The Effect of Anterosuperior Rotator Cuff Tears on Glenohumeral Translation

Wei-Ren Su, M.D., Jeffrey E. Budoff, M.D., and Zong-Ping Luo, Ph.D.

Purpose: The purpose of this study was to sequentially investigate the biomechanical effects of anterosuperior rotator cuff tear size on superior and anterosuperior translation, including tears interrupting the anterior cable attachment and the anterior force couple. **Methods:** Five cadaveric shoulders were subjected to different loading conditions in both the superior and anterosuperior directions in the intact state, with the supraspinatus cut and with sequentially larger anterosuperior rotator cuff tears. **Results:** Isolated tears of the supraspinatus had no significant biomechanical consequences under any condition tested. Anterosuperior translation was greater than superior translation in the intact specimen and for every combination of anterosuperior rotator cuff defect. With the supraspinatus and the superior half of the subscapularis (i.e., the anterior cable attachment) released, there was no significant increase in anterosuperior or superior glenohumeral translation in response to lower loading conditions (10 to 20 N). At higher loading conditions (40 to 50 N), tears of the supraspinatus and superior half of the subscapularis led to significantly increased translation in both directions. **Conclusions:** Simulated anterosuperior rotator cuff tears involving the superior half of the subscapularis significantly alter shoulder biomechanics and lead to increased anterosuperior and superior glenohumeral translation under higher loads. The anterior attachment of the rotator cuff cable is therefore an important determinant of the biomechanics of anterosuperior rotator cuff tears at higher loads but not at lower loads. Preserving the inferior half of the subscapularis was sufficient to maintain relatively normal shoulder kinematics under lower loading conditions. Tears of the entire subscapularis altered glenohumeral kinematics at essentially all loads. **Clinical Relevance:** Knowledge of the biomechanics of anterosuperior rotator cuff tears enhances our understanding of how to best treat these lesions. **Key Words:** Shoulder—Rotator cuff—Rotator cuff tear—Biomechanics—Subscapularis—Force couple.

It is well established that rotator cuff tears may lead to superior migration of the humeral head when the superior shear forces created by the deltoid are no longer effectively opposed.[1-4] It has also been shown that the deltoid may impart substantial anterior shear forces to the humeral head.[5,6] Hsu et al.[7] have reported that large rotator cuff tears lead to increased superior, anterior, and posterior translation, which may explain, in part, the pathogenesis of cuff tear arthropathy.[8] In addition, forces from the other large muscles about the shoulder (i.e., the pectoralis major and latissimus dorsi) transmit forces to the humeral head from multiple vectors.

Burkhart[9] has described the rotator cuff cable, which is a thickened area of the rotator cuff tendon that is important in force transmission. The cable inserts anteriorly just anterior to the anterior insertion of the supraspinatus and posteriorly near the inferior insertion of the infraspinatus tendon (Fig 1).[9] Rotator cuff tears involving the supraspinatus and the superior half of the subscapularis tear the anterior cable attachment. Burkhart has noted that rotator cuff tears not involving the cable (i.e., tears of the supraspinatus

From the National Cheng Kung University Hospital (W-R.S.), Tainan, Taiwan; Department of Orthopaedic Surgery, University of Texas (J.E.B.), Houston, Texas, and Florida Orthopaedic Institute (Z-P.L.), Tampa, Florida, U.S.A.

The authors report no conflict of interest.

Received May 5, 2008; accepted October 5, 2008.

Address correspondence and reprint requests to Jeffrey E. Budoff, M.D., 6620 Main St, 13th Floor, Houston, TX 77030, U.S.A. E-mail: Jebudoff@yahoo.com

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0749-8063/09/2503-8252$36.00/0

doi:10.1016/j.arthro.2008.10.005

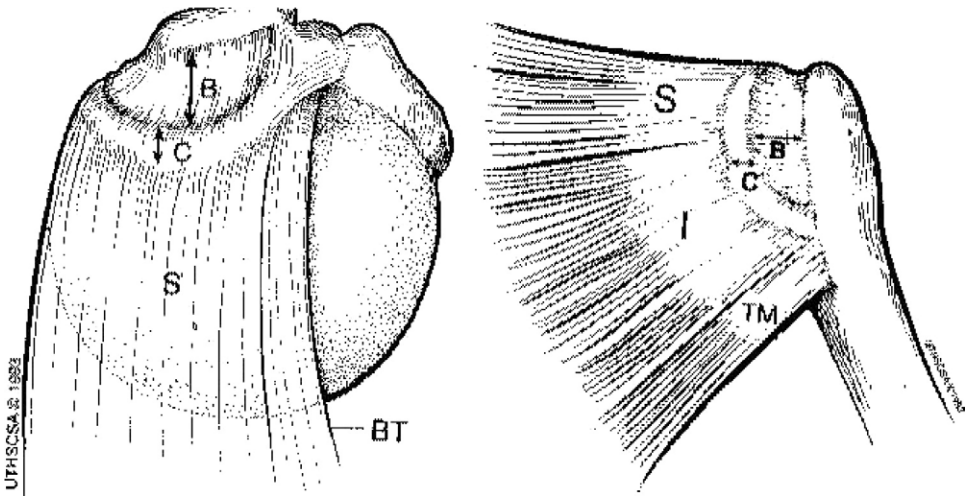

FIGURE 1. Rotator cuff cable. It should be noted that the cable's anterior attachment is between the supraspinatus and subscapularis. (B, crescent of rotator cuff, lateral to cable; BT, biceps tendon; C, rotator cuff cable; I, infraspinatus; S, supraspinatus; TM, teres minor.) Reprinted with permission.[9]

alone or with the superior infraspinatus) are functional and "biomechanically intact," because the rotator cuff cable remains intact. This has been confirmed by Halder et al.,[10] who noted that small tears of the supraspinatus not affecting the rotator cuff cable did not produce a substantial decrease in force transmission. Conversely, tears that interrupt the cable (i.e., tears involving the supraspinatus and superior subscapularis) alter the normal kinematics of the glenohumeral joint.[9] The biomechanical significance of rotator cuff tears disrupting the posterior cable attachment (i.e., posterosuperior tears involving the entire supraspinatus and infraspinatus) has been confirmed by Mura et al.[2] Burkhart also described anterior and posterior force couples, consisting of the entire subscapularis anteriorly and the infraspinatus and teres minor posteriorly. He reported that tears that did not interrupt these force couples were functional and "biomechanically intact."

Anterosuperior rotator cuff tears involve the supraspinatus and subscapularis tendons.[11-13] Anterosuperior rotator cuff tears involving only the superior subscapularis tear the rotator cuff cable but still leave a significant portion of the anterior-posterior force couple intact, potentially allowing functional biomechanics. It is unclear from the literature whether preserving the rotator cuff cable or the force couple is more important for maintaining normal shoulder kinematics after rotator cuff tears.

The purpose of this study was to investigate the effects of anterosuperior rotator cuff tears on superior and anterosuperior translation, with specific attention to sequentially increasing tear size, including tears interrupting the anterior cable attachment and the anterior force couple. The null hypothesis was that simulated anterosuperior rotator cuff tears would not lead to increased anterosuperior or superior glenohumeral translation.

METHODS

Five healthy fresh-frozen cadaveric glenohumeral joints were sectioned at the scapula from the thorax, with the humerus divided at its midshaft. There were 3 male and 2 female specimens, with a mean age of 73.4 years (range, 65 to 84 years). Each was visually inspected to ensure that the rotator cuff tendon and biceps tendon were intact and the articular cartilage and labrum were free from gross degenerative or traumatic changes. Specimens were stored at −20°C until the day before testing, when each specimen was thawed overnight at room temperature in preparation for dissection and testing. During dissection, preparation, and testing, the specimens were moistened with physiologic saline solution to prevent dehydration. We resected the skin, subcutaneous tissue, and deltoid musculature, retaining only the scapula, humerus, long head of the biceps tendon, coracoacromial ligament, glenohumeral capsular and coracohumeral ligaments, and rotator cuff tendons. The biceps tendon was left in its anatomic position within its groove, and the coracoacromial ligament and acromion were not altered. The supraspinatus, infraspinatus, subscapularis, and teres minor muscles were released from their origins but retained their original insertion on the humeral head. The vacuum effect was nullified by

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