Partial Subscapularis Release for Total Shoulder Arthroplasty
A Biomechanical Comparison of Two Techniques

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Abstract

Background: Glenohumeral joint exposure during total shoulder arthroplasty (TSA) is obtained by releasing the subscapularis (SSC) with either an osteotomy or a tenotomy. Recently, concerns regarding SSC dysfunction after TSA have been raised. In order to avoid this complication, alternative surgical approaches that release the inferior 50% or 10% of the tendon have been described. While a 10% release of the SSC would theoretically lower the likelihood of postoperative SSC dysfunction, releasing 50% would provide greater surgical exposure but possibly have a weaker SS attachment. Therefore, we sought to compare the SSC attachment strengths of these two techniques.

Materials and Methods: Each of eight matched pairs of cadaveric shoulders were tested. The inferior 10% of the SSC tendon was released on one side. On the contralateral side, the inferior 50% of the SSC was released and then repaired with a 5.5 mm suture anchor. The specimens were then mechanically tested to failure.

Results: The load to failure for the 10% release specimens was 682 ± 153 N and 493 ± 212 N for the 50% release specimens (p = 0.036). Failures in both groups occurred mainly at the musculotendonous junction.

Discussion: The SSC humeral attachment strength after releasing the inferior 10% was 30% greater than the 50% release with repair. Thus, although releasing the inferior 50% of the SSC tendon may provide greater surgical exposure, maintaining the SSC with minimal release may be preferable in decreasing the rate of post TSA SSC dysfunction.

Total shoulder arthroplasty (TSA) has been used to treat osteoarthritis of the glenohumeral joint with good to excellent results in majority of the patients. Most patients can expect pain relief and a functional range of motion. However, complications may compromise outcome. One of these recognized complications after TSA is subscapularis (SSC) dysfunction and rupture. Miller and coworkers demonstrated that 66% of patients had dysfunction of the subscapularis on physical exam after TSA. Similarly, MRI and ultrasound studies have demonstrated high rates of tendon rupture after TSA. Patients with failure of the subscapularis after TSA have inferior results than those with intact tendons.

In order to minimize the incidence of post TSA SSC dysfunction, several biomechanical and clinical studies have attempted to determine the optimal method to release and repair the SSC for TSA. Currently, most surgeons obtain exposure to the glenohumeral joint during TSA using one of three techniques: an osteotomy of the lesser tuberosity, a mid-substance release of the tendon, and releasing the tendon from the lesser tuberosity. There are advantages and limitations for all three techniques; as yet, there is no consensus on which is the best technique to minimize the incidence of SSC dysfunction.

To minimize the disruption of the SSC, LaFosse and associates described a surgical technique for TSA using the rotator interval. In their original description, the rotator interval is used to access the entire glenohumeral joint, and all of the SSC was preserved. As this approach limited the ability to identify and remove the inferior humeral head osteophytes, the technique has been modified to include the release of the inferior 5% to 10% of the SSC. This release creates a small window that can then be used to remove the osteophytes and the inferior capsule. More recently, Morishige and colleagues described an alternative approach where the inferior 50% of the SSC is released.
head can then be dislocated inferiorly to provide greater exposure to the glenohumeral joint, while the superior half of the SSC is preserved. Since Halder and coworkers demonstrated that the superior portion of the SSC possesses the highest load to failure, this technique may provide greater surgical exposure without sacrificing the overall pullout strength of the SSC.23

The purpose of our study was to evaluate the mechanical strength of the SSC humeral attachment after these two surgical techniques. Our hypothesis was that the SSC attachment strength of releasing and repairing the inferior 50% of the SSC tendon would be similar to that of releasing the inferior 10% of the SSC tendon. By comparing these values, it may be possible to determine which of these surgical techniques may be preferable in reducing the overall incidence of SSC dysfunction after TSA.

**Materials and Methods**

Eight matched fresh frozen shoulder pairs were obtained from a certified supplier; the shoulders were thawed prior to conducting the experiment. The rotator cuff was visually inspected, and the subscapularis was intact in all specimens. There were two female and six male donors with an average age of 73 (range: 62 to 86 years). The proximal humeri were removed with the entire subscapularis attached; all other soft tissues were removed. The length of the subscapularis insertion was measured with calipers, and 10% or 50% of the length was marked on the inferior aspect of the subscapularis tendon insertion (alternated between pairs). The tendon was then cut with a scalpel and repaired similar to the method described by Morishige.22 A 5.5 mm anchor loaded with two #2 non-absorbable suture was used at the midsection of the vertical tenotomy. Two mattress sutures were placed medially to restore the footprint of the tendon and then over-sewn laterally with the remaining limbs of the suture. A running #1 PDS was then used to close the horizontal limb of the subscapularis. Prior to testing the specimens were kept moist with saline in sealed bags.

The humeri were mounted horizontally in a bone clamp and rotated (approximately 20° ER) so that a vertical pull on the subscapularis was directed solely on its attachment. A tendon clamp (free to rotate on its vertical axis) with perforated faces was attached to the subscapularis 3 cm above its attachment perpendicular to the direction of the subscapularis muscle fibers (Fig. 1). Using a MTS (Eden Prairie, MN), the bone clamp was fixed to the machine, and the tendon clamp was distracted at 1.0 cm/min until failure (marked drop in sustained load) occurred. Load-displacement graphs were obtained and failures documented. Statistical analysis was performed by GraphPad software (internet shareware) on the matched pair results.

**Results**

As shown in Figure 2, the 10% specimens failed at an average of 682 N (SD 153; range 438-915 N) and the 50% at 493 N (SD 212; range: 235 N to 850 N). This difference was significant at 0.036 (two-tailed; power 0.48). Close examination of the specimens during testing demonstrated that the failures proceeded from the inferior aspect of the tendon to the superior aspect. Of the 10% specimens, five failed at the M-T (muscle-tendon) junction, two at the O-T (osseous-tendon) junction, and one in the muscle; of the 50%, five failed at the M-T junction and three at the O-T junction. It was noted that those specimens that failed at the O-T junction were the two female donors and the oldest male.

In five of the 50% specimens, the anchor was observed to have pulled out. This event could be observed on the load displacement graphs before the later, final failure (Fig. 3).
In order to minimize the incidence of SSC dysfunction after TSA, various surgical techniques have been described. Two of these techniques involve either minimally releasing the inferior 10% or releasing and repairing the inferior 50% of the SSC. The remaining SSC would be maintained during the entire TSA procedure and hopefully preserve the normal function of the SSC. Anatomically, the SSC insertion footprint is widest at its superior portion. In addition, Halder and coworkers demonstrated that, after dividing the SSC into fourths, the superior and mid-superior portions were stiffer than the inferior portion. Therefore, we tested the mechanical properties of these two surgical constructs with the hypothesis that releasing and repairing the inferior 50% of the SSC may provide greater surgical exposure of the glenohumeral joint without sacrificing the pull out strength of the SSC. Our data, however, demonstrated that minimally releasing the SSC was significantly stronger than releasing and repairing the inferior 50% of the tendon. Total shoulder arthroplasty without disruption of the middle third of the subscapularis will preserve tendon strength better than a 50% release and repair.

The modes of failure were noted to be similar in both groups, with the most common failure occurring at the musculotendinous junction. In the 50% release and repair group, five of the eight specimens demonstrated suture anchor pullout from the lesser tuberosity before final failure. This observation suggests that, while the superior portion of the SSC may be the “strongest,” the overall load to the SSC is also shared by the inferior portion. In addition, by improving the fixation of the 50% repair, the overall mechanical strength of this construct may be improved.

There are several limitations to this study. First, the bone density of the humerus was not measured, and this could have affected the data, especially for those specimen that failed at the osteotendinous junction. We did, however, minimize the effects of bone density by performing these studies on matched pairs and by randomizing the side of the surgical technique. Second, we only tested the specimen at 0° abduction. Halder and coworkers demonstrated that abduction angle may affect the biomechanical properties at different portions of the SSC unevenly. In addition, post TSA rehabilitation would include SSC loading at various angles of abduction. This angle of abduction was chosen to simplify the testing model and to allow comparison to previously published studies on SSC pullout strength. Third, our testing model was a simple load to failure and did not include cyclic loading. It is unclear whether this could have significantly affected the data, especially for those specimen that contained suture anchors. Fourth, the specimens failed at the musculotendon junction in five of eight specimens. Clinically, this is not the common mode of failure of the subscapularis after total shoulder arthroplasty.

Like many biomechanical studies, the clinical implications of the data are not clear. The benefit of preserving subscapularis tendon integrity during surgery may improve outcome and allow an accelerated physical therapy protocol. Typically, a limit on external rotation during the initial post-operative period after total shoulder arthroplasty is imposed to protect the subscapularis repair. Theoretically, this would be unnecessary if the strength and integrity of the tendon was not altered during surgery. Although minimally releasing the SSC demonstrated higher strengths than releasing and repairing the inferior 50%, neither were as high for intact SSC, which was reported by Halder and coworkers to be 706.2 ± 164.6 N. However, both constructs demonstrated load to failure values that were higher than those previously reported for SSC after traditional TSA procedures that utilize complete release and repair. The inferior release without repair was significantly stronger than a 50% release and repair. A surgical technique that preserves the majority of the tendon would be preferable to preserve subscapularis integrity.

In summary, the failure strengths of the SSC after minimal release (10%) were approximately 30% higher than after repairing the inferior 50% release, suggesting that the former technique may be better in withstanding the loads on the SSC after TSA. A surgical technique that leaves 90% of the subscapularis tendon undisturbed during total shoulder arthroplasty will maintain subscapularis strength better than a 50% release and repair.

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References


