INTRODUCTION:
Considerable research suggests that the long head of the biceps (BiL), either actively or passively, assists the rotator cuff muscles in providing compression and anterior-superior stability to the glenohumeral joint. However, electromyographic (EMG) studies have shown that the BiL is not active during isolated shoulder motions, suggesting that it provides only a passive contribution to shoulder stability. Furthermore, a number of clinical studies have reported good long-term outcomes with conservative treatment of isolated proximal rupture of the BiL tendon. This contradiction concerning the role of BiL in shoulder stability has generated debate about its conservative or surgical treatment following proximal tendon rupture.

Ruptures of the proximal tendon of BiL are most common in patients over the age of 50 and account for 96% of all biceps brachii injuries. These injuries are also highly correlated with rotator cuff pathology, and supraspinatus insufficiency is often cited as an antecedent to the biceps rupture. The results of a proximal biceps rupture appear to have a minimal effect on function. After rupture, elbow flexion strength decreases only as much as 16%. Although a 17% decrease in shoulder abduction strength was measured following rupture, those with “late” ruptures showed no significant difference in strength.

Surgical repair generally consists of a tenodesis procedure, in which the intra-articular portion of the tendon is resected and the proximal portion of the remaining tendon is fixed to the proximal humerus. It has been suggested that tenodesis results in smaller strength decrements than conservative treatment. However, recovery from a tenodesis procedure takes significantly longer than conservative treatment. Neither treatment method addresses the potential loss of glenohumeral joint stability in the absence of a BiL tendon.

It is difficult to quantify the roles of individual muscles at the shoulder because there is no method to measure muscle or joint force in vivo. In this study, a computer model of the upper extremity was used to estimate individual muscle and joint-reaction forces at the shoulder. The specific aim was to quantify the capacity of the BiL to contribute to glenohumeral joint stability during arm movement.

METHODS:
The capacity of the BiL and the cuff muscles to produce force at the glenohumeral joint was calculated using a detailed musculoskeletal model of the human upper extremity and computer simulation of arm abduction and flexion. A brief description of the model follows; details can be found in Garner and Pandy [1, 2]. The model was developed using high-resolution CT images of the bones and color cryosection images of the muscles obtained from the Visible Human Male (VHM) dataset. Thirteen degrees of freedom were used to describe the relative positions and orientations of seven bones in the model: clavicile, scapula, humerus, radius, ulna, carpal bones, and hand. The joints of the shoulder girdle – sternoclavicular joint, acromioclavicular joint, and glenohumeral joint – were each modeled as an ideal three degree-of-freedom ball-and-socket joint.

Eighteen muscle bundles were used to represent the lines of actions of the muscle groups spanning the glenohumeral and elbow joints in the model (Fig. 1). The path of each muscle bundle was calculated using the Obstacle-set method described by Garner and Pandy [3]. This method accounts for the way wrapping alters the lines of action of the muscles in the model. Peak isometric muscle force for each muscle was based on the physiological cross-sectional area (PCSA) of the muscles in the VHM and adjusted by matching the maximum isometric torques developed at all the joints in the model to those measured in healthy young subjects [2].

The input to the model consisted of the bone positions as the arm flexed from 0 to 135°, and abducted from 15 to 135° in 15° increments. The bone positions were measured in one healthy male subject (age: 34 yrs; height 179cm; weight 81 kg). In these experiments, Steinman pins were surgically inserted into the sternum, clavicle, scapula, humerus and radius and the X, Y, Z coordinates of the retro-reflective triad of markers mounted on these pins were then measured at 120 Hz using a 5-camera motion capture system [4].

RESULTS:
During arm flexion and abduction, the direction of pull of BiL relative to the glenoid is similar to that of the infraspinatus and subscapularis (Fig. 2, top). However, accounting for the size of the BiL muscle, its capacity to produce stabilizing compressive and shear forces at the glenohumeral joint is less than half that of the infraspinatus and subscapularis. For instance, the maximum inferior force produced by BiL during abduction was 200N, whereas that produced by infraspinatus was 600N (Fig. 2, bottom).

DISCUSSION:
Due to its line of action during flexion and abduction, the BiL is ideally positioned to produce stabilizing glenohumeral compression and to resist humeral head superior shear force rivaling that of the infraspinatus and subscapularis (Fig. 2, top). However, due to its smaller size, its real capacity to create stabilizing glenohumeral joint loads is less than half that of the infraspinatus and subscapularis (Fig. 2, bottom). The relatively small capacity of the BiL to contribute to shoulder forces may explain why rupture of the BiL tendon and its conservative treatment is reported to have no short or long term effect on glenohumeral joint function and stability.

REFERENCES:

Poster No. 1913 • 55th Annual Meeting of the Orthopaedic Research Society