion, and myofascial sleeve tension. The humeral component is removed, and a cement restrictor is placed down the humeral canal approximately 10 mm below the length of the distal tip of the chosen humeral stem prosthesis. Transosse-
ous sutures are placed in the proximal humerus and through the osteotomy site for repair of the subscapularis, which might be performed later in the procedure (Figure 10). The humeral canal is irrigated copiously and is dried meticulously. Cement is introduced with a cement gun into the distal half of the prepared humeral canal, and the humeral stem is implanted at the predetermined height and version. The selected humeral polyethylene insert is impacted on the humeral stem, and the joint is reduced and tested again for full range of motion, muscle tension, and stability. The subscapularis tendon is repaired to the lateral tendon stump and to bone using the previously placed transosseous sutures and tendon-to-tendon single interrupted sutures. Severe anterior contracture of the subscapularis might necessitate a more medial tendon repair to bone along the osteotomy site if the tissue is adequate. The wound is closed in layers over 1 or 2 hemovac drains. Postoperatively, the arm is placed in a sling for comfort.

Revision Reverse Shoulder Arthroplasty

We discuss typical technical strategies used for revision RSA for a failed cemented humeral head replacement, which had been used to treat a complex proximal humerus fracture or arthritis. This revision RSA involves removal of the original prosthesis through a deltopectoral approach. All steps of the procedure will not be discussed because most are similar to the technique described for primary reverse shoulder arthroplasty.

Preoperatively, the surgeon must identify if the joint is potentially septic; must identify the type of existing prosthetic replacement; and must have quality radiographs, an erythrocyte sedimentation rate, C-reactive protein, and complete blood count with differential. An aspiration of the glenohumeral joint under radiographic guidance also is considered if evidence of infection is present.

Through preoperative planning, the surgeon should anticipate potential glenoid-sided or humeral-sided bone loss, intraoperative fracture, and humeral osteotomy that would require stabilization at the completion of the procedure. Accordingly, allograft and autograft options should be available. If the surgeon does not suspect preoperative infection, prophylactic antibiotics should be given in the holding area, as described for the primary RSA procedure. If the surgeon strongly suspects preoperative infection, he or she might prefer to withhold prophylactic antibiotics until cultures of the joint and soft tissues have been taken during the procedure. Antibiotics would be given after cultures have been obtained.

The deltopectoral incision is ideally suited for revision RSA because soft tissue dissection and removal of hardware or previously placed prosthetic components are technically easier with this exposure. If a previous deltopectoral incision has been made, it generally should be extended proximal to the clavicle and distally for at least 1 inch (2.54 cm) below the distal extent of the previous incision to help demarcate between normal and scarred tissue. This is very helpful during the soft tissue dissection.

If the deltopectoral interval is difficult to identify and the cephalic vein is absent or previously ligated, the proper interval can be determined by palpating the empty space or triangle bound by the coracoid base, deltoid, and pectoralis major. Blunt and sharp dissection generally are required to release the subdeltoid and subacromial spaces, and rotation and positioning of the arm might improve visibility and access to these spaces. Spreading in the subdeltoid interval with a long-handled hemostat allows the surgeon to place a Darrach retractor in the proper interval, which then allows the surgeon to use Mayo scissors to release...
scar tissue and adhesions between the deltoid and the underlying prosthesis and proximal humerus (Figure 11). We prefer to place Mayo scissors over the humeral head with the concavity of the scissor tips pointing down to allow a safe release of scar and soft tissue over the humeral head and around the lateral and posterior extent of the greater tuberosity.

After anterior dislocation of the prosthesis into the wound, the modular head is removed, and fibrous tissue and excess cement are dissected from the proximal end of the humeral stem. The prosthetic cement interface is disrupted with a small, curved osteotome to loosen the prosthesis for about 1 cm. A few gentle attempts are made to extricate the cemented humeral stem from the shaft by placing a tamp or duck bill instrument under the collar of the prosthesis and by gently hitting the handle of the retractor in line with the prosthesis and shaft to remove it. Alternatively, some implants have a specific extraction device that can be used to remove the humeral stem. If the prosthesis is fixated solidly, a humeral osteotomy is performed.

The humeral osteotomy begins at the proximal humerus and extends to the distal tip of the original prosthesis, which is generally from 120 to 130 mm. This length of osteotomy can be verified using intraoperative C-arm fluoroscopy. A strip of humeral bone that is approximately 8 mm wide is removed as a single piece of bone just lateral to the lateral bicipital ridge and anterior to the insertion of the deltoid tendon on the humerus. Several 2-mm drill holes are placed 1 cm apart from each other from proximal to distal to outline the sides of the humeral strip (Figure 12A). These drill holes then are connected with a small oscillating saw, and the bone strip is disengaged from the underlying prosthetic stem and cement with a curved osteotome (Figure 12B). All exposed cement remaining in the humeral canal and obscuring full visualization of the humeral component is removed from top to bottom (Figure 12C). The prosthesis usually can be removed gently with a tamp or duck bill instrument and mallet. To avoid a humeral shaft fracture at the osteotomy site during the remaining portion of the procedure until humeral implantation, the trial humeral component is placed in the humerus with the humeral strip of bone replaced anatomically, and 2 or 3 cerclage cables are placed loosely around the humeral shaft and snugged but not tightened. These cables are tightened appropriately after implantation of the reverse humeral prosthesis (Figure 12D).
Removing the entire cement mantle from the humeral canal in a revision case is not necessary unless the revision is for infection. A long end-cut-end cutting drill bit or ultrasonic cement removal tool can be used to remove enough of the cement distal to the tip of the prosthesis and/or the cement restrictor to enable the surgeon to obtain distal cement fixation when implanting the reverse humeral stem. As necessary, a long-stem reverse humeral component can be used to bypass the distal end of the humeral osteotomy site, which potentially can be a stress riser, or can be used when an intraoperative humeral shaft stress fracture occurs during the procedure. Antibiotic-impregnated cement is recommended for all revision RSAs, particularly when a previously placed prosthesis is removed (Figure 13).

After the reverse prosthesis has been implanted, the surgeon reduces the joint and determines appropriate stability. The subscapularis can be repaired if it is of reasonable quality and has been mobilized adequately to allow passive external rotation with the arm at the side to at least 40° without tension on the suture line. If the subscapularis is of inferior quality and is contracted or scarred, it is not repaired during the procedure.

RESULTS

We observed 1 intraoperative complication in Group 1 and 8 intraoperative complications in 6 patients in Group 2 (Table 2). In Group 1, an 81-year-old woman had a small amount of cement outside the humeral canal at the distal tip of the prosthesis site on postoperative films. This cement extrusion did not affect her postoperative result. In Group 2, humeral shaft fractures occurred while cemented humeral head prostheses were removed in 2 patients; 1 patient had a humeral osteotomy, and 1 patient did not. Both patients had cerclage cables placed around the reduced humeral shaft for fracture stabilization. Their humeral fractures healed, but they developed postoperative complications, which are described later in this section. When removing previously placed humeral prostheses, we also noted 5 patients had medial calcar fractures; all were cemented. None of these calcar fractures were problematic after stabilization around the reverse humeral prosthesis with cerclage cables or suture fixation techniques. In 1 patient, a greater tuberosity fracture occurred during implant removal, and this was fixed with suture technique.

In Group 1, 11 postoperative complications occurred in 11 patients (Table 3). One of these patients had par-
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tial atraumatic disengagement of the glenosphere from the baseplate diagnosed by radiograph during a follow-up clinic visit 1 week after surgery. This was believed to be a surgical error, and the 40-mm glenosphere was exchanged for a 36-mm component 2 weeks after the original procedure was performed. One patient fell onto his shoulder, disengaged the polyethylene liner, and required revision of the liner. Another patient fell 7 months after his operation and landed on his elbow, sustaining a vertical fracture of the scapular spine and destabilizing most of the deltoid origin. Imaging showed that the fracture started at the tip of a screw placed to stabilize the glenoid baseplate; this was treated with locked compression plating. One patient who had severe Parkinson disease and bilateral deep-brain stimulators and who used the upper extremities to weight bear immediately after surgery sustained a glenoid failure, which was treated nonoperatively. One patient with a preoperative brachial plexopathy developed heterotopic ossification and stiffness. Two patients developed spontaneous onset of acromial pain at the base of the acromion that was self-limiting and treated with a neutral rotation sling. Four patients developed stiff, painful shoulders after RSA for cuff tear arthropathy (2 patients), posttraumatic arthrosis with preoperative ankylosis (1 patient), and fracture sequelae (1 patient), but all declined additional surgery for release of adhesions. For patients in Group 1, the postoperative visual analog scale pain score was 1.04, average active forward elevation was 126°, and average active external rotation was 26°.

In Group 2, 8 postoperative complications occurred in 5 patients (Table 3). Four patients had postoperative stiffness and pain. Of these patients, 2 had intraoperative humeral shaft fractures that healed after the reduced fractures were stabilized with cerclage cables. However, they developed painful, stiff shoulders as postoperative complications, and 1 patient eventually required a reoperation for lysis of adhesions in the subdeltoid space and removal of the cables. Of the 2 other patients with postoperative pain and stiffness, 1 patient developed a late acromial fracture noted 18 months after surgery and refused additional surgery, and 1 patient had a preoperative acromial fracture nonunion as a complication of a failed open rotator cuff repair and decompression that was not considered to be repairable at the time of the RSA. These 4 patients had postoperative visual analog scale pain scores equal to or greater than 4, average active forward elevation of 75°, and average active external rotation of 5°. The fifth patient had a superficial stitch abscess that resolved with routine wound care and postoperative antibiotics. For patients in Group 2, the average postoperative active forward elevation was 142°.

In Group 1, the average visual analog scale pain score improved from 9.09 preoperatively to 1.04 post-

### Table 2. Intraoperative Complications

<table>
<thead>
<tr>
<th>Type of Complication by Group</th>
<th>No. of Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1</strong></td>
<td></td>
</tr>
<tr>
<td>Cement outside the humerus</td>
<td>1</td>
</tr>
<tr>
<td><strong>Group 2</strong></td>
<td></td>
</tr>
<tr>
<td>Humeral shaft fracture</td>
<td>2</td>
</tr>
<tr>
<td>Medial calcar fracture</td>
<td>5</td>
</tr>
<tr>
<td>Tuberosity fracture</td>
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</table>

*Indicates 1 complication in 1 patient.

*Indicates 8 complications in 6 patients.

### Table 3. Early Postoperative Complications

<table>
<thead>
<tr>
<th>Type of Complication by Group</th>
<th>No. of Complications</th>
</tr>
</thead>
<tbody>
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<td><strong>Group 1</strong></td>
<td></td>
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<tr>
<td>Disengagement of the glenoid component</td>
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</tr>
<tr>
<td>Stiffness</td>
<td>4</td>
</tr>
<tr>
<td>Disengagement of polyethylene liner due to fall</td>
<td>1</td>
</tr>
<tr>
<td>Fracture of acromial spine due to fall</td>
<td>1</td>
</tr>
<tr>
<td>Heterotopic ossification with stiffness</td>
<td>1</td>
</tr>
<tr>
<td>Acromial pain that resolved</td>
<td>2</td>
</tr>
<tr>
<td>Glenoid failure</td>
<td>1</td>
</tr>
<tr>
<td><strong>Group 2</strong></td>
<td></td>
</tr>
<tr>
<td>Stiffness</td>
<td>4</td>
</tr>
<tr>
<td>Acromial fracture</td>
<td>1</td>
</tr>
<tr>
<td>Superficial stitch abscess</td>
<td>1</td>
</tr>
<tr>
<td>Tenderness/pain over cerclage cables</td>
<td>2</td>
</tr>
</tbody>
</table>

*Indicates 11 complications in 11 patients.

*Indicates 8 complications in 5 patients.
operatively (range, 0-5). In Group 2, the average visual analog scale pain score improved from 9.02 preoperatively to 1.34 postoperatively (range, 0-3).

In Group 1, 38 patients rated their results as excellent; 8, satisfactory; and 5, unsatisfactory. Forty-nine of 51 patients indicated that they would have the operation again. In Group 2, 23 patients rated their results as excellent; 8, satisfactory; and 4, unsatisfactory. The patients with unsatisfactory results had postoperative stiffness and pain. Thirty-two of 35 patients indicated that they would have the operation again.

**Subscapularis**

Only 10 of 51 patients in Group 1 and 11 of 35 patients in Group 2 had subscapularis repairs. We found no association between subscapularis integrity and instability in these patients undergoing RSA through the deltopectoral approach.

**Glenosphere Size**

We used 36-mm, 38-mm, 42-mm, and 46-mm glenospheres and found no association between glenoid size and results based on our population size.

**Notching**

In Group 1, 31 patients had Nerot grade 0 notching, meaning they had no signs of notching. Seventeen patients had Nerot grade 1 notching, meaning they had minimal changes at the most inferior scapular neck. One patient had grade 2 notching, indicating notching but not up to the inferior screw. The 1 patient with the acromial fracture due to a fall was considered to have grade 3 notching, and the 1 patient with a frank glenoid failure was considered to have grade 4 notching. Two patients with Nerot grade 0 notching rated their shoulders as unsatisfactory: 1 patient for pain and 1 patient for loss of motion. All patients with Nerot grade 1 notching rated their shoulders as satisfactory or excellent. The 1 patient with Nerot grade 2 changes had an unsatisfactory result because of stiffness. The patient with Nerot grade 3 changes rated his shoulder as satisfactory with minimal pain at 30 months after surgery, and the only patient with grade 4 notching had a complete glenoid failure and an unsatisfactory result.

In Group 2, 27 patients had grade 0; 7, grade 1; and 1, grade 2 notching. The 1 patient with an unsatisfactory result had no pain, 130° of elevation, 30° of external rotation, and Nerot grade 0 notching.

We found no pattern between Nerot grade and preoperative diagnosis, primary and revision surgeries, sexes, ages, preoperative and postoperative pain scores, surgical findings, glenosphere sizes, complications, surgical results, or levels of patient satisfaction.

**DISCUSSION**

**Overall Results of Reverse Shoulder Arthroplasty**

Several authors have studied RSA and have found it is a reliable salvage procedure for complex conditions of the shoulder.1,5,10-12,14 Our short-term results appear to support this argument, but one should not assume that short-term and long-term results will be similar. We prefer the deltopectoral approach for RSA because we are familiar with it, the deltoid is protected, and it can become an extensile approach as needed. We encountered 11 complications in the primary RSA group and 8 complications in the revision RSA group, with an overall rate of 22.1%. Despite this complication rate, the level of patient satisfaction in our study was high largely because of the improvement in pain and function after surgery.

**Subscapularis**

Instability of the RSA prosthesis has been considered one of the major problems associated with this operation. The factors associated with instability of an RSA have been inadequate tissue tensioning, mechanical impingement resulting in “open booking,” the use of the deltopectoral exposure, and subscapularis deficiency.14 Our finding of no association between subscapularis integrity and instability in patients undergoing RSA through the deltopectoral approach seems to contradict the findings of Edwards et al.,14 who believed that a deficient subscapularis increases the likelihood of instability after RSA.

**Glenoid Failure**

The 1 glenoid failure occurred in a patient who had severe Parkinson disease with bilateral deep-brain stimulators. As described, the patient immediately
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bore weight on the operated extremity and developed migration of the glenoid component. He rated his result as unsatisfactory but indicated that he would have the operation again, given the same situation. We do not recommend performing RSA in patients who must immediately bear substantial weight on the affected extremity and suggest using caution in patients with Parkinson disease.

Deltopectoral Approach

The superolateral approach may be used effectively for RSA surgery; however, it seems counterintuitive to elect an approach that surgically divides the muscle responsible for motion after RSA. The advantages of using a deltopectoral approach are surgeon familiarity, the ability to convert the exposure into an extensile approach if needed, and the absence of surgical trauma to the deltoid origin and insertion.

Seebauer reported on insertion of RSA through a superior (Mackenzie) approach. The complications that he reported were glenosphere separation from baseplate, axillary nerve injuries, brachial plexus stretch injury from inferior displacement of the humerus to visualize the glenoid, notching of the glenoid, loosening of noncemented implants, late deep infections, instability, and deltoid dehiscence. Infections and notching have been shown to occur in RSA regardless of approach. Axillary nerve injuries from extension of a deltoid split, plexus injuries from caudal retraction of the humerus, and deltoid dehiscence appear to be complications that are directly related to a superior approach. Mole and Sirveaux also reported that glenoid-sided complications are problems with the superior approach.

Overall, complications from RSA surgery are the most frequent in patients having a revision procedure to treat failed arthroplasty or fracture sequelae, and instability is the most frequent complication. Wall et al reported that complications were almost 3 times more likely in revision RSA surgery than in primary RSA surgery. Wall et al reported that the deltopectoral approach for RSA was more likely to result in instability. The rate of instability was 0 with a superolateral approach and was 6% with the deltopectoral approach. Interestingly, most instability cases involved revision arthroplasty, tumor reconstruction, and fracture sequelae; these surgical problems can be difficult, if not impossible, to manage safely and effectively through a superolateral approach. Preservation of the anteroinferior capsule in the superolateral approach is thought to be the reason that instability occurs less frequently through the superolateral approach. We believe that anteroinferior exposure of the glenoid via capsulotomy or capsulectomy is critical to optimize the placement and orientation of the glenoid baseplate. All patients in our study underwent extensive capsular release, including the inferior capsule.

Instability typically occurs within the first 30 days after surgery in more than two-thirds of the cases. In our patients, we used the deltopectoral approach and found no instability at an average 17.2-month follow-up. Instability in RSA surgery also has been reported after a deltoid splitting/superior approach.

Subscapularis insufficiency and the deltopectoral approach have been considered to cause instability after RSA. Sixty-five of 86 patients in our study had deltopectoral approaches and irreparable subscapularis tendons. Twenty-four of these patients were in Group 2 (revision-surgery group). Even in this highest risk group, we found no instability of the RSA at follow-up.

Mole and Sirveaux analyzed glenoid-sided failure in 527 consecutive cases of RSA. The most common cause of glenoid failure was malpositioning of the glenoid implant through a superior approach. The only glenoid baseplate failure was the result of weightbearing on the operative shoulder in a patient with Parkinson disease.

Humeral shaft fractures during revision shoulder arthroplasty are not uncommon. We encountered 8 fracture complications in 6 patients in Group 2. Similar to Chuinard et al, we found that a decrease in function was associated with humeral shaft fractures. The deltopectoral approach allows for easier intraoperative management of previous implant removal, including humerotomy, and the potential fractures that can occur during cement or implant extraction.

When considering potential approaches to the shoulder for RSA surgery, we recognize that specific risks are associated with the superior and deltopectoral approaches. The only major postoperative problem historically associated with the deltopectoral approach has been instability; however, several potential is-
issues related to a superior approach can jeopardize the results of a RSA. Excellent results can be achieved in experienced hands using either approach, and our preference is the deltopectoral approach.

CONCLUSIONS

The deltopectoral approach for RSA allows reliable exposure of the shoulder joint and provides the necessary extensile access needed for management of intraoperative complications and revision shoulder arthroplasty surgery. No instability problems were encountered in this series of patients operated through the deltopectoral approach despite only 21 of 86 patients having a subscapularis repair. We did not observe an association between instability and the subscapularis or the approach in our series. This report represents retrospective analysis from 2 higher volume, tertiary shoulder centers and provides early results; they should not be implied as long-term data.

We consider RSA to be an effective salvage procedure for complex shoulder disorders and counsel patients that improvements in pain are more reliable than restoration of full motion. In our series, 90% of patients with primary RSA and 89% of the patients with revision RSA rated their results as satisfactory or excellent, with an average active forward elevation of 126° in patients with primary RSA and 142° in patients with revision surgery.

REFERENCES