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Transfer of the long head of biceps to the conjoint tendon. A biomechanical study

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ABSTRACT

Background: Tenodesis of the long head of biceps has been intensively investigated and various surgical options exist. The aim of this biomechanical study was to compare the maximum strength of two different techniques for biceps tenodesis. Our hypothesis was that the two procedures have the same biomechanical properties.
Methods: We performed the two different tenodesis techniques using 12 fresh frozen shoulders divided into two groups of six. In the first group, the biceps was transferred to the conjoint tendon. In the second group, an intraossous suprapectoral tenodesis was performed. After a preload of 10 N, cyclical loading with a maximum of 60 N and 100 N with 100 cycles and 0.5 Hz was applied to the tendons for both groups. An axial ultimate loading to failure was conducted subsequently.
Results: No significant differences were found in age, bone mineral density, or weight between the two groups. During the cyclical loading with 60 N, one slippage of the tendon was observed in the suprapectoral group. The mean ultimate load to failure was 294.15 N in the transposition group and 186.76 N in the suprapectoral group, but this difference was not significant ($P = 0.18$).
Interpretation: The biomechanical results demonstrated equal biomechanical properties postoperatively for both transposition of the tendon and the current standard suprapectoral tenodesis procedure. The transposition can be performed as a primary or a salvage procedure in order to potentially reduce the proportion of patients with persistent postoperative bicipital groove pain and is comparable in strength to a standard tenodesis.

1. Introduction

Pathology of the long tendon of the biceps brachii (long head of biceps, LHB) is often a reason for anterior shoulder pain and is associated with limitation of forward flexion (Hitchcock and Bechtol, 1948; Neviaser, 1987; Post and Benca, 1989; Walch et al., 1998). The pathological processes may concern only the LHB as a primary tendinitis, an unstable SLAP lesion, or a pulley lesion with dislocation of the LHB, or may occur in combination with an anterosuperior rotator cuff tear (Boileau et al., 2009, 2007; Habermeyer et al., 2004).

The primary treatment depends on the cause of the pathological changes, but if surgery is indicated, there are several techniques available. Tenotomy is one possibility for the treatment of biceps pathology (Gill et al., 2001; Kelly et al., 2005; Walch et al., 2005), or alternatively, a tenodesis of the LHB can be performed. This can be conducted arthroscopically (Boileau et al., 2007, 2002; Mazzocca et al., 2005; Richards and Burkhart, 2005; Romeo et al., 2004) or using a mini-open (Mazzocca et al., 2005, 2003) or open technique (Froimson and O, 1975; Golish et al., 2008). Different positions (suprapectoral or subpectoral) for tenodesis are also possible. Biomechanical investigations observed different results in terms of biomechanical characteristics of the proximal biceps tenodesis. It has been shown biomechanically that interference screws are appropriate devices for suprapectoral and subpectoral biceps tenodesis, whereas the knotless suture anchors sustained a significant about 50% lower UFL and can only be recommended conditionally for LHB tenodesis (Patzer et al., 2012). In this study, a dislocation <3 mm was observed after cyclic loading for all techniques except the subpectoral Bio-Swivelock. Based on the results of Lorbach et al. and Richards et al., biceps tenodesis using an interference screw showed superior fixation strength compared with suture anchors (Lorbach et al., 2008; Richards and Burkhart, 2005). In contrast, after open subpectoral bone tunnel tenodesis, Mazzocca et al. observed a greater displacement compared to tenodesis with a subpectoral interference screw or suture anchor (Mazzocca et al., 2005). However, they did not find significant differences in the ultimate load of failure between the techniques. Furthermore, there are some studies in the current literature reporting on the transfer of the LHB to the conjoint tendon, possibly also involving the coracoid process (Dines et al., 1982; Post and Benca, 1989; Verma

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et al., 2005). The first transfer of the LHB to the coracoid process was described in 1926 by Gilcreest (1926). Based on the current literature, it is not possible to make a definite recommendation for either tenotomy or tenodesis (Frost et al., 2009).

Many studies have observed very good to excellent postoperative results after tenodesis of the LHB (Boileau et al., 2002; Checchia et al., 2005; Drakos et al., 2008; Franceschi et al., 2008; Kelly et al., 2005; Nord et al., 2005). However, current studies also describe persistent pain in 6.67–24% of patients after tenodesis (Checchia et al., 2005; Gill et al., 2001; Hsu et al., 2011). David et al., who described an arthroscopic technique for a suprapectoral tenodesis of the LHB, reported that they have often seen pathological conditions of the LHB within the bicipital groove extending distally to the lesser tuberosity, including synovitis, loose bodies, and longitudinal tears (David and Schildhorn, 2012). They concluded that only a method of tenodesis that removes the tendon from each of these sites can address these potential sources of pain and that these goals can only be achieved by a subpectoral tenodesis (David and Schildhorn, 2012). However, the transfer of the LHB to the conjoint tendon is another possible way of removing the LHB from the intertubercular sulcus and eventually reducing the chance of persistent postoperative pain. The transfer could also be performed as a salvage procedure for persistent pain after a tenodesis.

To our knowledge, no biomechanical investigation of the transfer of the LHB to the conjoint tendon has so far been performed, and so the aim of this study was to compare the fixation strength of a suprapectoral tenodesis of the LHB using an interference screw (SwiveLock 8 mm, Arthrex Inc., Naples, FL, USA) with the following transfer of the LHB to the conjoint tendon with suture fixation. Our hypothesis was that transfer of the LHB would have the same failure strength as the standard tenodesis using the interference screw.

2. Methods

A total of 12 cadaver shoulder specimens (five right and seven left) (Science Care Inc., Phoenix, AZ, USA) were obtained in which the LHB was macroscopically intact without higher-grade lesions, and on which no operations or injuries were recorded in the donors' medical histories. The Ethics Committee of the Medical School Hannover gave approval for the study (no. 2685–2015). The average age of the donors was 69.33 years (SD 11.87) and their average weight was 59.67 kg (SD 12.09). The specimens were thawed to room temperature 24 h before testing. Before the biomechanical tests, bone densitometry (Discovery QDR, Hologic Inc., Bedford, MA, USA) was performed on all specimens.

The specimens were divided randomly into two groups of six. In the first group, transposition of the LHB to the conjoint tendon using a Fiberwire no. 2 (Arthrex Inc., Naples, FL, USA) was performed. In the second group, a suprapectoral biceps tenodesis was conducted using an 8 mm SwiveLock (Arthrex Inc., Naples, FL, USA). In the first group, the donors had an average age of 72.33 years (SD 15.68) and a mean weight of 58 kg (SD 9.01); in the second group, the average age was 66.33 years (SD 6.5) and mean weight was 61.33 kg (SD 15.29).

The humerus was amputated approximately 20 cm distal to the center of the humeral head and the soft tissue was removed from the scapula up to the spina scapulae on both sides. The scapula was then embedded in casting resin (Gössl&Pfaff GmbH, Karlskron/Braulach, Germany) consisting of three components (Rencast FC 52/53 Isocaynate, FC 53 Polyol, and Füller DT 982), and cold-cured. Using the same resin the distal humerus was embedded in a brass cylinder with a diameter of 38 mm and a length of 52 mm. To fix the specimens in the materials testing machine, three 10 mm holes were drilled in the embedded scapula. All operations were performed by the senior author.

2.1. Surgical technique

2.1.1. Transposition of the LHB to the conjoint tendon

For the deltopectoral approach, a 10 cm skin incision was made and the subcutaneous tissue was divided. The deltopectoral interval was detected and the cephalic vein was prepared laterally. Both blunt and sharp dissections were performed through this interval and the subacromial and subdeltoid bursae were partially removed. The rotator interval was palpated, and then a 2 cm horizontal incision in the rotator interval was made above the subscapularis tendon. The LHB was identified in the glenohumeral joint and was detached at the superior labrum. The bicipital groove was opened along its entire length. The LHB was then exposed and prepared to the musculotendinous junction. The adhesions were removed. The conjoint tendon was exposed, followed by a tension-free transfer of the LHB to the conjoint tendon. The LHB was attached to the conjoint tendon with a continuous suture (Fiberwire No. 2, Arthrex Inc., Naples, FL, USA), beginning directly below the coracoid process running 4 cm distally with a surgeon's knot at the end. The LHB was cut at the musculotendinous junction, and at the end of the procedure, the protruding portion of the LHB was trimmed off.

2.1.2. Suprapectoral tenodesis

For suprapectoral tenodesis, the exposure of the LHB and preparation of the musculotendinous junction was performed according to the previously described technique. The site for the tenodesis was chosen 10 mm distal to the proximal entrance to the bicipital groove (Boileau et al., 2009, 2002; Mazzocca and Romeo, 2003; Romeo et al., 2004). In this position, a 2 mm K-wire was inserted into the bone. The proximal part of the LHB was then shortened by 2 cm and reinforced with 2 cm no. 2 Fiberwire (Arthrex Inc., Naples, FL, USA) in a running whipstitch technique. A 20 mm bone socket was drilled over the K-wire with a 7 mm drill. The whipstitched sutures were fed through the closed eyelet of the 8 mm PEEK SwiveLock tenodesis screw (Arthrex Inc., Naples, FL, USA). The driver was then used to place the tendon at the bottom of the bone socket and hold it in place while the SwiveLock tenodesis screw was advanced, providing secure fixation. The sutures were then removed and the LHB was cut distally at the level of the musculotendinous junction.

2.2. Biomechanical testing

Each specimen was clamped into a materials testing machine (MTS 858 Mini Bionix, Eden Prairie, MN, USA). The specimens were mounted inversely in the testing machine, so that the cyclical loading forces and the ultimate pull-out force were close to parallel to the longitudinal humeral axis and approximated the in vivo direction of the loading of the biceps muscle and tendon (Patzer et al., 2012) (Fig. 1). A 2.5 kN low-force load cell was used (FR10M-2.5KN-B007, Tovey Engineering Inc., Phoenix, AZ, USA). The distal end of the LHB was fixed in a clamp with a sinusoidal profile that was positioned 30 mm distal to the tenodesis to minimize tendon elongation (Patzer et al., 2012).

The tests were carried out at room temperature and the tendon was moistened with 0.9% NaCl to avoid desiccation. A preload of 10 N was applied to the LHB. All specimens were cyclically loaded with 60 N for 100 cycles at 0.5 Hz, and an increasing load to 100 N for 100 cycles at 0.5 Hz was applied. In the present study, the cyclical loading force was related to activities of daily living (Wolf et al., 2005). The 60 N load is about half of this and requires the LHB to be in 90° elbow flexion and holding 1 kg in the hand (Romeo et al., 2004). The 100 N load is comparable with the tension in the LHB at 90° elbow flexion and holding 1 kg in the hand (Nordin and Frankel, 2001). Finally, an axial load-to-failure test was conducted on the specimens at a rate of 1 mm/s until a load was observed, and the loading was then reduced. Data were recorded for both minimum and maximum cyclical loading, as