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ORIGINAL ARTICLE

Biomechanical characteristics of subscapularis-sparing approach for anatomic total shoulder arthroplasty

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Background: A technique for retaining the superior 50% of the subscapularis insertion for anatomic total shoulder arthroplasty has been described. This cadaveric study biomechanically evaluates this subscapularis-sparing approach and compares it with a complete subscapularis release and repair technique to determine whether there is a higher load to failure.
Materials and methods: Twelve matched pairs of human cadaveric arms were distributed into 3 test groups. Group 1 consisted of specimens with and without a 100% subscapularis release. Group 2 consisted of specimens with and without an inferior 50% subscapularis release. Group 3 consisted of specimens with either an inferior 50% or 100% release of the subscapularis footprint and repair. All tendon repairs were performed using bone tunnels and sutures. Specimens were biomechanically tested using non-destructive cyclic and tensile failure-inducing loads.
Results: In matched pairs, the following comparative results were obtained: native intact subscapularis specimens exhibited a load to failure of 1341.20 ± 380.10 N compared with 380.10 ± 138.79 N in the 100% release specimens ($P = .029$), native intact subscapularis specimens exhibited a load to failure of 1209.74 ± 342.18 N compared with 744.33 ± 211.77 N in the 50% release specimens ($P = .057$), and 50% release and repair specimens exhibited a load to failure of 704.62 ± 165.53 N compared with 305.52 ± 91.39 N in the 100% release and repair group ($P = .029$).
Conclusion: Preservation of the superior 50% of the subscapularis demonstrates a higher load to failure compared with complete subscapularis release and repair using bone tunnels.
Level of evidence: Basic Science Study; Biomechanics

Keywords: Shoulder arthroplasty; anatomic total shoulder arthroplasty; subscapularis-sparing approach; tendon strength; subscapularis tenotomy; rotator cuff–sparing approach; load to failure

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The subscapularis (SSC) is essential for implant stability and function after anatomic total shoulder arthroplasty (aTSA). The SSC provides the necessary soft-tissue balancing and support for various functional activities of the shoulder joint. SSC insufficiency after aTSA has been associated with implant instability and poor clinical and functional outcomes, often necessitating revision surgery.[2,6,9,10] All routine repair techniques following a complete SSC release for aTSA are susceptible to failure from elevated forces resulting from rehabilitation and activities of daily living (ADLs) after surgery. Furthermore, current postsurgical rehabilitation protocols for aTSA often require protection in a sling, thereby limiting the initial use of the operative arm for ADLs.

Surgical techniques that maintain SSC integrity during aTSA through an SSC-sparing approach[4,8,13-16] vary with the amount of SSC preserved (complete or partial release), as well as the approach for implant insertion. The goal of all SSC-sparing techniques is to limit the degree of violation of the native SSC, minimize the potential for failures arising from SSC insufficiency, and allow early aggressive rehabilitation and return to ADLs.

The biomechanical advantages of SSC preservation while performing an aTSA are still controversial, and literature supporting the use of these techniques is scant. The purpose of this study was to biomechanically determine whether preservation of the superior 50% of the SSC confers significantly increased strength to the SSC repair compared with a complete release and repair, as traditionally performed during aTSA. We hypothesized that preservation of 50% of the SSC and subsequent repair of the released portion would increase the load to failure of the tendon compared with a complete release and repair.

Materials and methods

We performed this biomechanical study to evaluate the load-to-failure characteristics of a partial SSC footprint release and repair compared with a complete tendon release and repair, as well as an intact SSC. We obtained 12 matched pairs (n = 24) of fresh-frozen cadaveric scapula-to-fingertip specimens (average age, 55 ± 10.3 years; 5 male and 7 female), devoid of any documented rotator cuff pathology, prior instrumentation, or shoulder surgery, from a tissue bank. Bone mineral density scans (dual-energy x-ray absorptiometry) were performed (Hologic QDR Discovery; General Electric, Waukesha, WI, USA) using the wrist scan template for each specimen, along with anteroposterior and lateral shoulder radiographs (Mini C-Arm; Orthoscan, Scottsdale, AZ, USA), to ensure the absence of any prior instrumentation or fractures. After thawing at room temperature, initial specimen preparation involved dissection and removal of skin, adipose tissue, the latissimus dorsi tendon insertion, and the pectoralis major tendon insertion of the shoulder joint. At this point, visual inspection was performed to ensure the SSC and other cuff muscles were intact. Following this, the 12 matched pairs were equally allocated into 3 groups, each consisting of 4 matched pairs, identified as follows: group 1, native versus 100% release; group 2, native versus 50% release; and group 3, 50% release versus 100% release. A specimen from each matched pair was randomly selected to receive either treatment procedure based on the test conditions allocated to the respective groups.

Surgical procedure

All surgical procedures were performed with intact rotator cuff muscle attachments and joint capsules at room temperature by a board-certified shoulder surgeon (J.S.) no more than 24 hours prior to biomechanical testing. Muscle and tendon insertions were left intact at the time of surgical intervention to maintain joint stability. Complete SSC widths at the humeral insertion were measured in triplicate using a surgical ruler for all specimens that would undergo the 50% inferior footprint release procedure.

For the 50% release test condition, the inferior half of the SSC footprint was marked and released off of bone using a No. 15 scalpel blade followed by a transverse or horizontal split up to the musculotendinous (MT) junction. These were subsequently repaired (Fig. 1, *B*) via reinsertion of the released inferior tissue to the humerus using No. 2 FiberWire (Arthrex, Naples, FL, USA) and 2 bone tunnels (2.7-mm-diameter holes) by use of modified Mason-Allen stitches. The lateral drill hole for each bone tunnel was created within the bicipital groove, and the medial drill hole was placed 1 cm medial to the lateral drill hole. Side-to-side tendon repairs were also performed using the same suture material to repair the transverse or horizontal split with 4 simple stitches. For the 100% release test condition, the entire footprint of the SSC insertion into the humerus was released from bone and then repaired (Fig. 1, *C*) using 4 bone tunnels and modified Mason-Allen stitches. The native test condition reflected a specimen with an intact SSC footprint insertion in the humeral lesser tuberosity (Fig. 1, *A*).

Specimen preparation for biomechanical testing

With all 3 surgical constructs (native, 50% release and repair, and 100% release and repair) now prepared, further resection of the supraspinatus, infraspinatus, and teres minor muscle-tendon insertions, as well as a release of the capsular tissue from the glenoid, was performed to completely disarticulate the humerus from the scapula. The SSC muscle belly was elevated sharply off the scapula bone thereafter and covered in saline solution (0.9%)–soaked gauze throughout the test procedure. A humeral osteotomy was performed approximately 15 cm inferior to the humeral head followed by potting of the distal end of the humerus using a Bondo and fiberglass resin mix (3M, St. Paul, MN, USA). A cylindrical potting mold was used such that approximately 8 cm of bone, including the humeral head, was exposed superiorly.

The SSC muscle belly along with its MT junction was gripped within a custom-designed clamp (Fig. 2) with smooth interdigitating ridges designed to increase the effective muscle area gripped. This clamp was then attached to a servohydraulic load frame (Shore Western, Monrovia, CA, USA) in line with a 1134-kg load cell, as shown in Figure 2, prior to initiation of biomechanical testing. The humerus was kept in neutral rotation and abduction with respect to the clamped SSC muscle belly and rigidly attached to the base of the load frame using a vice grip. The muscle belly clamp was also fitted with holders to contain dry ice slabs (10 cm × 7.5 cm) needed to freeze the muscle belly.