Use of the Subscapularis Preserving Technique in Anatomic Total Shoulder Arthroplasty

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Abstract
Subscapularis tenotomy for total shoulder arthroplasty has been the standard approach for shoulder surgeons that utilize the deltopectoral approach. The risk of subscapularis insufficiency after this approach has been well documented. In order to avoid subscapularis complications, Lafosse reported a technique for total shoulder arthroplasty that utilizes a trans-deltoid approach through the rotator interval that yielded satisfactory clinical outcomes. However, he also reported concerns about humeral head under-sizing and inadequate osteophyte resection. We present an alternative subscapularis preserving technique that is performed through the deltopectoral interval and allows complete osteophyte excision and accurate humeral head sizing. This technique requires modified instrumentation and is facilitated by the use of an adaptable prosthesis with dual eccentricity. Case examples using this technique are presented.

Primary total shoulder arthroplasty is a reliable method used to alleviate pain and improve function in patients with glenohumeral arthritis. The standard deltopectoral approach requires exposure through the subscapularis tendon by one of three methods including tenotomy, subscapularis tendon peel, or a lesser tuberosity osteotomy. Each technique requires a repair and healing of the subscapularis in order to restore stability and adequate function. It is the subscapularis detachment and repair that limits postoperative physical therapy protocols, requires protection in a sling, restricts initial use of the operative arm for activities of daily living (ADL), and is at risk for inadequate healing. Subscapularis dysfunction and inadequate healing are reported to be common in the literature. Subscapularis insufficiency after anatomic total shoulder arthroplasty (aTSA) has been linked to pain, poor function, and instability. It is a potential cause for early revision. Lafosse and coworkers reported mid-term follow-up of a subscapularis sparing aTSA approach using a deltoid splitting approach. This technique utilized special retractors, a cutting guide, a specialized inserter, and a reverse osteotome to remove osteophytes through the rotator interval window. Although clinical results were good, radiographic outcomes were suboptimal secondary to non-anatomic humeral head osteotomies, residual inferior humeral neck osteophytes, and humeral head under-sizing. Lafosse later modified this technique to perform the procedure through a deltopectoral approach that provided improved access to inferior humeral osteophytes and the anatomic neck. Despite these modifications, anatomic humeral reconstruction remained challenging.

We have used a unique set of instruments combined with a modified subscapularis preserving approach that provides excellent exposure of the glenoid, allows improved anatomic reconstruction, and eliminates the risk of subscapularis insufficiency. This technique utilizes the deltopectoral interval and does not require a deltoid split. This paper describes the technique utilized for this subscapularis preserving approach and reports several case examples to illustrate its use.

Operative Technique
Patients are identified preoperatively for a subscapularis preserving approach by verifying that their rotator cuff is intact. All patients are evaluated with a true AP and axillary...
lateral of the operative shoulder. Confirmation of rotator cuff integrity is achieved either by clinical exam or MRI.

A combination of general anesthesia and a single shot or indwelling interscalene block is utilized. Muscle relaxation (0 twitches), maintained throughout the procedure, is essential. The patient is placed in a beach chair position with the head of the bed elevated approximately 60° to 70°, which is slightly more vertical than used during the standard approach. The shoulder and scapula are widely exposed and draped.

An incision is made approximately 1 cm lateral to the standard deltopectoral incision (Fig. 1). The coracoid is used as a landmark. Full thickness skin flaps are developed in all directions. The cephalic vein is identified. The cephalic vein is mobilized and retracted in the direction that it favors while all bridging vessels are coagulated. The subacromial and subdeltoid spaces are mobilized with release of all adhesions. The clavipectoral fascia is incised lateral to the conjoint tendon and muscles, and these structures are mobilized. A spiked Hohman retractor is placed superior to the coracoacromial ligament, and once visualized, it is completely resected allowing excellent visualization of the rotator interval. Finally, the anterior humeral circumflex artery and two accompanying venae comitantes (three sisters) are cauterized or tied. The axillary nerve can be palpated and should be appreciated at this point.

Exposure of the humerus begins inferiorly. Adequate removal of humeral neck osteophytes and soft tissue release of the inferior capsule requires direct exposure through a subscapularis window. However, the tendinous portion of the subscapularis is preserved. The inferior muscular portion (approximately 5 mm) is released from the humeral neck and

**Figure 1** Incision is approximately 1 cm lateral to the standard deltopectoral incision.

**Figure 2** Inferior osteophytes are resected through a muscular window. The tendinous portion of subscapularis is not violated.

**Figure 3** Bicipital groove (inferiorly) and rotator interval (superiorly) outlined in blue marker prior to exposure.

**Figure 4** Specialized spiked Hohman retractors utilized to retract the rotator interval and protect the rotator cuff insertion. Forceps are pointing to superior border of the subscapularis tendon. The humeral head articular surface is well exposed.
retracted inferiorly. The inferior capsule is then released from its attachment to the humeral neck in an anterior to posterior direction. With progressive external rotation, the inferior and posterior osteophytes become accessible. Osteophytes are removed with a combination of rongeurs and small curved osteotomes (Fig. 2). Depending on the surgeon’s preference, the muscular subscapularis portion that is reflected can be repaired at the conclusion of the case although we generally have not found this to be necessary.

Next, the biceps sheath is opened, and the biceps is secured to the pectoralis major tendon insertion using two non-absorbable stitches. The biceps tendon is divided above the level of tenodesis, and its course is traced proximally to the rotator interval. The rotator interval is opened to expose the biceps, and the biceps is excised from its superior glenoid attachment.

The margins of the rotator interval must now be appreciated. The anterior border of the supraspinatus and the upper rolled border of the subscapularis are now visualized and palpated (Fig. 3). Starting laterally, the thin rotator interval capsular tissue is excised between these two structures. The excision continues medially to the superior glenoid.

Specially designed spiked and angled Hohman retractors are inserted anteriorly deep to the subscapularis tendon and posteriorly along the anatomic neck of the humerus deep to the posterior rotator cuff insertion (Fig. 4). This allows visualization of the anatomic neck of the humerus and provides protection of the rotator cuff insertion.

An extramedullary cutting guide, which references off the bicipital groove, is used to determine the angle of resection of the humeral head (Fig. 5). An attempt is made to match the patient’s anatomic version and neck shaft angle. A version arm can be attached to the cutting guide to estimate version based off the forearm. The guide is provisionally fixed with multiple 2 mm Kirschner wires. The angle of the resection can be confirmed by palpating the inferior aspect of the humeral head through the inferior subscapularis window. A microsagittal saw is used to initiate the head cut, which is then completed with a sharp straight osteotome. Residual osteophytes can be removed at this time. The angle of resection inferiorly can be checked by visualization through the previously made subscapularis muscle window or using fluoroscopy. The resected humeral head is measured to obtain an estimate of the prosthetic head diameter and thickness. An adequate humeral head resection is important to facilitate exposure of the glenoid. If there is concern that an insufficient amount humeral head was removed then the osteotomy should be redone.

The arm is then adducted and extended allowing optimum exposure of the cut surface of the humerus through the rotator interval. A modified Gelpi retractor is then used to retract the anterior and posterior rotator cuff, thus widening the exposure through the rotator interval. The canal is sequentially reamed until cortical chatter is noted. A modified low profile broach handle is then used to sequentially broach the humeral canal (Fig. 6). Next, a trial stem one size smaller than the last broach used is inserted into the humeral canal with a flat metal disc attached to protect the humeral surface during glenoid preparation.

The arm is returned to a neutral position and variably externally rotated to allow glenoid exposure. In general,
minimal external rotation is necessary. The glenoid is exposed by placing a retractor anteriorly along the scapular neck and posteriorly on the edge of the glenoid. A forked or “rabbit ear” retractor is typically used along the inferior glenoid to lever the humerus inferiorly and posteriorly allowing exposure of the glenoid. A 360° capsular release and labral resection is essential for exposure (Fig. 7). The glenoid is then prepared with routine instrumentation to accept either a keeled or pegged component. If a pegged component is desired, a modified articulating angled drill can be used to facilitate preparation of the inferior peg holes (Fig. 8). An appropriately sized glenoid component is then cemented into the glenoid using standard technique. Cement is allowed to cure before returning to the humeral preparation.

The arm is again adducted and extended, and the modified Gelpi retractor is used to retract the margins of the rotator interval. Offset of the humerus is judged by comparing the center of the trial prosthesis to the margins of the humeral cut surface. With greater offset, a 4.5 mm modified short replicator plate is used; if there is minimal offset, a 1.5 mm modified short replicator plate should be used. Modified instruments are used to secure the selected replicator plate to the trial stem. A low profile humeral plate dial is coupled to the short replicator plate. Low profile instruments are then used to rotate the replicator plate and humeral plate dial into the appropriate version, inclination, and offset to yield the best metaphyseal coverage and anatomic restoration (Fig. 9). Once the position is satisfactory, a low profile wrench is used to tighten the torque screw. A trial head is then secured to the replicator plate and a trial reduction performed. Offset of the trial humeral head is noted relative to the offset of the replicator plate and stem.

A back table assembly of the final components is completed (Fig. 10). The replicator position is matched (offset, version, and inclination) and secured to the final stem with a torque limiting wrench and torque screw. The humeral head...
position is dialed to the appropriate offset based on the trial position and impacted in usual fashion to engage the morse taper.

The arm is then positioned in adduction and slight external rotation providing improved exposure through the rotator interval. A low profile humeral insertion device is used to introduce the prosthesis through the rotator interval (Fig. 11). The initial introduction is done with the prosthesis in external rotation, but once the coracoid is cleared, the prosthesis is turned into correct rotation and impacted flush with the cut surface of the bone.

After irrigation and hemostasis is achieved, the rotator interval is closed starting from lateral to medial with interrupted non-absorbable sutures. A drain is used if necessary or depending on surgeon preference.

A sling is provided for comfort but discontinued within 10 to 14 days. Active and active assisted ranges of motion are started immediately, and strengthening is begun once forward elevation to 90° is achieved. Patients are permitted to use the arm for activities of daily living as soon as comfort allows.

Case Examples

Case 1
A 65-year-old, left hand dominant female with osteoarthritis of the left glenoid joint reported a preoperative subjective shoulder value (SSV) of 40% and a pain score of 6 on a 10 point visual analog scale (VAS). Preoperative range of motion was 110° of flexion, 80° of abduction, 15° of external rotation and internal rotation to L5. A subscapularis preserving approach was utilized without the inferior subscapularis muscular window. Osteophyte resection and humeral head sizing was done entirely through the rotator interval. At 1 year and 5 months post-surgery, the SSV was 80% and a pain score of 3 was reported with the patient noting that there was pain intermittently with reaching. Range of motion postoperatively was 155° of flexion, 135° of abduction, 30° of external rotation and internal rotation to L3. Postoperative radiographs demonstrated humeral head under-sizing and a residual inferior osteophyte (Fig. 12). The investigators subsequently added an inferior subscapularis muscular window to avoid this.

Case 2
A 72-year-old, right hand dominant male with osteoarthritis of the right glenoid joint reported a preoperative SSV of 25% and a pain score of 9 on a 10 point VAS. Preoperative range of motion was 70° of flexion, 45° of abduction, 30° of external rotation and internal rotation to the posterior ilium. Two years prior, a contralateral total shoulder arthroplasty was performed using a lesser tuberosity osteotomy. A subscapularis sparing approach with an inferior subscapularis window was utilized to perform a right total shoulder arthroplasty. Follow-up at 1 year and 4 months on the right and 3 years and 6 months on the left have demonstrated a SSV of 90% and 95%, respectively. The VAS pain score on the right and left were 1 out of 10. Postoperative range of motion of the right shoulder was 165° of flexion, 155° of abduction, external rotation to 55° and internal rotation to L1. Postoperative radiographs demonstrated an aTSA in good position and alignment (Fig. 13).

Case 3
A 68-year-old, right hand dominant female diagnosed with osteoarthritis of the right shoulder reported a preoperative subjective shoulder value of 35% and pain score of 8 on a 10 point VAS score. Preoperative range of motion was 90° of flexion, 80° of abduction, 20° of external rotation.
and internal rotation to L5. A subscapularis preserving approach with an inferior window was utilized to perform a right aTSA. At 1 year follow-up, the patient reported a SSV of 90% and a pain score of 0 out of 10. Postoperative radiographs demonstrated an aTSA (Fig. 14).

Discussion

A wide range of subscapularis disruption and dysfunction are reported in the literature.1-6 There is no consensus on how frequent true subscapularis incompetence occurs. However, significantly compromised clinical outcomes have been associated with subscapularis insufficiency. Clinical evidence of subscapularis insufficiency has been reported by Miller and coworkers to be as high as 67.5% in a small series.5 Ultrasound evidence of subscapularis insufficiency after total shoulder arthroplasty has been reported by Armstrong and associates to be 13.3% in a small series.3 Subscapularis insufficiency is a mode of aTSA failure, and Miller and colleagues reported a 5.8% revision rate after total shoulder arthroplasty in a large series.4 Avoiding this complication is clearly desirable. A subscapularis preserving approach avoids this pitfall and allows early active range of motion and return to ADLs.

Traditional aTSA through a deltopectoral interval and subscapularis reflection requires positioning of the patient’s arm in extreme ranges that place a stretch on the brachial plexus including external rotation, abduction, and extension. Nagda and coworkers reported on nerve dysfunction detected intraoperatively during aTSA using intraoperative nerve monitoring.7 A majority of nerve dysfunction was appreciated with the arm in abduction, external rotation, and extension, typically during humeral preparation. Anatomic total shoulder arthroplasty through a subscapularis preserving approach minimizes the time the shoulder is positioned.
in abduction, external rotation, and extension. The majority of the procedure including the entire glenoid preparation and implantation is done with the arm in adduction and only slight external rotation.

Lafosse and associates previously described a rotator interval approach to aTSA using a deltoid splitting approach. We believe the subscapularis preserving approach provides a significant advantage over this previously described technique as it does not violate the deltoid muscle. In addition, one of the most significant self-reported limitations of the previously described technique was inadequate osteophyte resection and humeral head under-sizing. While we initially noted this limitation, it was addressed with the addition of an inferior subscapularis muscular window used to visualize and resect all osteophytes directly while also ensuring adequate humeral head sizing and positioning. We have not appreciated any clinical sequelae of violating the inferior muscular portion of the subscapularis with or without its repair at the conclusion of the surgery.

Our early experience indicates that the subscapularis preserving approach to aTSA is safe and reproducible. There is a relatively steep learning curve. This technique should not be used in a revision setting where wide exposure is necessary. Relative contraindications to this technique include obesity, significant medial glenoid erosion, significant glenoid deformity, or situations in which glenoid bone grafting is needed. Care should also be taken in patients with severe rotator cuff tendinopathy due to the risk of iatrogenic rotator cuff injury from retraction.

Future studies will examine and report on the clinical and radiographic outcomes of aTSA through a subscapularis preserving approach compared to the standard subscapularis reflection method. A prospective randomized study comparing these two approaches is currently underway. In addition, a postoperative ultrasound study will be performed to confirm the integrity of the anterior superior rotator cuff following the subscapularis preserving approach.

Disclosure Statement
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