J Shoulder Elbow Surg (2015) 24, 511-519

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

The anatomy and histology of the bicipital tunnel of the shoulder

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Background: The bicipital tunnel is the extra-articular, fibro-osseous structure that encloses the long head of the biceps tendon.
Methods: Twelve cadaveric shoulder specimens underwent in situ casting of the bicipital tunnel with methyl methacrylate cement to demonstrate structural competence (n = 6) and en bloc harvest with gross and histologic evaluation (n = 6). The percentage of empty tunnel was calculated histologically by subtracting the proportion of cross-sectional area of the long head of the biceps tendon from that of the bicipital tunnel for each zone.
Results: Cement casting demonstrated that the bicipital tunnel was a closed space. Zone 1 extended from the articular margin to the distal margin of the subscapularis tendon. Zone 2 extended from the distal margin of the subscapularis tendon to the proximal margin of the pectoralis major tendon. Zone 3 was the subpectoral region. Zones 1 and 2 were both enclosed by a dense connective tissue sheath and demonstrated the presence of synovium. Zone 3 had significantly greater percentage of empty tunnel than zones 1 and 2 did ($P < .01$).
Conclusion: The bicipital tunnel is a closed space with 3 distinct zones. Zones 1 and 2 have similar features, including the presence of synovium, but differ from zone 3. A significant bottleneck occurs between zone 2 and zone 3, most likely at the proximal margin of the pectoralis major tendon. The bicipital tunnel is a closed space where space-occupying lesions may produce a bicipital tunnel syndrome. Careful consideration should be given to surgical techniques that decompress both zones 1 and 2 of the bicipital tunnel.
Level of evidence: Basic Science, Anatomy/Histology.

Keywords: Long head; biceps tendon; bicipital tunnel; biceps tendinitis; tenodesis

Whereas intra-articular delivery of the long head of the biceps tendon (LHBT) during glenohumeral arthroscopy with a probe is considered the ''gold standard'' diagnostic modality,[1] recent studies showed that this offers a limited evaluation of the biceps-labral complex.[8,20] Furthermore, in their large clinical series, Taylor et al[20] identified a hidden extra-articular lesion affecting the LHBT in 47% of chronically symptomatic patients (Fig. 1). They defined the bicipital tunnel as the extra-articular fibro-osseous confinement of the LHBT that extends from the articular margin through the subpectoral region.

IRB: This study was approved by the IRB at Hospital for Special Surgery, New York, NY (IRB #13200).

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1058-2746/$ - see front matter © 2015 Journal of Shoulder and Elbow Surgery Board of Trustees.
http://dx.doi.org/10.1016/j.jse.2014.09.026

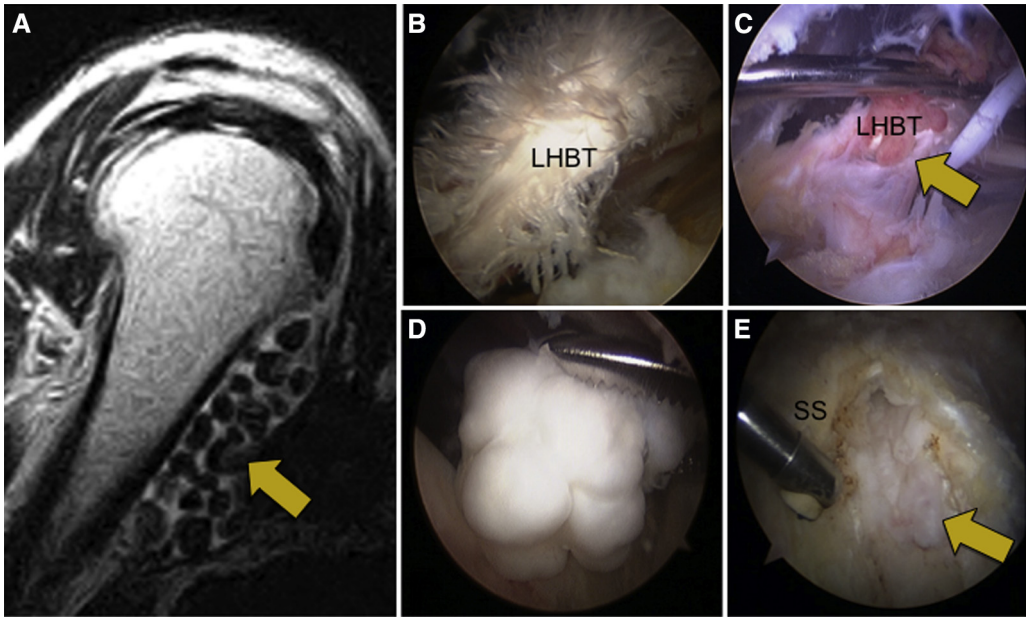

Figure 1 The extra-articular bicipital tunnel is a closed space in which lesions such as loose bodies can aggregate (**A**, *arrow*) as seen on this sagittal view magnetic resonance image. Several different space-occupying extra-articular lesions have been identified within the bicipital tunnel at the time of transfer of the long head of the biceps tendon (*LHBT*) to the conjoint tendon in symptomatic patients that would not have been visualized arthroscopically, including partial tears (**B**), adhesion and scar formation (**C**, *arrow*), loose bodies (**D**), and osteophyte formation (**E**, *arrow*). *SS*, subscapularis.

This discovery of the bicipital tunnel becomes clearly clinically relevant in considering data from a systematic review that indicate persistent biceps symptoms in nearly 25% of patients after tenodesis or tenotomy.[19] It is our experience that the extra-articular LHBT is consistently contained by a soft tissue sheath in all patients to the proximal margin of the pectoralis major tendon (PMPM), creating a tunnel within which space-occupying lesions can aggregate. Sanders et al[18] explored the role of the bicipital sheath on tenodesis outcomes by stratifying results by surgical technique. They demonstrated a significantly higher failure rate (20.6% vs. 6.8%) for procedures that did not release the extra-articular bicipital sheath compared with those that did.

Defined herein is the anatomy and histology of this clinically essential structure called the bicipital tunnel, which we have divided into 3 distinct anatomic zones (Fig. 2). Zone 1 represents the traditional bony bicipital groove and extends from the articular margin (defined by the confluent fibers of the biceps pulley) to the distal margin of the subscapularis tendon (DMSS). The majority (78%) of the LHBT within zone 1 can be visualized during standard diagnostic arthroscopy.[20] Zone 2 extends from the DMSS to the PMPM and represents a ''no man's land'' because it remains entirely hidden from arthroscopic view above[20] and from open subpectoral exposure below. Zone 3 is the subpectoral region.

The purpose of this study was to define the 3-dimensional anatomy and histology of the bicipital tunnel. Such information would advance the collective understanding of the pathogenesis of ''biceps tendinitis,'' explore why some biceps procedures are unsuccessful, and guide surgical technique. On the basis of our previous clinical experience, we hypothesized that (1) the bicipital tunnel is a closed space, (2) it consists of 3 distinct anatomic and histologic zones, and (3) a functional bottleneck exists between zones 2 and 3.

Materials and methods

Fifteen adult human fresh frozen cadaveric specimens (mid-clavicle to fingertips) were considered for evaluation. No surgical scars, evidence of prior trauma, or gross deformities were evident before arthroscopic examination. Passive glenohumeral and elbow ranges of motion were full for all specimens. Three specimens were disqualified after diagnostic arthroscopy because of preexisting disease (subscapularis tear, n = 1; high-grade partial tear of the LHBT, n = 1; complete LHBT rupture in the setting of supraspinatus tear, n = 1). The remaining 12 specimens were divided randomly into 2 groups: 6 specimens would undergo cement casting of the bicipital tunnel, and 6 specimens would undergo en bloc resection of the bicipital tunnel and histologic evaluation to test our 3 hypotheses.

Hypothesis 1: the bicipital tunnel is a closed space

Six cadaveric human, fresh frozen, upper extremity specimens (3 male and 3 female) underwent cement casting of the bicipital tunnel. The average age of these specimens was 65.2 years (range, 45-81 years). Each specimen underwent arthroscopic release of the LHBT from its intra-articular origin. A standard posterior