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Safety of open suprapectoral and subpectoral biceps tenodesis: an anatomic assessment of risk for neurologic injury

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Background: Surgical techniques for proximal biceps tenodesis that include penetration of the posterior humeral cortex for fixation may pose risk to the surrounding neurovascular structures.
Hypothesis: The risk of neurologic injury with techniques that involve penetration of the posterior humeral cortex for fixation in proximal biceps tenodesis will increase as the tenodesis site moves proximally from the subpectoral to the suprapectoral location.
Methods: Proximal biceps tenodesis was performed on 10 cadaveric upper extremities with 3 separate techniques. The proximity of the hardware to the relevant neurovascular structures was measured. The distances between the tenodesis site and the relevant neurovascular structures were measured.
Results: The guide pin was in direct contact with the axillary nerve in 20% of the suprapectoral tenodeses. The distance between the axillary nerve and the tenodesis site was 10.5 ± 5.5 mm for the suprapectoral location, 36.7 ± 11.2 mm in the subpectoral scenario, and 24.1 ± 11.2 mm in the 30° cephalad scenario ($P = .003$). The distance between the radial nerve and the anterior tenodesis site was 41.3 ± 9.3 mm for the suprapectoral location and 48.0 ± 10.7 mm for the subpectoral location. The distance of the musculocutaneous nerve from the tenodesis site was 28.4 ± 9.2 mm for the suprapectoral location and 37.4 ± 11.2 mm for the subpectoral location.
Conclusion: In a cadaveric model of open biceps tenodesis, penetration of the posterior humeral cortex at the suprapectoral location results in proximity to the axillary nerve and should be avoided. Subpectoral bicortical button fixation drilled perpendicular to the axis of the humerus was a uniformly safe location with respect to the axillary nerve.
Level of evidence: Basic Science, Anatomy.

Keywords: Biceps; tenodesis; subpectoral; suprapectoral; nerve; cortical button

Open subpectoral biceps tenodesis (OSPBT) is a well-established treatment for disease of the long head of the biceps brachii tendon.[3,4,6,7,10] Many fixation techniques are available; cortical button fixation is a reliable, biomechanically strong and effective technique.[1]

Subpectoral repair with both unicortical and bicortical fixation has been described with success.[1,8] Mithoefer reported that bicortical button fixation optimizes the strength of initial tendon fixation and minimizes gap formation.[8] It was further proposed that this minimally invasive fixation of the long head of the biceps, with unique tensioning

Cadaveric studies are exempted from the Greenwich Hospital MRI approval.

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technique, may help accelerate return to activities.[8] Whereas the bicortical button fixation technique is appealing for these reasons, penetration of the posterior humeral cortex introduces potential new neurologic complications.[8]

Two recent studies have examined the proximity of the axillary nerve to the subpectoral biceps tenodesis site with differing results.[1,3] In one study, the nerve is directly in line with the tenodesis site; in the other, it lies 33.8 mm away.[1,3] Resolution of this difference is important in evaluating the safety of any tenodesis technique that involves penetration of the proximal posterior humeral cortex.[2,8]

The purpose of this study was to use a cadaveric model to define the anatomic relationships of the suprapectoral and subpectoral tenodesis sites with respect to the axillary, radial, and musculocutaneous nerves. These relationships were evaluated in 3 separate scenarios: an open suprapectoral tenodesis location, a perpendicularly drilled subpectoral tenodesis, and a subpectoral tenodesis with the drill aimed 30° cephalad. Our hypothesis was that penetration of the posterior humeral cortex may put neurologic structures at risk, particularly as the tenodesis site moves more proximally from the subpectoral to the suprapectoral location.

Materials and methods

This was a cadaveric anatomic study. Ten frozen, unpaired, human cadaveric upper extremities were studied; the elbow and hand remained on the specimen to maintain neurovascular relationships. All specimens were thawed for 24 hours at room temperature before experimentation. No limbs underwent prior shoulder surgery.

The specimens were placed supine on the operating table, and an open subpectoral biceps approach was performed as previously described.[3,7,8] This was performed to imitate the clinical setting. Each step of this study was performed by board-certified fellowship-trained upper extremity surgeons. The key component of the procedure was that the subpectoral tenodesis was started on the anterior humeral cortex, 1 cm proximal to the inferior border of the pectoralis major and centered at the inferior aspect of the bicipital groove. The pectoralis was pulled taught to make this measurement. A guide pin was then drilled perpendicularly into the shaft of the humerus to represent the site of tenodesis, and the intramedullary depth was measured. A 12-mm bicortical button (Arthrex, Naples, FL, USA) was then placed in accordance with the reported technique.[8] A careful dissection was then carried out to identify the relevant neurologic anatomy with careful attention not to disrupt normal anatomic relationships. The axillary, radial, and musculocutaneous nerves were methodically identified.

The distances between the tenodesis site and the axillary (posteriorly), radial, and musculocutaneous (anteriorly) nerves were measured with standard digital calipers. In an effort to accurately measure the more anterior structures, the guide pin was inserted into the drilled hole and used as an anterior reference point for the digital calipers (Figs. 1 and 2). Posteriorly, the

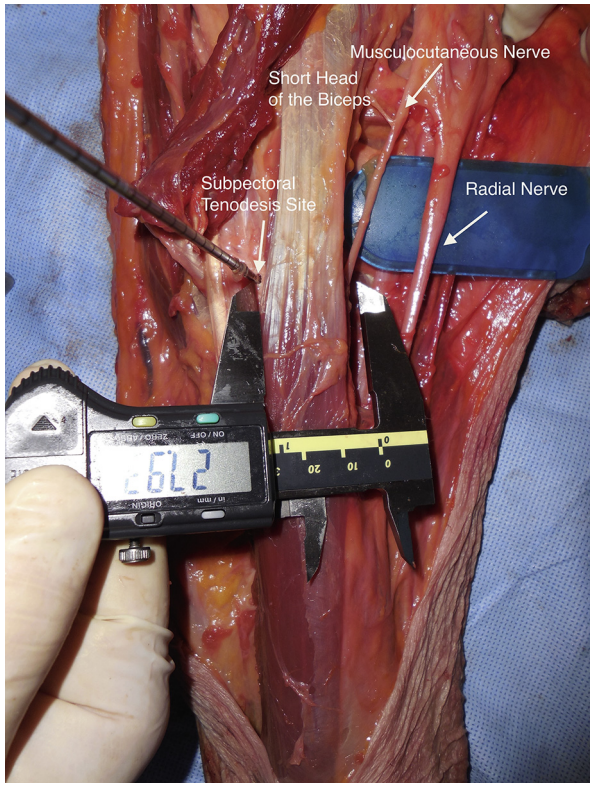

Figure 1 The distance between the musculocutaneous nerve and the tenodesis site.

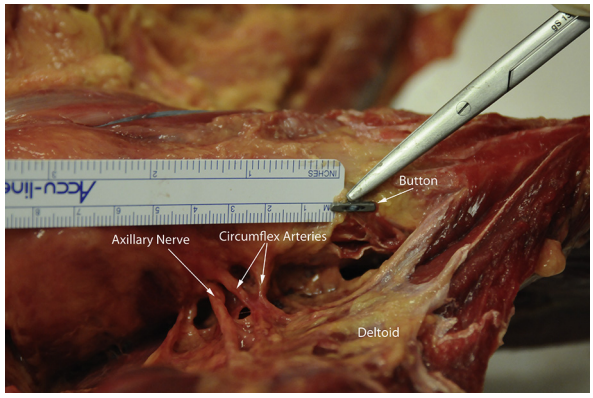

Figure 2 The distance of the button to the axillary nerve and circumflex arteries.

distance from the nerve to the closest aspect of the button was recorded. These distances were measured 3 times, and the mean of the 3 measures was recorded.

With the same starting point from the first tenodesis, the second tenodesis was made with a goniometer aiming 30° cephalad. The same surgical steps were then followed with placement of a cortical button. The same sequence of measurements was obtained.

A third tenodesis site was created at the base of the bicipital groove, perpendicular to the humerus and in line with the bicipital groove to represent the suprapectoral location for tenodesis. This was cephalad to the superior edge of the pectoralis tendon, in contrast to 1 cm above the inferior edge for the subpectoral location. After 2 of the first 4 specimens had the drill pin directly