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BASIC SCIENCE

The effect of biceps adhesions on glenohumeral range of motion: a cadaveric study

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Background: Previous studies have demonstrated that the humerus slides along the long head of the biceps tendon (LHBT). Blocking this motion may result in decreased glenohumeral (GH) range of motion (ROM). The goal of the study was to characterize the excursion of the LHBT and measure the effect of biceps adhesions on GH ROM.

Materials and methods: A custom biomechanical testing setup was used to measure the excursion of the LHBT and rotation of the humerus at 0°, 15°, 30°, 60°, and 90° of GH abduction in the scapular plane. An in situ biceps tenodesis with the biceps anchor still intact, thus simulating biceps adhesions, was sequentially performed in 2 positions: 0° abduction and maximum external rotation, followed by 0° abduction and maximum internal rotation. The effect of tenodesis on ROM was measured.

Results: There was an average excursion of 19.4 ± 5.4 mm of the LHBT as the humerus was taken through ROM in the scapular plane. Tenodesis in 0° abduction and maximum internal rotation resulted in a significant decrease in GH external rotation of 47.3° ± 12.2° ($P = .007$) with the arm in 0° abduction.

Conclusions: Tenodesis in maximum internal rotation limited rotation significantly, such that in situ tenodesis without proximal tenotomy should not be performed. Furthermore, in situations where the biceps is at risk for scarring, such as proximal humeral fractures, shoulder arthroplasty, and the stiff shoulder, the biomechanical consequence of biceps adhesions may be similar to in situ tenodesis and may limit ROM and clinical outcomes.

Level of evidence: Basic Science Study, Biomechanics.

Keywords: Long head of biceps tendon; tenodesis; in situ tenodesis; tendon excursion; shoulder range of motion

Despite being the focus of multiple anatomic, biomechanical, and clinical studies, the exact contribution of the long head of the biceps tendon (LHBT) to shoulder function in the healthy and pathologic state is incompletely understood. Most biomechanical studies are cadaveric and may not accurately simulate the role of the tendon in vivo. Despite this limitation, multiple studies have been performed in an attempt to elucidate the role of the biceps.[8,9,11-13,16,20,23,24] In addition to its functional role, the LHBT can also serve as a source of pain and morbidity. In cases of bicipital tendonitis, instability, or degeneration, biceps tenotomy or tenodesis can result in significant pain relief.[4,15]

Institutional Review Board approval was not required for this study.

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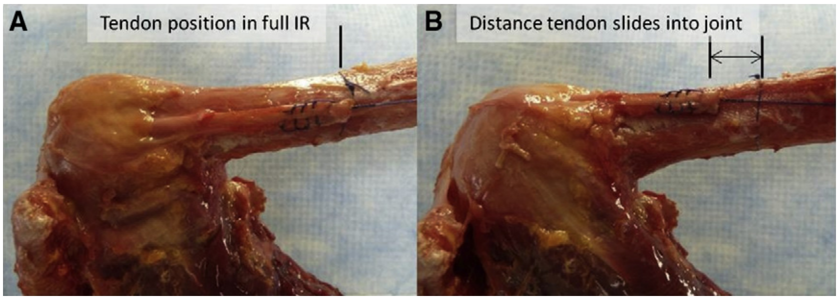

Figure 1 The amount of tendon that is intra-articular varies with the position of the humerus. (**A**) In adduction and internal rotation, the biceps tendon slides out of the joint. (**B**) As the humerus is externally rotated, the biceps tendon slides into the joint.

In 1944, Lippmann[14,18] reported on the biomechanics of the LHBT. He observed that the tendon does not slide in the bicipital groove; rather, the humerus moves along the stationary tendon much like a train travels on a track. As the humerus is taken through full range of motion (ROM), the humerus moves a distance of 2 to 5 cm along the tendon. Accordingly, the amount of tendon that is intra-articular varies with the position of the humerus (Fig. 1). Because of the several centimeter excursion of the tendon, any block to this motion may result in decreased ROM and poorer clinical outcomes. Clinically, this could take the form of adhesions and fibrosis of the tendon within the bicipital groove.

No study to our knowledge has directly studied the effect of biceps adhesions on shoulder ROM. This is a clinically relevant topic because adhesions may result in poorer clinical outcomes. In fact, several authors have already reported on the contribution of biceps adhesions to pain and limitations in ROM in the setting of total shoulder arthroplasty[7,19,21] and frozen shoulders.[10] Despite these reports, this may actually be an under-recognized clinical problem considering the relative paucity of literature on the topic combined with the recent increase in the volume of total shoulder arthroplasty and the surgical treatment of proximal humeral fractures. The objective of this study was to characterize the excursion of the LHBT and to measure the effect of in situ biceps tenodesis on glenohumeral (GH) ROM. Our hypothesis is that an in situ tenodesis, acting as a surrogate for biceps adhesions, will prevent sliding of the humerus on the tendon and thus limit GH rotation.

Materials and methods

Cadaveric preparation

Five fresh, frozen shoulders from scapula to midforearm were acquired from a national tissue bank. Inclusion criteria were donor age of less than 70 years and a body mass index of less than 30 kg/m^2, and exclusion criteria included previous shoulder surgery or significant shoulder pathology. The deceased donors (3 women and 2 men) were an average age of 59 years (range, 43-69). The specimens were inspected to ensure the biceps anchor was intact and the tendon glided freely in the bicipital groove.

The cadavers were dissected in the following manner: the skin, subcutaneous fat, clavicle, deltoid, trapezius, teres major, latissimus dorsi, pectoralis major, and conjoined tendon were removed. The subscapularis, supraspinatus, infraspinatus, teres minor, rotator interval, coracoacromial ligament, and capsule were left in place. The LHBT was sharply transected at the musculotendinous junction. Care was taken to protect the biceps tendon sling, transverse ligament, and proximal soft tissue attachments to ensure that the tendon was centered in the groove. The humerus was internally and externally rotated to visualize the tendon gliding smoothly. The entire humerus distal to the rotator cuff muscles and proximal biceps tendon was removed of all soft tissue attachments. The humerus was disarticulated from the radius and ulna.

The rotator cuff muscles were subperiosteally elevated off the medial 1 cm of the scapula to allow for potting. The medial border of the scapula was potted in a smooth cast epoxy resin. The distal humerus was similarly potted in an epoxy resin. The distal end of the LHBT was whipstitched with No. 2 FiberWire (Arthrex, Naples, FL, USA). These sutures were passed through a pulley system with a 1-N weight at the end to apply a resting tension to the tendon in line with its anatomic course. This tension eliminated slack so that accurate excursion measurements could be made. This tension was consistent with the experimental findings of a previous study that investigated the resting tension of the native biceps tendon.[6] With the aid of a needle driver, an O-Nylon suture (Ethicon, Somerville, NJ, USA) was placed in the periosteum of the proximal humerus adjacent to the biceps tendon and was secured with a knot. This knot served as a reliable reference point from which to measure biceps tendon excursion (Fig. 1).

Biomechanical testing setup

The potted scapula and distal humerus were secured to our laboratory's Instron 8521 test frame (Instron, Norwood, MA, USA; Fig. 2). The glenoid was oriented perpendicular to the floor at 0° degrees abduction and parallel to the floor at 90° abduction. The humerus was oriented such that abduction was in the plane of the scapula. Neutral rotation was determined using the distal aspect of the bicipital groove as a reference and defined with the bicipital groove rotated 30° externally.[2] The sutures in the biceps tendon were used to apply a resting tension force of 1 N, which is consistent with the experimental findings of a previous study.[6] Throughout the study, a 22-N joint compressive force was applied to the scapula to ensure the humerus was centered on the glenoid.[6,24] The compressive force was applied through the