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Role of the superior shoulder capsule in passive stability of the glenohumeral joint

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Background: The shoulder capsule is the main static stabilizer of the glenohumeral joint. However, few studies specifically address the function of the superior shoulder capsule, which is usually damaged in patients with complete rotator cuff tears. Therefore, the purpose of this study was to determine the biomechanical contribution of the superior shoulder capsule to passive stability of the glenohumeral joint.
Methods: Seven cadaveric shoulders were tested with a custom testing system. Glenohumeral translations, subacromial contact pressure, and glenohumeral external and internal rotations were quantified at 5°, 30°, and 60° of glenohumeral abduction. Data were compared among 3 conditions: (1) intact superior capsule, (2) after detaching the superior capsule from the greater tuberosity (tear model), and (3) after complete removal of the superior capsule from the greater tuberosity to the superior glenoid (defect model).
Results: A tear of the superior capsule significantly ($P < .05$) increased anterior and inferior translations compared with those in the intact capsule. Creation of a superior capsular defect significantly ($P < .05$) increased glenohumeral translation in all directions, subacromial contact pressure at 30° of glenohumeral abduction, and external and internal rotations compared with those of the intact capsule.
Conclusion: The superior shoulder capsule plays an important role in passive stability of the glenohumeral joint. A tear in the superior capsule at the greater tuberosity, which may be seen with partial rotator cuff tears, increased anterior and inferior translations. A defect in the superior capsule, seen in massive cuff tears, increased glenohumeral translations in all directions.
Level of evidence: Basic Science Study, Biomechanics.

Keywords: Capsule; defect; shoulder; stability; superior; tear

The superior shoulder capsule is a thin membranous structure beneath the rotator cuff.[5,6,23] Although often damaged in patients with complete tears of the supraspinatus or infraspinatus tendon,[20] the superior capsule has not received great attention in regard to the treatment of rotator cuff tears. However, a recent anatomic study has

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shown that the superior shoulder capsule is attached to a substantial area (30% to 61%) of the greater tuberosity,[23] suggesting that the superior shoulder capsule is an important component of the glenohumeral joint.

Articular-sided partial-thickness tears of the supraspinatus and infraspinatus tendons include detachment of the superior shoulder capsule from the greater tuberosity. Because shoulder capsule tears can lead to increases in glenohumeral translation, articular-sided partial-thickness supraspinatus and infraspinatus tendon tears may be associated with increased glenohumeral joint laxity.

In a cadaveric model of irreparable rotator cuff tear, reconstruction of the superior shoulder capsule restored superior stability of the glenohumeral joint.[18] Furthermore, in 24 consecutive patients with irreparable rotator cuff tears who underwent arthroscopic superior capsule reconstruction, acromiohumeral distance increased from 4.6 $\pm$ 2.2 mm preoperatively to 8.7 $\pm$ 2.6 mm postoperatively, mean active elevation increased significantly from 84° to 148°, and the American Shoulder and Elbow Surgeons score improved from 23.5 to 92.9.[20] These results suggest that the superior shoulder capsule is important for shoulder stability and function.

The shoulder capsule is well understood as the main static stabilizer of the glenohumeral joint.[2-4,24-26,30,32] Previous biomechanical studies have shown that the anterior capsule (including the superior, middle, and anteroinferior glenohumeral ligaments) provides glenohumeral stability anteriorly[3,24,26,30,32] and that the posterior capsule (including the posteroinferior glenohumeral ligament) stabilizes the glenohumeral joint posteriorly.[3,24,26,30] However, the function of the superior shoulder capsule has not been directly addressed in previous studies. Therefore, the purpose of this study was to determine the biomechanical contribution of the superior shoulder capsule to passive stability of the glenohumeral joint for a superior capsule tear, commonly seen with partial supraspinatus tears, and a capsule defect, seen in massive rotator cuff tears. Specifically, glenohumeral translation, glenohumeral range of motion, and subacromial contact pressure will be quantified. We hypothesized that the superior shoulder capsule tear and the large defect will increase glenohumeral joint translation, rotational range of motion, and subacromial contact pressure.

Materials and methods

Specimen preparation

The study used 7 fresh frozen cadaveric shoulders (2 female and 5 male) from donors who were an average age of 79.7 years (range, 70-91 years) at the time of death. The specimens were thawed overnight at room temperature before testing. The shoulders were screened by means of visual inspection for signs of abnormality and pathologic changes. Each specimen was dissected free of skin, subcutaneous tissue, and all muscles; the glenohumeral joint capsule was preserved. The supraspinatus, infraspinatus, subscapularis, and teres minor were peeled away from their origins on the scapula toward their insertions on the greater or lesser tuberosity of the humerus. The superior capsule was isolated by the careful removal of the supraspinatus with a scalpel.

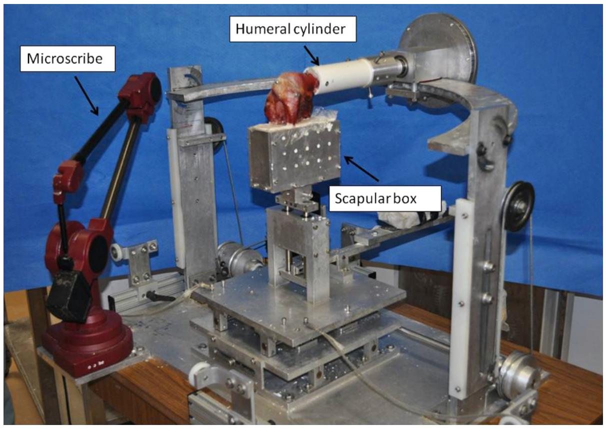

Figure 1 Shoulder-testing system.

The separation between the supraspinatus tendon and superior capsule was clearly found with careful observation in all specimens, as described in a previous anatomic study.[23] The width of the supraspinatus at the greater tuberosity was marked on each specimen before removal. The coracohumeral ligament, superior glenohumeral ligament, and biceps tendon were also preserved because they may be confluent with the superior capsule. After dissection, the rotator interval was opened in all specimens to ensure all specimens were vented to atmospheric pressure.

The humeral shaft was potted in polyvinyl chloride pipe (diameter, 1.5 inches) with plaster of Paris, aligning the humeral intramedullary axis with the long axis of the pipe. One screw was placed through the polyvinyl chloride pipe and humeral shaft to provide additional rigidity to the humeral fixation. The scapula was potted in plaster of Paris with the glenoid oriented parallel to the top edge of an aluminum box used for mounting the shoulder on the testing system. The shoulder then was mounted on the shoulder-testing system (Fig. 1). All specimens were kept moist with 0.9% saline throughout the experiment. Compressive force (22 N) was applied to the glenohumeral joint throughout the entire test.[1,10-13,28,29,31] This was determined to be the minimum glenohumeral joint compressive force required to prevent dislocation on application of 20 N of translation loads.

Shoulder-testing system

A shoulder-testing system was used to measure glenohumeral translation and humeral rotation. This system allowed 6° of freedom for positioning the glenohumeral joint. Anterior–posterior and superior–inferior translations were provided by manipulating 2 translation plates. Compression–distraction was applied by using a lever arm and bearing system attached to the top translation plate, where the scapula box was mounted. The humeral cylinder was attached along the top arc of the shoulder-testing system. The angle of the arc could be adjusted to generate various degrees of shoulder abduction. The humerus could be positioned along any point of the arc, simulating horizontal