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Contact between the coracoacromial arch and the rotator cuff tendons in nonpathologic situations: A cadaveric study

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Hypothesis: A recent ultrasound study has shown that impingement phenomenon was observed in healthy shoulders. We hypothesized that nonpathologic contact beneath the coracoacromial arch occurs in normal shoulders.
Materials and methods: Seven fresh-frozen cadaveric shoulders were studied. Each specimen was attached to a custom-designed shoulder-positioning device. A 22-N force was applied to the humeral head to keep it centered in the glenoid fossa. Contact pressure beneath the coracoacromial arch was measured by a flexible force sensor during flexion, abduction, internal and external rotation, extension, and horizontal abduction motions. Bending deformation of the coracoacromial ligament was measured by a linear variable differential transducer sensor. Data were recorded with the arm from 0° to maximum range of motion with 10° increments.
Results: Contact pressure with the coracoacromial ligament and acromion was not zero in the neutral position and increased during particular motions, such as flexion, abduction, horizontal abduction, and extension, whereas it was almost constant during internal and external rotation. Bending deformation of the coracoacromial ligament during flexion, abduction, and horizontal abduction motions was also shown to be greater than that during internal and external rotation.
Discussion: It is possible that repetitive contact of the coracoacromial ligament may cause degenerative changes, and a ridge of proliferative acromial spurs may be the result of nonpathologic contact.
Conclusions: Contact phenomenon of the coracoacromial arch was observed during all motions. Nonpathologic contact beneath the coracoacromial arch may be present in normal shoulders.
Level of evidence: Basic Science Study.

Keywords: Subacromial impingement; contact pressure; bending deformation; nonpathologic contact

It is well known that subacromial impingement is a common cause of shoulder pain.[3,13,14] In addition to subacromial impingement, internal impingement—such as posterosuperior impingement of the supraspinatus tendon[16]

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and anterosuperior impingement of the deep surface of the subscapularis[8]—has also been reported. As observed in these reports, the term ''impingement'' or ''impingement phenomenon'' has been traditionally considered to be a pathologic condition that should be treated. However, a recent ultrasound study has shown that impingement phenomenon between the coracoacromial ligament and cuff tendons was observed during extension and internal rotation motion in shoulders of healthy volunteers.[20] In addition, there are several biomechanical and clinical reports showing that the coracoacromial ligament makes contact with the cuff tendons, restricting superior humeral head migration during movement.[4,18,19]

These facts suggested that contact phenomenon of the cuff tendons with the coracoacromial arch may occur in normal shoulders without shoulder pain. Our hypothesis was that nonpathologic contact beneath the coracoacromial arch occurs during all motions in normal shoulders and changes as the arm position changes. The purpose of this study was to evaluate this phenomenon quantitatively by measuring contact pressure beneath the coracoacromial arch and the bending deformation of the coracoacromial ligament.

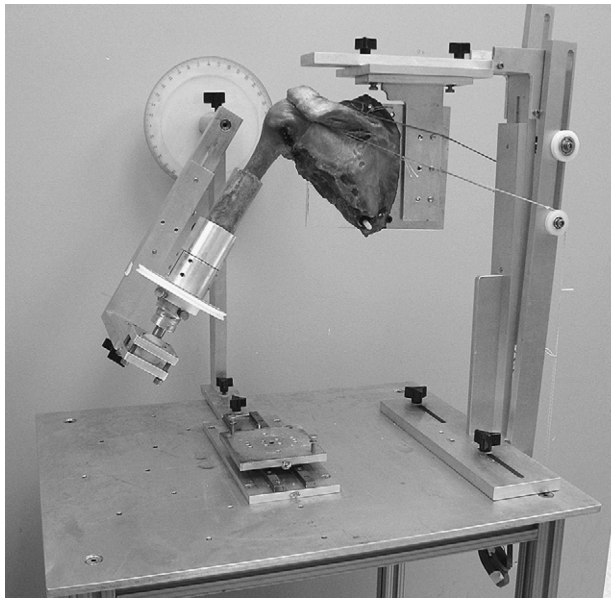

Figure 1 Specimen and custom-designed shoulder-positioning device.

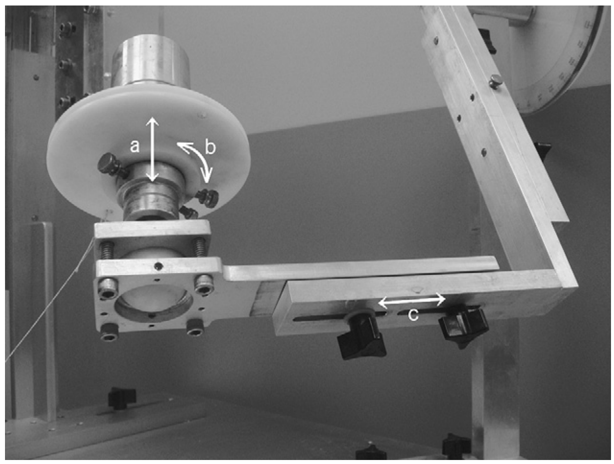

Figure 2 The device had mechanisms to allow for unrestrained motions, with superior-inferior translational (*a*), humeral rotational (*b*), and medial-lateral translational (*c*) degrees of freedom.

Materials and methods

Preparation of specimens

We studied 7 fresh-frozen cadaveric shoulders (5 male and 2 female specimens). The mean age of the subjects at the time of death was 74 years (range, 58-88 years). These specimens showed no evidence of glenohumeral arthritis, subacromial bony spur, rotator cuff tear, or joint contracture. The shoulders were thawed overnight at room temperature for experimentation, and the skin, the subcutaneous tissue, and all muscle were removed, with preservation of the rotator cuff and subacromial bursa. The specimen was then attached to a custom-designed shoulder-positioning device (Figure 1). An acrylic plate attached to the positioning device was fixed to the scapular body by means of plastic screws. The device allowed the humerus to be placed in a given plane of elevation (such as the scapular or coronal plane), at a given angle of glenohumeral elevation, and at a given angle of humeral rotation (external or internal). In addition, the device had mechanisms to allow for unrestrained motions: humeral rotational, superior-inferior translational, and medial-lateral translational degrees of freedom (Figure 2). The plane including the long axis of the scapular body was defined as the scapular plane of the glenohumeral joint, the plane parallel to the trunk as the coronal plane, and the plane perpendicular to the coronal plane as the sagittal plane.

A 22-N compressive force[17] was applied to the humeral head against the glenoid fossa through the cables attached to the subscapularis (10-N force), supraspinatus (3.5-N force), and infraspinatus/teres minor (8.5-N force) tendons with pulleys and weights to keep the humeral head centered in the glenoid fossa. Although we divided a 22-N compressive force according to the physiologic cross-sectional area of each muscle[1] as used in previous studies,[9,21] the total axial compressive force might not be 22 N because the load applied to those muscles was not oriented along the same axis.

Because it was expected that the vertical position of the center of movement of the humeral head might affect the subacromial contact pressure, we confirmed the vertical position in each specimen before starting the test by using fluoroscopy so that the vertical position was at the level of the center of the glenoid length. The ranges of glenohumeral motion of the cadaveric shoulders used in this study were measured under a constant torque with pulleys and weights (800 N-mm for measurement of abduction and flexion and 250 N-mm for measurement of internal and external rotation) as follows: $102° \pm 10°$ in abduction, $101° \pm 8°$ in flexion, $30° \pm 17°$ in internal rotation at 0° of abduction, and $55° \pm 12°$ in external rotation at 0° of abduction. The specimen was kept moist with a spray of saline solution applied every 10 to