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Original article

Evaluation of the Subscapularis Split Created with Passive Rotation During Arthroscopic Dynamic Anterior Stabilization (DAS): a Cadaveric Study.

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Abstract

Introduction: The purpose of the present study was to analyze the ability to create a subscapularis split by passive rotation of the arm during dynamic anterior stabilization (DAS) and to analyze the new geometry of the the long head of the biceps LHB.

Hypothesis: The hypothesis was that this passive simple technique can create subscapularis split without additional dissection giving rise to new position of LHB with a new stabilization function.

Material and Methods: A technique of subscapularis split using the LHB was used in 12 fresh-frozen human cadaveric shoulders. A subscapularis split was created by passive rotation of the arm after the LHB is shuttled into the joint during DAS. The length of the subscapularis split, post-DAS position and length of the LHB, and the angulation of the LHB relative to bicipital groove were measured after DAS and if this new geometry can give a new dynamic effect on subscapularis muscle.

Results: The mean length of the subscapular split after maximal rotation was 20.4 ± 6.0 mm (range, 10-32 mm). The mean elongation of the LHB was 0.6 ± 1.4 mm (range, -1 to +3 mm). The final angle of the LHB relative to the bicipital groove was 45 ± 5 degrees (range, 41 to 55 degrees).

Discussion: There is no need to create a distinct split prior to DAS. Additionally, DAS maintains the length-tension relationship of the LHB. The post-procedure medial angulation of the LHB relative to the bicipital groove may provide a lowering of the subscapularis, helping explain the anterior reinforcement of this technique.

Level of evidence: Basic science study, cadaver study.

Keywords: shoulder instability; Bankart; Sling effect; Hammock; Latarjet; Treatment.

Introduction

The subscapularis split is a required but difficult step of several instability procedures includes as dynamic anterior stabilization (DAS),[1-2] Latarjet,[3-5] Eden-Hybinette,[6-7] or open bony Bankart fracture fixation. The arthroscopic creation of such as split in particularly challenging and has been a challenge in the learning curve of arthroscopic bone block procedures or DAS.

The subscapularis split can be performed with several variations: before[4] or after the coracoid osteotomy,[3-5] with inside-out or outside-in approaches, using a knife then scissors to spread the muscle (a common open technique) or a electrocautery to burn the muscle fibers (a common arthroscopic technique). The level of the split can be difficult to establish.[8] The proximity of the axillary nerve and brachial plexus makes its creation inherently risky. Furthermore, it is the natural tendency to begin the split laterally, in the robust tendinous part of the subscapularis, even if the aim should be to spread only the medial and fragile muscular fibers. The sling and hamac effects on subscapularis have been previously described for Latarjet.[9] Changes in long head of the biceps (LHB) new length-tension relationship and its new positioning in relation to subscapularis have not been yet reported concerning DAS technique. Consequently, development of a safe and reproducible technique to perform the split, particularly arthroscopically, is appealing.

The purpose of the present study was to analyze the ability to create a subscapularis split by passive internal and external rotation of the arm during DAS and to analyze the new geometry of LHB. The hypothesis was that this passive simple technique can create subscapularis split without additional dissection giving rise to new position of LHB with a new stabilization function.

Material and Methods

DAS transfers the long head of the biceps within a subscapularis split to the anterior glenoid margin, thereby creating a “sling effect” (Figure 1).[10]

Objectives

The primary study objective was to evaluate the ability to create a subscapularis split by passive rotation of the arm during DAS. The secondary objective was to analyze the new position of LHB after DAS.

Cadavers Selection

Twelve fresh-frozen human cadaveric shoulders were used. No institutional review board approval was required for a cadaveric study at our institution. The mean donor age was 81.8 ± 6.7 years (range, 66-89 years). Five of the donors were male, and 7 were female. There were 9 left shoulders 3 right shoulders. The specimens were mounted in a simulated beach-chair position, secured with a clamp on the medial scapula, and mounted onto an aluminum frame with the arm in gentle traction in neutral elevation. Cadavers with previous shoulder surgery or a full thickness rotator cuff tear were excluded.

Initial Exposure and Portal Placement

An intra-articular approach was used through a standard 3-portal (posterior, anterosuperolateral (ASL), and anterior portals) technique. The posterior portal was established at the “soft spot” 2 cm inferior and 1 cm medial to the posterolateral edge of the acromion. A standard diagnostic arthroscopy was performed with a 30 degree arthroscope and a pump maintaining pressure at 40 mm Hg. ASL and anterior working portals were then established with an outside-in technique using a spinal needle as a guide. The rotator interval was opened with an electrocautery in order to visualize the superior tendinous border of the subscapularis for later measurement and instrument access. From the ASL portal the capsule posterior to the subscapularis muscle was horizontally opened with electrocautery.[11] A 70 degree measurement probe (Arthrex, Inc., Naples, FL) was to mark the intended split at approximately 35 mm in males and 30 mm in females inferior to the upper border of the subscapularis tendon.[8]

The arthroscope was then advanced anteriorly through the window in the rotator interval. From the ASL, the subcoracoid space was cleared with electrocautery and shaver to obtain complete visualization of the anterior deltoid, the subscapularis on 3 sides, the lateral margin of the conjoint tendon and the pectoralis major. With an electrocautery introduced through the anterior portal, a mark was made on the LHB at the upper level of the pectoralis major for subsequent measurement of new length of LHB.

Addressing the LHB

The LHB was then tenotomized at its origin with curved arthroscopic scissors. The arthroscope was then moved to the ASL portal. A suture grasper was introduced through the anterior portal and the LHB was exteriorized and prepared. The 2 first cm were reduced to 4 mm of diameter. The proximal 3 cm of the tendon was whipstitched (Figure 2). The LHB was then pushed between the subscapularis and the conjoint tendon (Figure 3).

Subscapularis Split Technique

While viewing from the ASL portal, a retrograde suture passage (BirdBeak; Arthrex, Inc., Naples, FL) was introduced through the posterior portal and through the subscapularis at the level of the previously marked split location (Video 1). The retrograde passer was used to retrieve the ends of the LHB whipstitch sutures and then pull the LHB tendon into the glenohumeral joint (Figure 4). With the LHB passed through the desired split level, the arm was then passively maximally internally and externally rotated to spread the muscle fibers of the subscapularis (Video 2, reproduced from Beemed, with permission). Through the anterior portal, a 4 mm hole is performed at the junction bone-cartilage at 4 O'clock. The sutures are passed through the rotator interval and the anterior portal, allowing to fix the LHB on the glenoid with a knotless anchor (3.9 Swivelock; Arthrex, Inc., Naples, FL) (Figure 5).

Measurement of Length of the Split

Following arthroscopic creation of the split, open measurements were performed. The skin, deltoid, conjoint tendon, pectoralis minor, the bursa and the clavipectoral fascia were completely removed to accurately visualize the subscapularis and surrounding structures. Four measurements were performed: (1) the diameter of the LHB tendon 3 cm distal to its origin was measured with a caliper. This measurement corresponds to the initial length of the split after passage of the tendon but before maximal internal and external rotation; (2) the split length after maximal rotation of the arm measured with a ruler (Figure 6); (3) the position the preformed mark on LHB and its new relation to pectoralis major giving rise to either elongation (+) or shortening (-) of the LHB in relation to the upper border of the pectoralis major (Figure 7), and (4) the angle between the bicipital grove and the LHB after its fixation on the glenoid (Figure 8). In case of shortening, the pectoralis major was detached to allow measurement. The last measurement was performed digitally based on photograph using (Osirix; Pixmeo, Geneva, Switzerland) (Figure 8). Measurements were performed one time by one examiner and confirmed by a second examiner who was observing the measurement.

Statistics

The descriptive analysis consisted of frequencies and percentages for discrete data. Means and standard deviations were used for continuous data.

Results

No specimens required exclusion. The mean diameter of the LHB tendon 3 cm distal to its origin was 5.6 ± 0.6 mm (range, 4.6-6.2 mm). The mean length of the subscapular split after maximal rotation of the arm was 20.4 ± 6.0 mm (range, 10-32 mm). Therefore, the rotation maneuver increased the length of the split by approximately 15 mm (final split length – LHB diameter). Following the DAS, the LHB was moved 0.6 ± 1.4 mm (range, -1 to +3 mm) proximally. The final angle of the LHB relative to the bicipital groove was 45 ± 5 degrees (range, 41 to 55 degrees).

Discussion

The findings of the current study confirmed our hypothesis that it is not necessary to create a distinct large split in the subscapularis tendon prior to shuttling the LHB into the glenohumeral joint for DAS (primary objective). This finding as well as the observation of the new position of the LHB tendon post-procedure (secondary objective) have several implications relevant to the DAS and arthroscopic creation of a subscapularis split.

Previous reports on arthroscopic Latarjet stabilization procedures have described the creation of a distinct wide subscapularis split via electrocautery prior to shuttling into the glenohumeral joint.[5] This step increases the technical difficulty of the procedure and requires additional work around the axillary nerve and brachial plexus. This step may partially explain the 1% rate of neurological injury following arthroscopic Latarjet.[12] In contrast to the Latarjet in which a large bone block is shuttled into the joint, with the DAS only the LHB is shuttled into the joint as this procedure relies upon the sling effect only. Clinically we observed that the LHB was easy to shuttle into the joint without creation of a distinct split and that subsequent passive rotation created the split. The present study confirms these observations. A significant split length can be obtained with passive internal and external rotation of the arm. This technique is appealing in that it is less invasive than the active creation of a split. Furthermore, the necessary length of the split can be patient dependent in that is will vary based on each individual’s maximal rotation. This technique may also be adapted to arthroscopic Latarjet. For instance, rather that creation of a split with electrocautery, it is feasible to pass a switching stick through the subscapularis into the joint and then passively internally and externally rotate the arm; in this case the switching stick would perform the same function as the LHB did in the current study. Then, the surgeon would only need to slightly enlarge the hole in the capsule to accommodate a bone block.

Another important finding of this study is that the length-tension relationship of the LHB was maintained. Following the DAS the LHB only moved proximally a mean of 0.6 mm and never more than 3 mm. This is important for several reasons. First, maintenance of length is required for a muscle to generate adequate tension.[13] Second, under-tensioning may result in a postoperative Popeye deformity. This is important given that patients demonstrate strong preferences for avoiding postoperative Popeye deformity. Lastly, over-tensioning may result in cramping or even anchor pull-out.[14]

Finally, we demonstrated that the angle change of the LHB relative to the bicipital groove (Figure 8) is favorable. During evolution, the upper limb of humans changed from an internally to an externally rotation position. The humerus undergoes torsion that has, in turn, affected the position and size of the humeral tubercles. In primitive forms, the bicipital groove lays approximately midway between the two tubercles, which are of almost equal size. The effect of the torsion has displaced the bicipital groove medially, so that it encroaches upon, and reduces the size of the lesser tubercle. The illogical pathway of the LHB, going from a primarily horizontal to a secondary vertical position without strong medial pulley is mainly responsible for the high prevalence of its medial subluxation without having any stabilizing effect. In contrast, the position of the LHB after DAS with the 45 degrees angulation has a favorable stabilizing consequence.

Limitations

There are several limitations to this study that warrant discussion. First, the sample size was small. Second, we did not measure external rotation before and after the procedure to see if there was any limitation of the split upon external rotation. However, in our clinical observations we have not noted lack of external rotation after the DAS after early rehabilitation. Third, this cadaveric study does not take into account muscle tone. Cadavers may present different muscle quality that could change the length of the split. Finally, we only evaluated the angle of the LHB relative to the bicipital groove with the arm in adduction; the angle may change with different positions of abduction.

Conclusions

A subscapularis split can be created by passive rotation of the arm after the LHB is shuttled into the joint during DAS. Therefore, there is no need to create a distinct split prior to DAS. Additionally, the DAS maintains the length-tension relationship of the LHB. The post-procedure medial angulation of the LHB relative to the bicipital groove may provide a lowering of the subscapularis, helping explain the anterior reinforcement of the technique.

~~Figure Legend~~

~~Figure 1: Anterior view of a left shoulder after DAS stabilization. The long head of the biceps is transferred and fixed to the anterior glenoid, lowering the inferior part of the subscapularis muscle. Reproduced with permission form Goetti et al.[10]~~

~~Figure 2: Superior view of a right shoulder. The LHB is exteriorized. Its diameter was decreased to 4 mm diameter for the proximal 2 centimeters. The 3 proximal centimeters of the proximal tendon were then secured with a whipstitch. Reproduced from www.wikiBeeMed.com, with permission.~~

~~Figure 3: Subcoracoid view of a right shoulder from an ASL viewing portal. The LHB was pushed between the subscapularis and the conjoint tendon. Reproduced from www.wikiBeeMed.com, with permission.~~

~~Figure 4: Intra-articular view of a right shoulder, ASL viewing portal. The LHB tendon has been shuttled through the subscapularis into the glenohumeral joint. Reproduced from www.wikiBeeMed.com, with permission.~~

~~Figure 5: The LHB has been secured onto the glenoid at approximately 4 O'clock. Reproduced from www.wikiBeeMed.com, with permission.~~

~~Figure 6: Measurement of the length of the subscapularis split following maximal passive external rotation of the arm. The black arrow corresponds to the measurement. * indicates the LHB (SSc, subscapularis). Reproduced from www.wikiBeeMed.com, with permission.~~

~~Figure 7: Left arm in neutral rotation. Measurement from the upper border of the pectoralis (delimited by the right blue suture) to the mark on LHB (highlighted by the left blue suture for clarification). Reproduced from www.wikiBeeMed.com, with permission.~~

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~~Video 1: Intra-articular view of a left shoulder from an ASL viewing portal. A retrograde suture passage was introduced through the posterior portal, the horizontal capsulotomy and the subscapularis. Reproduced from Ibrahim et al., with permission.[11]~~

~~Video 2: Passive internal and external rotation of the arm is performed to automatically spread the muscle fibers of the subscapularis.~~

Conflict of interest:

Dr. Lädermann is a paid consultant for Wright, Arthrex and Medacta. He received Royalties from Wright, outside the submitted work.

Dr. Arrigoni has nothing to disclose.

Dr Philippe Collin is a paid consultant for Wright and Arthrex and received Royalties from Wright.

Dr. Ibrahim has nothing to disclose.

Dr. Narbona reports personal fees from Arthrex Inc., outside the submitted work.

Dr. Denard reports grants and personal fees from Arthrex, outside the submitted work.

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Authors' contribution:

Ibrahim: 1) Conception and study design, analysis and interpretation of data, 2) drafting and revision of the manuscript, 3) final approval of the submitted manuscript.

Narbona: 1) Conception and study design, analysis and interpretation of data, 2) drafting and revision of the manuscript, 3) final approval of the submitted manuscript.

Arrigoni: 1) Conception and study design, analysis and interpretation of data, 2) revision of the manuscript, 3) final approval of the submitted manuscript.

P. Collin: 1) Conception and study design, analysis and interpretation of data, 2) revision of the manuscript, 3) final approval of the submitted manuscript.

Denard: 1) Analysis and interpretation of data, 2) drafting and revision of the manuscript, 3) final approval of the submitted manuscript.

A. Lädermann: 1) Conception and study design, analysis and interpretation of data, 2) Revision of the manuscript, 3) final approval of the submitted manuscript.

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Figure Legend

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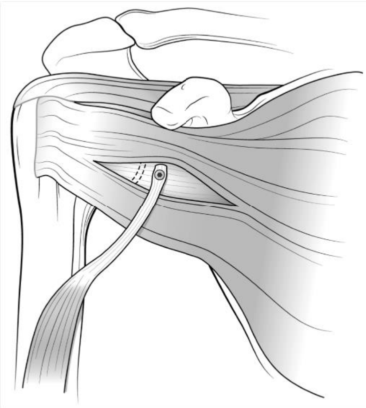

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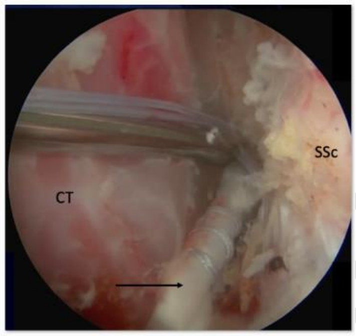

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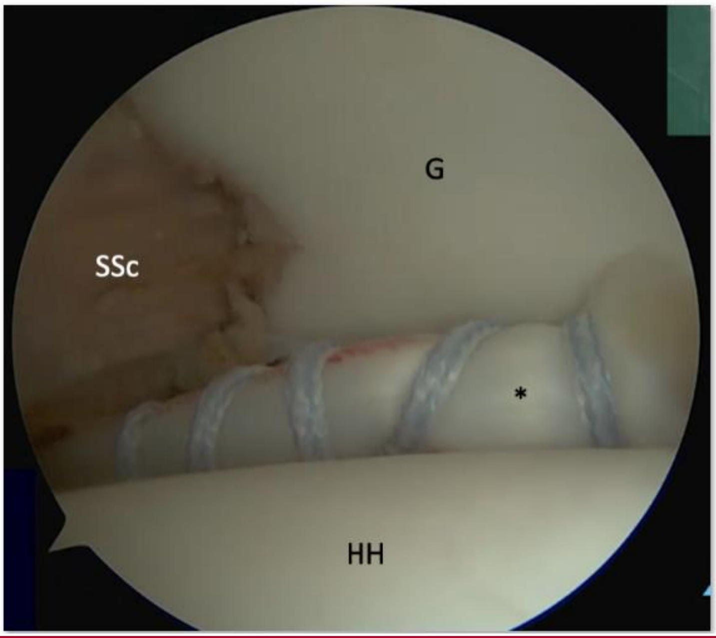

Figure 5: The LHB has been secured onto the glenoid at approximately 4 O'clock.

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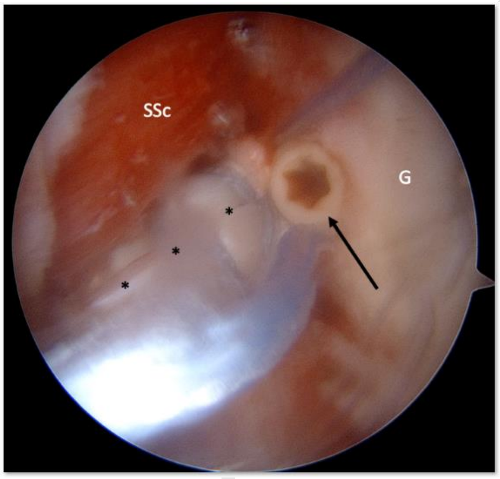

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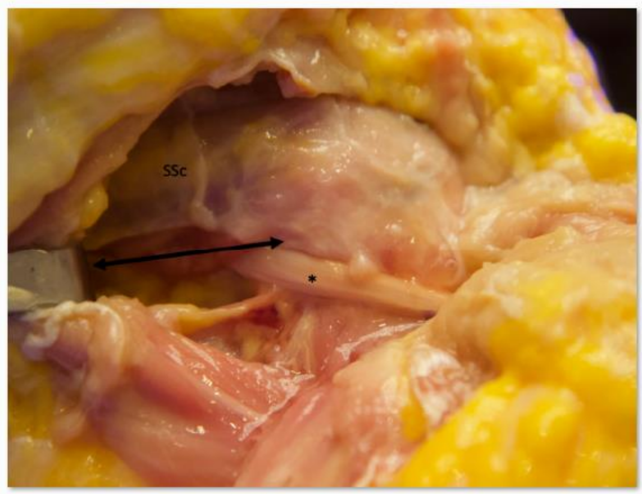

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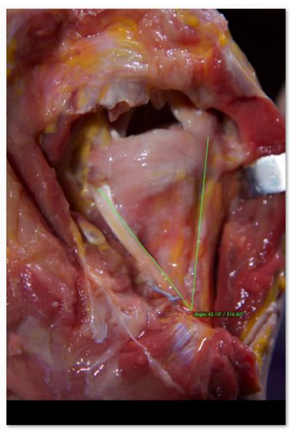

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Video 2: Passive internal and external rotation of the arm is performed to automatically spread the muscle fibers of the subscapularis.