Subscapularis insufficiency and the risk of shoulder dislocation after reverse shoulder arthroplasty

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Hypothesis: Dislocation is the most common serious complication after reverse shoulder arthroplasty. One theorized cause is subscapularis insufficiency because the tendon cannot be repaired at the time of surgery. There are no documented risk assessments of reverse total shoulder arthroplasty dislocation related to this cause. The study objective was to quantify the risk of postoperative dislocation after reverse total shoulder arthroplasty in patients with a subscapularis tendon that was irreparable at the time of surgery.

Method: A prospective evaluation was done of 138 consecutive reverse arthroplasties performed through a deltopectoral approach by a single surgeon (average follow-up, 36 months).

Results: The subscapularis was reparable in 62 patients and irreparable in 76 at the conclusion of the procedure. Seven postoperative dislocations occurred; all dislocations were in patients whose subscapularis was irreparable (P = .012). Dislocations were more likely in patients with complex diagnoses, including proximal humeral nonunion, fixed glenohumeral dislocation, and failed prior arthroplasty.

Conclusions: This report documents that an irreparable subscapularis tendon at the time of reverse total shoulder arthroplasty using a deltopectoral approach results in a statistically significant risk for postoperative dislocation.

Level of Evidence: Level IV, Case Series, Treatment Study
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Keywords: Subscapularis; irreparable; reverse; shoulder; arthroplasty; complication; instability; dislocation

Paul Grammont8 first reported his modern design for a reverse shoulder prosthesis in 1987. The reverse shoulder was initially designed for end-stage rotator cuff arthropathy and pseudoparalysis with inability to elevate the arm. The development and improvement of Grammont’s original design has led to the reverse shoulder prosthesis becoming an important tool in the treatment of difficult shoulder pathologies.4,5,13-15 The exciting treatment possibilities and results offered by the reverse prosthesis has led to an explosion of its use. However, the excitement must be tempered by the higher complication rate of reverse shoulder arthroplasty compared with unconstrained shoulder arthroplasty. Studies of reverse total shoulder arthroplasty (TSA) that included more than 30 patients have reported overall complication rates of 10% to 47%, with dislocation rates of 0% to 9%.3,5,6,9,10,14-17 In these studies, dislocations accounted for up to 44% of all complications.

Causes of reverse TSA dislocation are often discussed and include the number of prior procedures, surgical approach, bone deficiency, subscapularis insufficiency, mechanical factors, and trauma. The literature contains no risk assessments of reverse TSA dislocation based on known possible causes. Many patients requiring reverse TSA do not have a sufficient subscapularis tendon to repair...
because of a chronic tear with retraction and fatty infiltration or loss of the lesser tuberosity. Boulahia et al\textsuperscript{2} stated that repair of the subscapularis did not affect the functional outcome in reverse TSA patients operated on for cuff tear arthropathy. Wall et al\textsuperscript{16} also reported no effect of subscapularis repair on postoperative complications in their series. The objective of this study is to definitively quantify the risk of postoperative dislocation after reverse TSA in patients with an irreparable subscapularis tendon.

Materials and methods

Study group

This study prospectively evaluated 138 consecutive reverse TSAs performed through a deltopectoral approach by a single surgeon between July 2004 and December 2006. Of these, 44 shoulders belonged to men (32%), and 94 belonged to women (68%), and their average age was 67.5 years and 69.0 years, respectively. The dominant shoulder was the operative side 57% of the time. Average follow-up was 36 months (range, 21-56 months).

Patients undergoing reverse TSA in the treatment of an acute proximal humeral fracture were not included in this study group. The diagnoses of patients that were included were rotator cuff arthropathy (43.5%), revision arthroplasty (23.9%), proximal humeral malunion or nonunion (15.3%), massive rotator cuff tear with pseudoparalysis and no arthritis (7.2%), fixed shoulder dislocation (4.3%), rheumatoid arthritis with massive rotator cuff tear (3.6%), and postinfectious arthropathy with massive rotator cuff tear (2.2%).

Patient evaluation

The condition of the rotator cuff was evaluated by preoperative magnetic resonance imaging (MRI) or computed tomographic arthography. Advanced preoperative imaging is routine in our practice. The preoperative rotator cuff integrity, muscle quality, and grade of fatty infiltration and atrophy are important in discussions of postoperative expectations and outcomes. Detailed preoperative planning may be required in cases of large glenoid cysts or glenoid bone defects not appreciated on plain x-ray films. These bone defects, if not considered before surgery, could have an adverse effect on seating of the glenoid component. Isolated supraspinatus or subscapularis tears were found in 21.1%, subscapularis and supraspinatus tears in 5.8%, 3-tendon tears in 28.9%, and 4-tendon disruptions in 24.6%.

The presence and grade of fatty infiltration in the rotator cuff musculature was documented for each patient using the classification system of Goutallier et al\textsuperscript{7} for patients with preoperative CT scans. In patients with preoperative MRI, the Goutallier classification was adapted using the same axial sequences described for CT assessment. Fatty infiltration data are reported in Table I.

Radiographs were analyzed postoperatively at 1, 6, and 12 weeks, 6 months, and 1 year. Radiographs were reviewed to determine if dislocation of the reverse TSA had occurred and for the presence or absence of proximal humeral bone loss (Figure 1).

Bone loss was evaluated postoperatively and was defined as the absence of the lesser tuberosity or proximal medial cortex. In 17 of the 32 patients undergoing revision arthroplasty, the bone was lost intraoperatively during removal of the primary prosthesis. In the other instances of bone loss, the bone loss was evident preoperatively in patients with malunion/nonunion (15 of 20), postinfectious arthropathy (2 of 3), rheumatoid arthritis (1 of 5), and cuff tear arthropathy (1 of 61).

Operative technique

The Aequalis reverse total shoulder system (Tornier Inc, Eden Prairie, MN) was used in all patients. In all patients the reverse prosthesis was implanted through the deltopectoral approach. The coracoacromial ligament and superior 1 cm of the pectoralis major were released in all patients. A tenodesis or tenotomy of the long head of the biceps tendon was also routine. The subscapularis, if intact at the time of surgery, was released using a transtendinous tenotomy and was circumferentially released to increase postoperative external rotation and facilitate repair.

Preparation of the glenoid included reaming an inferior tilt of 10°, and a 36-mm glenosphere was used universally. The humeral implant was cemented in 10° of retroversion in all patients. Deltoid tension was assessed with the patient under complete neuromuscular paralysis. Humeral component length was increased using incrementally sized polyethylene spacers until axial motion between the glensosphere and the humeral component was less than 2 mm with longitudinal traction.

The status of the subscapularis tendon and whether or not it was repairable was assessed and recorded at the time of surgery. When repair was possible, a combined transseous and transstendinous subscapularis repair was completed using high-tensile-strength nonabsorbable No. 2 suture. Repair of the subscapularis tenotomy was successful in 62 shoulders (44.9%) as part of the procedure, but 76 (55.1%) had an insufficient subscapularis that was not amenable to repair (Table II).

A closed suction drain was placed at the time of wound closure and removed the day after surgery in all cases to decrease hematoma formation. Associated procedures in 68 patients (49.3%) at the time of reverse shoulder implantation included humeral bone grafting in 6 (4%), glenoid bone grafting in 14 (10.1%), and concomitant hardware removal in 48 (34.8%), including prostheses, fracture fixation hardware, and suture anchors. No patient underwent concomitant tendon transfers.

Postoperative protocol

All patients wore a neutral rotation brace for 3 to 4 weeks before beginning physical therapy. After this period, aquatic therapy

<table>
<thead>
<tr>
<th>Table I</th>
<th>Fatty infiltration of the rotator cuff musculature</th>
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<tr>
<td>Fatty infiltration grade</td>
<td>Rotator cuff muscle</td>
</tr>
<tr>
<td></td>
<td>Supraspinatus</td>
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<tr>
<td>0, No. (%)</td>
<td>11 (7.9)</td>
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<td>1, No. (%)</td>
<td>13 (9.4)</td>
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<td>2, No. (%)</td>
<td>15 (10.9)</td>
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<tr>
<td>3, No. (%)</td>
<td>13 (9.4)</td>
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<tr>
<td>4, No. (%)</td>
<td>86 (62.4)</td>
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rehabilitation was prescribed whenever possible to improve shoulder range of motion. Therapy was directed to improve elevation, extension, horizontal adduction, external rotation, and then internal rotation in succession. Patients who were unable to participate in aquatic therapy were started on a land-based regimen. After at least 5 weeks of aquatic therapy, if acceptable range of motion was gained, patients graduated to a self-directed land-based program. Strengthening exercises were not prescribed in any patient.

**Postoperative dislocation management**

Patients who presented with postoperative reverse shoulder dislocations were treated with an attempted closed reduction, followed by open reduction and prosthetic augmentation if necessary. Intraoperative fluoroscopy was evaluated to ensure the humeral component was well seated and pointing directly at the glenosphere (Figure 2). After reduction, the patients wore an abduction orthosis for 6 weeks.

**Statistical analysis**

Descriptive statistics were used to analyze the demographic information. Relative risk statistics and $\chi^2$ were used to test the association of various risk factors, namely an irreparable subscapularis tendon, with the occurrence of postoperative dislocation after reverse shoulder arthroplasty. Significance level was set at $P \leq .05$.

**Results**

Within 2 months after implantation, a reverse prosthesis dislocation had occurred in 7 shoulders in 7 patients (5.1%). A closed reduction was possible in 2 patients, and 5 required open deltoid retensioning with a prosthetic augmentation. At the latest follow-up, all of the dislocated prostheses were stable.

All dislocated shoulders had had an irreparable subscapularis at the time of surgery. The relative risk of
postoperative dislocation after reverse TSA in patients with an irreparable subscapularis tendon vs those with a repairable tendon was 1.90 (95% confidence interval [CI], 1.61-2.23; \( P = .013 \)). Therefore, the risk of dislocation after reverse TSA was nearly twice as high in patients with an irreparable subscapularis tendon but no proximal humeral bone loss. Thus, dislocation occurred in the presence of an irreparable subscapularis tendon regardless of the presence of bone loss, but not vice versa.

Of the 36 patients (26.1%) with proximal humeral bone loss (Table II), 35 also had an irreparable subscapularis tendon. No patient with proximal humeral bone loss who had a repairable subscapularis tendon sustained a dislocation, whereas dislocation occurred in 2 patients with an irreparable subscapularis tendon but no proximal humeral bone loss. Thus, dislocation occurred in the presence of an irreparable subscapularis tendon regardless of the presence of bone loss, but not vice versa.

The underlying diagnosis had significant effect in the occurrence of postoperative dislocation. No postoperative dislocations occurred in patients with rotator cuff tear arthropathy or rheumatoid arthritis \( (P < .05) \). Preoperative diagnoses that were involved with dislocations were nonunion of proximal humeral fractures in 4, and 1 patient each with massive rotator cuff tear without arthritis, fixed glenohumeral dislocation, and revision arthroplasty.

The risk of postoperative dislocation after reverse TSA was not significantly related to demographic factors such as gender, age, or upper extremity dominance. A history of dislocation before reverse TSA was not significantly related to postoperative risk of dislocation. Risk of dislocation was not significantly related to the preoperative condition of the other 3 muscles of the rotator cuff, including the presence of fatty infiltration, complete tears of the infraspinatus, supraspinatus, or teres minor tears, and the presence of multiple (combined) rotator cuff tendon tears.

### Discussion

Dislocation is the most common and one of the most serious complications of reverse TSA, with an incidence of up to 9% \(^{3,5,6,9,10,14-17} \) and representing nearly half of all complications in a recent large series. \(^{12} \) A dislocated prosthesis leaves the patient with a nonfunctional shoulder, and often requires an open reduction with polyethylene exchange. Although seemingly benign, operating on the shoulder a second time leaves the patient more vulnerable to infection, a devastating complication, as well as other surgical risks such as hemorrhage, neurovascular injury, and adverse reactions to anesthesia. Avoidance of dislocation is paramount, and understanding the potential causes of reverse prosthesis dislocation is fundamental to improved outcomes.

Our results demonstrate that an insufficient subscapularis at the time of reverse arthroplasty significantly increases the risk of postoperative dislocation when the procedure is performed through a deltopectoral approach. Irreparability of the subscapularis occurred most frequently when using reverse TSA in the treatment of proximal humeral nonunions and other complex diagnoses such as failed prior arthroplasty and fixed dislocation. Irreparability of the subscapularis occurred in only 29% of patients with rotator cuff arthropathy, and no dislocations occurred in this group. Consequently, the risk of dislocation associated with irreparability of the subscapularis appears to be highest in patients with nonunions and other complex diagnoses.

A review of demographic data failed to prove consequential in our study group in regard to postoperative dislocation. Muscle quality, namely fatty infiltration and continuity of muscle-tendon units, were evaluated for the rotator cuff. Fatty infiltration was not related to the incidence of dislocation, nor was the presence of preoperative rotator cuff tears in the supraspinatus, infraspinatus, and teres minor. Tears of these tendons, whether isolated or combined, were not related to dislocation risk.

We did find a correlation between the underlying diagnosis and the occurrence of dislocation. Our primary reverse TSA patients with rotator cuff arthropathy or rheumatoid arthritis had no dislocations. Dislocations were more likely in patients with complex diagnoses including proximal humeral nonunion, fixed glenohumeral dislocation, and failed prior arthroplasty. The increased occurrence of dislocation in these patients was not a surprise and illustrated the reason that early reports of reverse shoulder arthroplasty described high complication rates, namely, that revision surgeries are more difficult and fraught with postoperative problems. No single diagnosis, however, was significantly related to postoperative dislocation.

We found that proximal humeral bone loss was more common in the patients whose prosthesis dislocated. Although 2 dislocations occurred in patients without bone loss, no dislocations occurred when the subscapularis tendon was repaired. We consequently believe this indicates an irreparable subscapularis tendon is the more important component leading to dislocation.

Regardless of the preoperative tendon quality, the ability or inability to repair the subscapularis tendon at the
completion of the procedure is key. This information has a prognostic value for the shoulder surgeon with regard to postoperative patient education. We have begun informing patients with an irreparable subscapularis of their increased risk of dislocation. We continue to follow our routine postoperative protocols, which include abduction bracing for 4 weeks in these patients. Patients with an irreparable subscapularis are not advanced to unprotected range of motion before completion of the 4-week bracing period. We recommend an attempt to repair the subscapularis during reverse TSA through the deltopectoral approach in every case, even in the face of severe fatty infiltration, muscle atrophy, and bone loss.

An appreciation for the causes of postoperative dislocation after reverse shoulder arthroplasty is required. Understanding the effect of these causes is important in perioperative discussions between the surgeon and the patient, and in surgical planning and technique. Our study included a large number of patients operated by the same surgeon using a standardized technique. This obviates many factors related to surgeon variability.

**Conclusions**

The most significant risk factor to postoperative dislocation using the deltopectoral approach is an irreparable subscapularis tendon at the time of surgery. An attempt to repair the subscapularis should be made in every case.

**References**