SUBSPECIALTY PROCEDURES

SUBSCAPULARIS-SPARING ROTATOR INTERVAL APPROACH FOR ANATOMIC TOTAL SHOULDER ARTHROPLASTY

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Abstract

Background: A subscapularis-sparing approach to anatomic total shoulder arthroplasty (TSA) is used for patients with glenohumeral osteoarthritis who have an intact rotator cuff and sufficient bone volume.

Description: A 7 to 10-cm anterosuperior incision is made with the patient in the beach chair position. The anterolateral deltoid muscle raphe is split, and the shoulder is externally rotated to bring the rotator interval to the field. A flap of interval tissue is incised, tenodesis of the biceps tendon is performed, and the interval tissue is incised straight back to the glenoid from the upper edge of the subscapularis, creating a triangular piece of tissue referred to as a “trapdoor.” Two Darrach retractors are placed to expose the humeral head. An intramedullary guide is placed, and a humeral head osteotomy is performed. The glenoid is exposed, and the glenoid component is placed after sizing, preparation, drilling, and insertion of trial components per the surgical technique. The humeral head size is estimated by measuring, and the humeral stem size is decided by sequentially inserting the trial components. The permanent humeral stem is inserted, and the permanent humeral head is implanted after insertion of trial components. The trapdoor is sutured, the deltoid is reattached, and subcutaneous tissue and skin are sutured.

Alternatives: The traditional surgical approach for anatomic TSA involves release and reattachment of the subscapularis tendon.

Rationale: Nearly all anatomic TSA techniques require the subscapularis to be released, with a peel, tenotomy, or osteotomy, and then repaired on completion of the arthroplasty. Failure of the subscapularis to heal is an unfortunate and potentially devastating complication following anatomic TSA that has been linked to decreased function, instability, and pain¹⁻⁴. Subscapularis dysfunction following anatomic TSA is seen in one-third to two-thirds of patients, with evidence of complete tears in up to 50% of asymptomatic patients using ultrasound examinations¹⁻⁵.

Sling immobilization with avoidance of excessive passive external rotation and active internal rotation is recommended to help prevent

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postoperative rupture of the subscapularis repair⁶⁻⁸. However, postoperative motion restrictions to protect the subscapularis may lead to stiffness and may negatively impact function and satisfaction.

We describe a subscapularis-sparing TSA, in which we address and improve on 3 technical difficulties identified by Lafosse et al.⁹: (1) difficulty ensuring an anatomic humeral neck cut because of the difficulty visualizing the anterior aspect of the shoulder, (2) inadequate resection of inferior humeral neck osteophytes, and (3) undersizing of the humeral head.

Introductory Statement

We describe the reasoning and technical considerations of performing a subscapularis-sparing anatomic total shoulder arthroplasty (TSA) using an extensile anterosuperior skin incision and proceeding through the rotator interval that is appropriate in indicated patients.

Indications & Contraindications

Indications

- Osteoarthritis
- Rheumatoid arthritis
- Posttraumatic arthritis
- Osteonecrosis

Contraindications

- Infection in progress
- Rotator cuff tear
- Charcot arthropathy
- Severe neurological pathologies
- Substantial glenoid wear

Step-by-Step Description of Procedure

Step 1: Preoperative Workup (Video 1)

Obtain the history, perform a physical examination, make standard radiographs, and use computed tomography (CT) and magnetic resonance imaging (MRI) to better assess glenoid bone wear and the integrity of the rotator cuff.

- Obtain a thorough history and perform a physical examination to determine the course of the pathology and the current functional limitations of the patient.
- Obtain standard imaging, with all patients receiving anteroposterior, lateral, and axillary radiographs of the shoulder to assess joint space narrowing, humeral head and glenoid deformity, and the size of humeral osteophytes (Figs. 1-A and 1-B).
- Use CT and MRI to better visualize glenoid bone wear and the integrity of the rotator cuff.
- After the patient has had failure of a course of conservative treatment and imaging is consistent with glenohumeral arthritis with an intact rotator cuff, he or she is offered anatomic TSA via the rotator interval approach. The ideal surgical candidate has a normal body mass index (BMI) without a large inferior humeral head osteophyte.
- Contraindications to this procedure are the same as those for an anatomic TSA using the deltopectoral approach and may include substantial glenoid wear or rotator cuff pathology. The patient must have at least neutral external rotation in order to allow adequate visualization of the rotator interval.

Fig. 1-A

Fig. 1-B

Figs. 1-A and 1-B Preoperative radiographs showing the anteroposterior (**Fig. 1-A**) and the axillary (**Fig. 1-B**) view of the right shoulder.

Video 1 Preoperative workup.

Step 2: Positioning (Video 2)

Place the patient in the beach-chair position with all osseous prominences well padded.

- Place the patient on a traditional beach-chair table in the supine position at 45° with all osseous prominences well padded.
- Place a pillow sheet behind the patient to stabilize the scapula.
- Place the torso lateral enough on the operative side so that the medial border of the scapula is on the edge of the bed. This allows for full extension of the arm during the case.

Video 2 Positioning.

Step 3: Initial Incision and Dissection (Video 3)

Make the primary incision and perform subcutaneous dissection.

- Make the primary incision, which is an anterosuperior straight “saber” incision along the Langer line starting 1 cm medial to the anterolateral acromial margin in the anteroinferior direction, and extend it approximately 3 to 4 in (7 to 10 cm), depending on the size of the patient (Fig. 2).
- Beneath the skin, carry the dissection medially to the level of the acromioclavicular (AC) joint and anteroinferiorly so that the raphe between the anterior and middle deltoid is exposed.

Fig. 2

Fig. 2 Rotator interval skin incision based at the anterolateral corner of the acromion extending approximately 6 cm distally toward the axillary crease. The acromion (A), coracoid (C), and clavicle (asterisk) are marked prior to incision.

Video 3 Initial incision and dissection.

Step 4: Splitting of the Deltoid (Video 4)

Split the deltoid and release subdeltoid adhesions.

- Release the deltoid off the anterior aspect of the acromion in the periosteal plane in the shape of a wide V from the AC joint to just over 1 in (3 to 4 cm) anteroinferior to the acromial edge within the anterior and middle deltoid raphe.
- Take care to avoid splitting of the deltoid beyond this level to avoid iatrogenic injury to the axillary nerve. A stay suture may be placed at the inferior extent of the split to help avoid propagation and potential injury to the axillary nerve.
- Palpate the nerve on the deep side of the deltoid to better appreciate its location.
- Place 2 self-retaining retractors with blunt tips at 90° angles to each other to achieve subdeltoid exposure (Fig. 3).
- Perform a subdeltoid adhesion release with either a Langenbeck elevator or the surgeon's finger. Release of the subdeltoid adhesions is an important step to mobilize the tissue planes and thereby facilitate deeper exposure, particularly in patients with limited preoperative motion.

Fig. 3

Fig. 3 Rotator interval approach for subdeltoid exposure. Subperiosteal peel (dotted line) of the deltoid off the anterior edge of the acromion (A) is extended distally (solid line) through a raphe split of the deltoid, which should not extend >4 cm distally to protect the axillary nerve.

Video 4 Splitting of the deltoid.

Step 5: Procession Through the Rotator Interval (Video 5)

Proceed through the rotator interval, remove the biceps tendon from the interval, and incise the interval tissue back to the glenoid, creating a so-called trapdoor attached to the supraspinatus.

- Externally rotate the shoulder to bring the rotator interval into the field and place the subscapularis under tension.
- Palpate the biceps tendon, superior aspect of the subscapularis, and anterior aspect of the supraspinatus.
- Incise a flap of interval tissue from 5 mm posterior to the long head of the biceps tendon, exiting the shoulder joint and piercing the coracohumeral ligament.
- Carry the incision down to the articular insertion of the subscapularis.
- Once the long head of the biceps is clearly identified, release it from the supraglenoid tubercle and then perform tenodesis at the transverse ligament once the arcuate artery within the groove is cauterized.
- Distally, perform tenolysis of the biceps to help ensure proper tension of the long head of the biceps.
- After removing the biceps tendon from the interval, incise the interval tissue straight back to the glenoid from the upper edge of the subscapularis, creating a triangular piece of tissue referred to as a trapdoor attached to the supraspinatus.
- Tuck the trapdoor under the supraspinatus and retract using a deep set of modified Kolbel retractors (Fig. 4).
- Preserve the triangular interval tissue piece for closure on completion of the arthroplasty.
- Use a Darrach retractor to define the interface between the rotator cuff tendon and the articular cartilage. The insertion of the subscapularis onto the humerus should be readily visible.

Fig. 4

Fig. 4 The “trapdoor” incision is made posterior to the biceps tendon and is extended medially to the glenoid tubercle. Laterally, an incision in the rotator interval tissue is made from the upper subscapularis. The leading edge of the supraspinatus is visible superior to the humeral head (H).

Video 5 Procession through the rotator interval.

Step 6: Humeral Head Osteotomy (Video 6)

Perform an osteotomy of the humeral head.

- Place a second Darrach retractor under the supraspinatus to expose the hinge point where the supraspinatus attaches at the junction of the humeral articular surface and the greater tuberosity footprint.
- Use the electrocautery to mark a line from the articular side of the subscapularis to the articular side of the supraspinatus. This marks the line for the saw blade entrance for the humeral head osteotomy after the intramedullary guide is placed (Fig. 5).
- The typical native retroversion is readily apparent as the surgeon is directly visualizing the relationship between the humeral head and the glenoid.
- Place the custom intramedullary guide in the starting insertion point that is identified posterior to the biceps nearest the highest point of the humerus and approximately 5 mm away from the supraspinatus insertion. Take care to retract the supraspinatus out of the cutting plane.
- Open the medullary canal with a rongeur and insert the intramedullary guide.
- Insert the slotted cut portion of the guide in the interval created by the trapdoor (Fig. 6).
- Place the oscillating safety saw (Stryker) in the slot of the guide and perform osteotomy of the humeral head at 132.5°. The use of the safety saw is critical to avoid injury to the anterior and posterior cuff from excessive excursion of the saw blade. Overaggressive advancement of the saw blade medially may place medial structures such as the axillary nerve and artery at risk for injury.
- Remove the humeral head. In larger shoulders or those with excessive deformity, it may be necessary to cut the head into 2 pieces to facilitate extraction.
- Remove the humeral head osteophytes. In most cases, the medial “goat’s beard” osteophytes are removed with the humeral head without an excessively varus cut; however, in some cases, a curet or a medial chamfer cut with the saw may be required to remove them. In addition to sweeping the calcar region with an instrument, the removed osteophyte should match the preoperatively measured inferior osteophyte. If a large superior osteophyte is encountered, the osteophyte can be removed with either a rongeur or a saw using a so-called feathering technique.
- As a check, review the preoperative templating as it will also provide insights as to whether the fixed neck-shaft cutting angle will be sufficient to remove the humeral head osteophytes. Early in the learning curve, intraoperative fluoroscopy may be useful to ensure complete osteophyte excision. At this point, direct attention toward the glenoid.

Fig. 5

Fig. 6

Fig. 5 Humeral head (H) exposure through the rotator interval approach. The rotator interval tissue is seen after elevating the anterior to superior edge of the subscapularis.

Fig. 6 Rotator interval approach with the use of a rotator interval-specific intramedullary guide for a humeral head cut.

Video 6 Humeral head osteotomy.

Step 7: Capsular Release, Glenoid Preparation, and Glenoid Component Implantation (Video 7)

Prepare the glenoid and implant the component.

- Place the self-retaining retractors deeper and adjust to expose the glenoid.
- Inspect the cuff to confirm its integrity.
- Circumferentially resect the labrum and biceps stump and use electrocautery around the glenoid in the periosteal plane to release the capsule to a depth of 1 to 2 cm for approximately the inferior two-thirds of the glenoid. Release of the capsule in the periosteal plane around the glenoid helps to avoid the axillary nerve. The capsule on the undersurface of the subscapularis is not routinely released.
- Readjust the retractors to better visualize the glenoid (Fig. 7). One self-retaining retractor is placed to retract the skin only, while the other deep retractor is used to retract the subscapularis and the trapdoor tissue is flipped deep to the supraspinatus.
- Place the final glenoid component after sizing, preparation, drilling, and insertion of trial components per the surgical technique.

Fig. 7

Fig. 7 Rotator interval approach for glenoid exposure. After the humeral head osteotomy and appropriate retractor placement, adequate exposure of the glenoid is obtained with a guide pin placed for preparation of glenoid implantation.

Video 7 Capsular release, glenoid preparation, and glenoid component implantation.

Step 8: Humeral Component Insertion (Video 8)

Determine the appropriate size of the humeral head and stem and insert the permanent components.

- Estimate the humeral head size by measuring the medial-to-lateral distance across the previously made humeral head cut. This measurement can be compared with the removed head size for secondary confirmation of the measurement. Custom flat rings that mirror the diameters of the humeral head prosthesis are used.
- Enter the canal and sequentially insert the trial stems until the proper height and rotational stability are achieved (Fig. 8). Unfortunately, not all humeral trial components and implants can be used in this step, and especially not the longer diaphyseal fitting stems. Shorter metaphyseal fitting stems are needed as placement requires a nonlinear path.
- Once the appropriate size is determined, insert the permanent humeral stem in the same fashion with 1 to 2 mm of the prosthesis sitting proud to allow for trial insertion and eventual engagement of the Morse taper with the final head implant. A high-offset humeral head is usually used to provide better posterior coverage. The head should closely approximate the rotator cuff in the superior, anterior, and posterior directions without abutment or overhanging of the osteotomy. An eccentric head trial can be adjusted relatively easily to maximize humeral head coverage without impingement of the deep surface of the cuff.
- Range the shoulder to check for stability; translation of approximately 50% posteriorly should be followed by spontaneous reduction. Normal anterior translation is less than posterior, and this is appreciated with this technique. If abutment of the humeral head component on the rotator cuff is a concern, a prosthesis with a smaller head size may be used, or the offset may be adjusted. If excessive laxity is evident, the head thickness can be increased or the posterior capsule can be plicated with an absorbable suture.
- Once the proper size and orientation of the humeral head prosthesis are established (Fig. 9), identify the rotational position of the head on the stem to ensure accurate placement of the final head implant.
- Remove the trial prosthesis.
- Irrigate the joint.
- Check the humeral surface a final time for any residual deformities or osteophytes.
- Insert the permanent humeral head prosthesis, properly rotated and impacted.

Fig. 8

Fig. 9

Fig. 8 Rotator interval approach for humeral stem preparation. Humeral shaft preparation is performed with the arm in adduction, extension, and external rotation.

Fig. 9 Rotator interval approach revealing the trial stem and head placement and reduction. The superior edge of the subscapularis tendon (asterisk) has not been damaged. The rotator interval tissue is reflected and retracted underneath the self-retaining retractor.

Video 8 Humeral component insertion.

Step 9: Closure (Video 9)

After irrigating the shoulder for a final time, close the trapdoor and suture it shut, then reattach the deltoid to the acromion, and close the lateral deltoid.

- Irrigate the shoulder joint for a final time.
- Close the trapdoor (Fig. 10) and rotate the shoulder externally.
- Use interrupted number-1 Vicryl sutures (Ethicon, Johnson & Johnson) to suture the trapdoor shut starting posteriorly at the supraspinatus margin and moving to the corner of the subscapularis and then to the rotator interval and the glenoid. Take care to not overconstrain the interval by excising the interval tissue and suturing the subscapularis to the supraspinatus.
- Change the retractors and reattach the deltoid to the acromion using a transosseous permanent number-2 suture in the medial-to-lateral direction with the knots placed deep.
- Close the lateral deltoid using number-1 Vicryl sutures.
- Close the subcutaneous tissue and skin with application of a sealant to create a watertight closure.
- Apply a waterproof dressing and manage the patient with a temporary sling for comfort.
- A postoperative radiograph is displayed in Figure 11.

Fig. 10

Fig. 11

Fig. 10 The rotator interval approach following the placement of the glenoid and humeral implants and closure of the rotator interval trapdoor.

Fig. 11 Postoperative anteroposterior radiograph of the right shoulder.

Video 9 Closure.

Step 10: Postoperative Care

The patient may remove the brace on postoperative day 1 if the regional anesthetic block has dissipated to allow for supervised shoulder motion.

- Remove the brace during the evening of the day of surgery as long as the regional anesthetic block has dissipated and allow the patient to resume shoulder motion the next day, although most patients wear a sling for 1 to 7 days for their comfort. Restrictions focus on limiting activities that may jeopardize the anterior deltoid repair such as resisted forward elevation, extension, and weight-bearing by the shoulder.
- Note: As only a small portion of the anterior deltoid is detached from the acromion and then repaired with a transosseous permanent suture, we are comfortable with early active elevation and have not found this clinically to be an issue. However, a delay in active elevation may be recommended if a larger portion of the deltoid was detached and repaired, or during the early adoption of this technique.
- Use preemptive analgesia postoperatively; routinely only oral pain medications are needed.
- Use <24 hours of antibiotics as recommended per Surgical Care Improvement Project guidelines¹⁰.

Results

The initial outcomes published in the original technique paper by Lafosse et al.⁹ were a preoperative to postoperative improvement in the Constant score (25.1 to 68.5; $p < 0.001$), visual analog scale for pain (8.1 to 2.4; $p < 0.01$), Simple Shoulder Test (16.1 to 86.8; $p < 0.05$), active forward flexion (71.2° to 48.2°; $p < 0.001$), and strength (3.24 to 8.88 kg). By revisiting the Lafosse technique, we expect improved results by providing a better humeral head visualization and consequent better osteotomy, less residual inferior humeral osteophytes, and enhanced humeral head sizing.

Pitfalls & Challenges

See Table I.

TABLE I Tips, Possible Problems, and Solutions

Step	Tip	Problem	Solution
1. Preoperative workup	Ensure rotator cuff sufficiency and adequate glenoid bone stock	Inconclusive physical examination	Obtain MRI or CT
2. Positioning			
3. Initial incision and dissection			
4. Splitting of the deltoid	Use a finger or retractor to clear posterior subdeltoid adhesions	Axillary nerve injury	Identify and protect the axillary nerve
5. Through the rotator interval	Create the trapdoor: use electrocautery to cut beginning posterior to the bicipital groove and moving anteriorly to the superior part of the subscapularis and then posteriorly to the glenoid rim along the rotator interval	Difficulty visualizing the plane between the subscapularis tendon and the articular cartilage	Use a Darrach retractor to define the interface between the rotator cuff tendon and the articular cartilage
6. Humeral head osteotomy	Make the osteotomy along the plane between the subscapularis tendon and the articular humeral cartilage	Difficulty removing a large or deformed humeral head	Cut the resected piece of bone in half in the same direction as the osteotomy and remove in 2 pieces
7. Capsular release and glenoid component implantation	Use the drill to depress the humerus while drilling into the glenoid	Peripheral holes for the glenoid component are too shallow	Drill additionally into peripheral holes without the guide to augment depth
8. Humeral prosthesis implantation	Leave the humeral stem 1-2 mm proud above the cut surface	Inaccurate sizing of the humeral head due to osteophytes	Measure the distance across the previously made humeral head cut from the medial humeral cortex to the lateral humeral cortex, adjacent to the rotator cuff
9. Closure			
10. Postoperative care	Use only oral pain medications, but do so in a preemptive fashion	Inadequate healing of the deltoid	Limit resisted forward elevation and extension of the shoulder

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