The Role of Subscapularis Repair in Reverse Total Shoulder Arthroplasty

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Abstract

Background: Controversy surrounds the role of the subscapularis (SSC) in reverse shoulder arthroplasty (rTSA) and the need for repair, if possible, at the conclusion of the procedure.

Questions and Purpose: Some investigators have concluded that an intact SSC is critical for stability; others have found no such correlation. What factors should be part of the decision-making matrix on SSC management for surgeons considering rTSA?

Findings: The data on management of the SSC in rTSA support a design-based approach. Researchers have shown that the SSC is critical to stability when the surgeon uses an implant with a medialized humeral component and medialized glenoid component. However, lateralized designs allow for more stability from horizontal deltoid compression and may not require repair of the SSC. In addition, SSC repair has been shown to increase the workload of the residual posterior rotator cuff and the deltoid in rTSA, both of which may have negative consequences on overall function. Lateralization from the glenoid component increases deltoid work, whereas lateralization from the humeral component maintains deltoid efficiency while improving stability.

Conclusions: The need for SSC repair in rTSA can vary based on the implant selected. Humeral and glenoid offset influence the stability and kinematics of rTSA.

The subscapularis has a critical function in stabilizing the prosthesis after anatomic total shoulder arthroplasty. Loss of its integrity results in varying levels of functional loss.1,2 Reverse shoulder arthroplasty (rTSA) has a completely different biomechanical design that governs the function and stability of the prosthesis. Information regarding the role and importance of the subscapularis in rTSA has been variable. The change in function of the subscapularis after the insertion of a rTSA, the implications of differing preoperative deformity patterns, and impact of the device design on the need for subscapularis repair in rTSA will be discussed as a guide for surgeons to use in decision making for subscapularis management in rTSA.

Subscapularis Basic Science

Lo and Burkhart3 identified the subscapularis as “the forgotten tendon”; however, surgeons performing shoulder arthroplasty have long recognized its importance. The subscapularis is the largest and most powerful muscle of the rotator cuff.4 The muscle originates from the anterior surface of the scapula, and its tendinous upper two-thirds and muscular bottom one-third attach to the lesser tuberosity of the humerus (Fig. 1).5-8 It is innervated by the upper and lower subscapular nerves. In addition to its muscular attachments, the subscapularis provides contributions to adjacent anatomic structures. Its upper portion connects with the anterior edge of the supraspinatus to form the rotator interval, coracohumeral ligament, transverse humeral ligament, and biceps pulley.

The primary role of the subscapularis is internal rotation, but it also can contribute to shoulder adduction, abduction, flexion, and extension.9,10 Given that the contraction of the upper subscapularis can cause abduction and is innervated by the upper subscapular nerve and contraction of the lower subscapularis can cause adduction and is innervated by the lower subscapular nerve, some researchers believe that these two portions of the muscle may function independently.11,12 The subscapularis can be considered a “biphasic” muscle because it will rotate the humerus differently based on the position of the upper extremity in space during contraction.


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The biphasic nature of the subscapularis muscle dictates that:
1. if the summation vector of the muscle pull is above the center of joint rotation, shoulder motion is abduction, and;
2. if the summation vector of muscle pull is below the center of joint rotation, shoulder motion is adduction (Fig. 2). In the healthy shoulder, the upper two-thirds of the subscapularis function as abductors, and the lower one-third functions as an adductor. The combination of the subscapularis pull and balanced posterior rotator cuff function also helps stabilize the glenohumeral joint via a concavity-compression mechanism.

The Subscapularis in Anatomic Shoulder Arthroplasty
Rotator cuff failure is a major cause of dysfunction after anatomic total shoulder arthroplasty (aTSA). Miller and coworkers reported up to two-thirds of patients demonstrated subscapularis dysfunction after aTSA, but their clinical findings were inconsistent. Glenoid loosening, instability, and loss of motion have been associated with loss of subscapularis integrity following aTSA. Thereby, subscapularis integrity following aTSA has received abundant attention from researchers evaluating the most effective method to repair the tendon to avoid postoperative problems. Emphasizing the importance of subscapularis integrity, Lafosse and associates published their results of a “subscapularis on” approach in which the arthroplasty is performed through the rotator interval. This avoids the need for postoperative immobilization and the need to protect the subscapularis. In summary, subscapularis failure in aTSA is a significant problem and can result in instability, pseudoparalysis, and compromised glenoid component fixation due to uneven forces applied to the glenoid component.

Reverse Shoulder Arthroplasty and the Subscapularis
Reverse shoulder arthroplasty has been reported to effectively treat a variety of conditions with good to excellent results in the vast majority of patients. Reverse shoulder arthroplasty has been reported to effectively treat a variety of conditions with good to excellent results in the vast majority of patients.
ports, instability was recognized as a potential postoperative complication, and the likelihood was higher in patients with certain characteristics. Studies identified revision surgery, the deltopectoral approach, and subscapularis deficiency as predisposing factors for postoperative instability following rTSA.\(^\text{21,22}\) Edwards and coworkers\(^\text{22}\) reported their results of 138 consecutive rTSAs and confirmed that an irreparable subscapularis can lead to instability following rTSA.\(^\text{22}\) In all of these series involving subscapularis-deficient, unstable rTSAs, a Grammont-style design was used.\(^\text{21,22}\) Roche and colleagues\(^\text{23,24}\) subsequently characterized this Grammont-style design as medialized on both the glenoid and humeral sides, resulting in rotator cuff shortening and a minimized deltoid wrapping angle that decreases the horizontal (compressive) component of deltoid force. In patients who have medially eroded glenoids before surgery, using a device with medialized glenoid and medialized humeral components can lead to the deltoid origin being lateral to the insertion. This design characteristic can make the prosthesis more prone to instability and can help explain why having the subscapularis as a medial tether or joint compressor improves stability. Consequently, increasing the lateralization of the Grammont-style prosthesis has been shown to improve its stability.\(^\text{25,26}\) The initial reports of the correlation between subscapularis integrity and rTSA instability were based on a single rTSA design. Other investigators evaluating the effect of subscapularis integrity with a more lateralized rTSA design have not found a correlation.\(^\text{27}\) According to Roche and colleagues,\(^\text{23,24}\) this device in its most frequent iteration would be characterized as lateralized on the glenoid side but medialized on the humeral side. Roche and colleagues\(^\text{23,24}\) and Hamilton and coworkers\(^\text{13}\) allowed for normalization among different devices and implanted three different styles of rTSA design in the same computer-based virtual shoulder. They found that the “total lateralization” of the construct was a good measure of deltoid wrapping and subsequent contribution to the compressive component of stability (Fig. 3). This may explain why one set of investigators identified the subscapularis as critical to success and another group found that it did not contribute. The influence of the subscapularis on rTSA stability may be design specific and correlated with overall construct lateralization.

**Discussion**

The recognition that the subscapularis may not be critical for rTSA stability has encouraged further study. Roche and colleagues\(^\text{13,23,24}\) identified that the subscapularis in rTSA functions as an adductor for the first 70° of abduction with most rTSA designs. This results in the line of action of the subscapularis opposing the deltoid in low and midhumeral elevation in both the scapular and coronal planes, which in turn requires the deltoid to generate a more substantial force to achieve motion.\(^\text{28–30}\) This finding was clarified further by the work of Onstot and associates\(^\text{30}\) that confirmed the subscapularis, when intact after rTSA, resulted in an increase of joint reactive force of 426%, and the required deltoid force increased 132% (at 15° of abduction). In addition to increasing the deltoid effort necessary for abduction, the intact and firing subscapularis resulted in a 460% increase force generated by the posterior cuff (at 15° abduction) to eliminate a hornblower’s sign during shoulder movement and maintain neutral rotational alignment.\(^\text{30}\) Given that deltoid fatigue and acromial stress issues and loss of external rotation are recognized postoperative problems,\(^\text{31}\) this data clearly shows that the need for subscapularis repair should be evaluated on an individual basis.

**Figure 3** The drawings show the differences among three different type of rTSA and the location of both the center of rotation and the relative lateral displacement of the humerus based upon the design of the implant.
Conclusion

Although critically important to the function and stability of an anatomic aTSA, the subscapularis may not be as important in certain designs of rTSA prostheses. Data is now available to show that with certain prosthetic designs, repair of the subscapularis may have negative biomechanical consequences.\(^\text{22,24,30}\) Sufficient evidence has shown that, in a medialized Grammont-style design, repair of the subscapularis may be critical for stability and this effect is magnified by the presence of medial glenoid wear.\(^\text{22-24}\) However, other designs of rTSA prostheses, particularly when the construct is lateralized so the deltoid wraps around the greater tuberosity more effectively, are inherently more stable and may not require an intact subscapularis for additional stability. The practical question to be answered is: If using a lateralized device and the subscapularis appears to be repairable, should the surgeon repair it? The argument in favor of repair includes the potential benefit of improved internal rotation and a decrease in the deadspace (possibly avoiding hematoma and wound healing problems). The contribution to stability in a lateralized construct without significant medial wear of the glenoid appears to be negligible clinically.\(^\text{27}\) and is understandable based upon the impact on deltoid wrapping. The arguments against subscapularis repair in a lateralized rTSA prosthesis are improved external rotation mechanics\(^\text{30}\) and abduction efficiency,\(^\text{12,21,24,30}\) both of which have been identified as problems following rTSA and which repairing the subscapularis has been shown to worsen.\(^\text{30}\) The investigator’s preference is to use a lateralized design and to not repair the subscapularis for this reason. However, based on reports using the medialized Grammont-style prosthesis, repairing the subscapularis is advisable,\(^\text{22}\) and the importance is only magnified in the setting of medial erosion of the glenoid. The amount of lateralization needed in an rTSA construct to render subscapularis repair unnecessary has not yet been identified.

Disclosure Statement

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