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The influence of partial subscapularis tendon tears combined with supraspinatus tendon tears

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Background: With the advent of arthroscopy, more partial subscapularis tears are being recognized. The biomechanical effects of partial subscapularis tears are unknown, and there is no consensus as to their treatment. Therefore, the objective of this study was to evaluate and to quantify the changes in range of motion and glenohumeral kinematics for isolated subscapularis partial tears, combined subscapularis and supraspinatus tears, supraspinatus repair, and combined supraspinatus and subscapularis repair.
Methods: Six cadaveric shoulders were tested in the scapular plane with 0°, 30°, and 60° shoulder abduction under 6 conditions: intact; ¼ subscapularis tear; ½ subscapularis tear; ½ subscapularis and complete supraspinatus tear; supraspinatus repair; and supraspinatus and subscapularis repair. Maximum internal and external rotation and glenohumeral kinematics were measured under physiologic muscle loading condition. A repeated measures analysis of variance with a Tukey post hoc test was used for statistical analysis.
Results: Maximum external rotation was significantly increased after ¼ subscapularis tear at 30° abduction and in all abduction angles with ½ subscapularis tear ($P < .05$). The 2 repair conditions did not restore external rotation to the intact level. At maximum internal and external rotation, there was a significant superior shift in the humeral head apex position with ¼ subscapularis tear at 30° abduction and with ½ subscapularis tear at 60° abduction ($P < .05$). Repair of the supraspinatus tendon partially corrected abnormal kinematics; however, neither repair restored abnormal kinematics to intact.
Conclusion: Additional repair of the partial subscapularis tear with supraspinatus tear did not affect external rotation or glenohumeral kinematics. Further studies are needed to evaluate different subscapularis repair techniques.
Level of evidence: Basic Science Study, Biomechanics.

Keywords: Subscapularis; kinematics; range of motion; arthroscopy

IRB: Not applicable (Basic Science Study).
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Whereas numerous studies have been devoted to supraspinatus-infraspinatus tendon tears, subscapularis tendon tears have been fairly underestimated and unrecognized.[4,24,26-28,31] This may be partly due to the assumption that an isolated subscapularis tendon tear is a rare entity[5,19,24,28,31] or that partial subscapularis tendon tears can be difficult to visualize arthroscopically, especially in

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tight shoulders.[22] With the advent of arthroscopy, more partial subscapularis tendon tears, with or without supraspinatus or infraspinatus tendon tears, are being recognized and treated.[2,4,20,35] Some authors have classified this lesion,[6,11,24,33] but there is no universally accepted system.

Subscapularis partial tear combined with supraspinatus or 3-tendon tears are more common than isolated subscapularis tendon tears.[12,13,28] Although upper portion subscapularis partial tendon tears are considered relatively benign, their true effect has not been described.[32] Furthermore, there is still unsolved controversy about repair of a subscapularis tendon tear, which might cause postoperative stiffness, especially in open procedures.[13,24] Therefore, the first objective of this study was to quantify the changes in range of motion and glenohumeral joint kinematics for isolated subscapularis tears of increasing size and further in combination with supraspinatus tears. The second objective was to quantify the effects of repairing only the supraspinatus tendon tear while leaving the subscapularis partial tear alone and then repairing both tendon tears. We hypothesize that there will be changes in the kinematics even with ¼ tear of the subscapularis tendon and that complete repair of both tendons will restore the kinematics and range of motion.

Methods

Specimen preparation

Six cadaveric shoulders were used (mean age, 59 years; range, 44-78 years). There were 1 female and 5 male specimens, thereof 1 left and 5 right shoulders. Specimens with a rotator cuff tear, glenohumeral joint contracture, glenohumeral arthritis, history of previous fractures, or previous shoulder surgery were excluded. The specimens were stored at −20°C until the day before testing, and each specimen was thawed overnight at room temperature in preparation for dissection and testing. The specimens were kept moist with physiologic saline solution to prevent dehydration. All soft tissues were removed except the rotator cuff muscles, glenohumeral joint capsule, coracoacromial ligament, and coracohumeral ligament. The supraspinatus, infraspinatus, teres minor, and subscapularis muscles were released from their origins, but their original insertions on the humerus were retained. The glenohumeral joint was vented by a 15-mm longitudinal incision through the rotator interval to remove the negative intra-articular pressure and for arthroscopic evaluation of the status of the upper portion of the subscapularis tendon and supraspinatus intra-articular tendon. Any specimens with evidence of intra-articular partial tears (both subscapularis and supraspinatus) were excluded. Suture loops were made with a modified Kessler stitch at the insertion of each muscle with 2-0 FiberWire (Arthrex, Inc, Naples, FL, USA). Multiple lines of pull were used for each muscle. Previous studies have shown the subscapularis to have 4 distinct tendons[7,21,36,39]; therefore, we chose 4 lines of pull for subscapularis loading. Four lines of pull were also used for the infraspinatus/teres minor to balance the lines of pull with the subscapularis. The supraspinatus was sutured with 2 suture loops for 2 lines of pull, 1 anterior and 1 posterior. Three reference screws were inserted on the scapula (coracoid, anterior acromion, and posterior acromion) and the humerus (proximal bicipital groove, distal bicipital groove, and greater tuberosity) to provide consistent digitization markers to define local coordinate systems on each bone for kinematic measurement.[25] The scapula was secured to an aluminum bracket that was attached to the custom shoulder testing apparatus in the anatomic resting position with 20° anterior tilt in the sagittal plane (Fig. 1).[8,16] An aluminum rod was inserted into the medullary canal and secured to the distal humerus. The rod was then placed in a custom device attached to the testing system, which allows axial rotation of the humerus and shoulder abduction.[17]

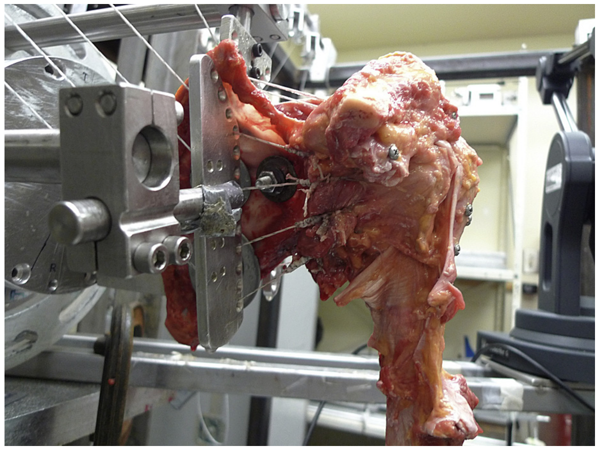

Figure 1 Anterior view of a cadaveric shoulder mounted on the custom testing system showing 4 lines of pull for the subscapularis muscle.

Muscle loading conditions and testing positions

The amount of muscle loading was determined on the basis of physiologic muscle cross-sectional area ratios[1,40]: supraspinatus, 20 N (10 N for each line of pull); subscapularis, 30 N; infraspinatus/teres minor, 30 N (7.5 N for each line of pull). On the basis of data from 2 pilot studies that included rotator cuff, deltoid, pectoralis major, and latissimus dorsi loading, we chose to load only the rotator cuff to accentuate the effect of its conditions. Loading the deltoid, pectoralis major, and latissimus dorsi resulted in trends similar to rotator cuff loading alone, with lower magnitudes of changes due to the stabilizing effect of these muscles. Testing was performed in the scapular plane (30° anterior to the coronal plane) at 0°, 30°, and 60° shoulder abduction, considering a 2:1 ratio of glenohumeral to scapulothoracic abduction.

Biomechanical testing

Rotational range of motion was measured with a goniometer located at the distal humeral aluminum rod. Before testing, neutral humeral rotation was defined as the midpoint between maximum internal and external rotation in 30° abduction in the scapular plane with 3.3 Nm of torque using an electronic torque wrench (Jetco, Irwindale, CA, USA); 3.3 Nm of torque was an adequate torque to reach a consistent capsular endpoint but low enough not