GLIDING PROPERTIES OF THE LONG HEAD OF THE BICEPS BRACHII

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Introduction: Rupture of the long head of the biceps brachii is thought to occur on the basis of preceding degenerative lesions. Mechanical forces that oppose tendon gliding, especially within the bicipital groove, have been proposed to play a role in the development of degenerative changes in the tendon [1,2]. Although the morphology and mechanical properties of the tendon [3], as well as the surface of the bicipital groove [4] have been described, there is no report describing the forces resisting the motion of the long head of the biceps brachii in the intertubercular groove during glenohumeral motion. These fundamental gliding properties may provide insight into the development of pathological changes of the long head of the biceps brachii. The purpose of this study was to determine the forces that resist motion of the biceps tendon in the bicipital groove during abduction and adduction.

Methods: We developed a method of rotating the humeral head, while permitting the biceps tendon to passively slide on the humeral head and through the bicipital groove. 9 human cadaver shoulder specimens were obtained. The specimens were mounted on the testing device (Fig 1). A fiberglass rod in the medullary canal was connected to a drive mechanism and load transducers were connected to each end of the tendon. The distal load transducer (F1) was connected to a weight of 5N, which was hung over a low friction pulley and followed the physiological line of action. The proximal end of the biceps tendon was cut from the glenoid and sutured to another load transducer (F2) to allow the proximal tendon to follow a physiological course. The humerus was moved in the abduction direction beginning from the hanging arm position at a rate of 6 degrees/second by a computer-controlled drive mechanism. Each trial was repeated 3 times.

Statistics: At five different glenohumeral angles (15, 30, 45, 60, and 75 degrees) the difference in force measurements between abduction and adduction were analyzed statistically using a paired t-test (α=0.05).

Results: While the force measured distal to the bicipital groove (close to the weight) was almost identical to the applied weight of 5N, the force measured at the proximal load transducer (F2) differed in both directions (Fig 2). During abduction, that is the proximal part of the tendon is moving into the bicipital groove, the average gliding resistance at 15 degrees of abduction was 0.41N. This difference diminished gradually with greater abduction. At 30 degrees it was 0.4N, at 45 degrees 0.36, at 60 degrees 0.32 and at 75 degrees of abduction it was 0.28N.

In the reverse direction, that is the proximal tendon is moving out of the groove back to its original position, the loads recorded by the distal (F1) and proximal load transducers (F2) were almost identical. At 75, 60, 45, 30, and 15 degrees of abduction the differences were 0.007, 0.012, 0.011, 0.007 and 0.007N, respectively. Although the relative gliding motion was reversed, the average value of the proximal load transducer (F2) was, like in abduction, lower than the distal load transducer. The difference between both directions was significant (p<0.05).

Discussion: The results of the present study indicate that the resistance to gliding is not mainly caused by frictional forces. It would seem intuitive that the normal biceps tendon moving through the bicipital groove in a lubricated environment should mainly be resisted by frictional forces between the tendon and the bone. In terms of our experiment we expected that during abduction, F1 should be greater than F2 due to friction resisting the relative tendon motion. When the relative tendon motion reversed (adduction motion), we expected that friction would once again oppose gliding causing F1 to measure lower forces than F2. However, our results indicate that during passive adduction, as the tendon moves out of the groove, F1 remained lower than F2. Thus, the average resistive force in adduction was found to be working in the same direction as tendon motion, which contradicts what is expected of a purely frictional force.

These findings might be explained by the interaction between the geometry of the tendon and the bicipital groove. In abduction the flat proximal portion of the tendon enters the bicipital groove. Due to tendon elasticity, deformation permits the tendon to follow the shape of the groove. Meanwhile, in adduction the proximal portion of the tendon regains its original shape as it exits the groove.

We believe that this reversible elastic deformation of the tendon imposes an additional force on the tendon during gliding. During tendon gliding into the groove the resistance to deformation acts in the same way as the frictional forces, thus increasing the difference between the two load transducers and therefore increasing the overall gliding resistance. In adduction the elastic force is reversed and opposes the frictional force, which has an effect similar to a spring releasing. The “spring effect” might be larger than the frictional forces, which explains why the load transducer at the proximal end of the tendon measured less than the applied weight of 5N even during adduction.

Therefore, during tendon gliding, friction between surfaces and energy storage during tendon deformation both affect the gliding resistance. The directional dependence on gliding resistance was also shown for higher and lower loading (1N, 2N, 10N and 15N, data not shown). Since we only tested the tendon at a single speed of abduction/adduction (6 degrees/second), future work could study how gliding resistance is affected by rapid glenohumeral movements as observed in sports activities, such as pitching.

These findings suggest a mechanism explaining the etiology of degenerative lesions involving the proximal part of the tendon. Deformation generates internal shear stresses, which cause delamination. Such longitudinal delamination of that portion of the biceps tendon that moves in and out of the bicipital groove is seen commonly in patients with degenerative lesions of the long head of the biceps brachii.

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Fig 1: Experimental set-up

Fig 2: Mean values of force at the proximal (F2) and distal (F1) load transducers during abduction and adduction.