The Shoulder Trans-pectoralis Arthroscopic Portal Is a Safe Approach to the Arthroscopic Latarjet Procedure: A Cadaveric Analysis

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Purpose: To assess the proximity of neurovascular structures in a layered approach during medial portal placement and determine standardized measurements for establishing a portal medial to the coracoid used in arthroscopic Latarjet-type procedures. **Methods:** Twelve shoulders (6 right and 6 left) in 6 fresh frozen cadaveric torsos were mounted in the modified beach-chair position. A standard posterior portal and 3 anterior portals—central, lateral, and medial—were used. A long spinal needle was placed along the path of the medial portal to the lateral tip of the coracoid, superficial to the conjoined tendon and pectoralis minor. A second long spinal needle was directed toward the medial base of the coracoid, penetrating the pectoralis minor. Superficial and deep plane dissections were performed, and distances to surrounding neurovascular structures were recorded. **Results:** In the superficial plane, the cephalic vein and lateral pectoral nerve were located a mean distance (± standard deviation) of 4.6 ± 1.9 mm and 9.4 ± 2.6 mm from the spinal needle, respectively. In the deep plane, the axillary nerve was 24.9 ± 7.4 mm from the needle; the lateral cord of the brachial plexus, 25.5 ± 8.1 mm; the axillary artery, 34.1 ± 6.0 mm; and the musculocutaneous nerve, 42.2 ± 9.2 mm. The portal was consistently established 45.0 to 50.0 mm distal and 30.0 to 35.0 mm medial to the coracoid, which was a minimum distance of 10 mm to the lateral pectoral nerve. **Conclusions:** In a cadaveric model, the creation of a medial trans–pectoralis major portal used in the arthroscopic Bankart-Bristow-Latarjet procedure can avoid compromise of vital neurovascular structures, alleviating concerns of creating a portal medial to the coracoid. Portal placement 45.0 to 50.0 mm distal and 30.0 to 35.0 mm medial to the palpable tip of the coracoid process may be a safe approach to perform the arthroscopic Bankart-Bristow-Latarjet procedure. **Clinical Relevance:** Creation of a portal medial to the level of the coracoid may pose a risk to neurovascular structures. This cadaveric study establishes a working zone for medial trans-pectoralis portal placement, which avoids vital neurovascular structures, and provides standardized measurements for establishing this portal for use in the arthroscopic Bankart-Bristow-Latarjet procedure.

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Surgical and technical improvements in shoulder arthroscopy have led to major changes in the treatment of anterior shoulder instability over the past 20 years. Despite these advancements, the rate of recurrence of instability after arthroscopic Bankart repair in the setting of large bony defects ranges from 67% to 89% in the literature.[1,2] The recurrence rate, still unrecognized by many authors, has led to regained popularity of alternative procedures including the Latarjet procedure, which has become a topic of increased discussion.[3-8]

Originally described by LaFosse et al.[9,10] and modified by Boileau et al.,[11,12] the arthroscopic Latarjet procedure has been shown to yield good outcomes in patients with glenoid bone loss greater than 25% in some series.[13-17] However, high complication rates with the all-arthroscopic Latarjet procedure continue to be of concern.[13,16,18-25] Total complication rates for open and arthroscopic Latarjet procedures have been reported to be 13.8% and 12% to 30%, respectively, in several

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systematic reviews.[18,19,21] Although coracoid graft nonunion is the most common (8.1% ± 4.1%), neurovascular injuries, including transient and permanent neurovascular injuries to the musculocutaneous, axillary, radial, and suprascapular nerves, brachial plexus, and axillary artery, are not uncommon and have been reported at a rate as high as 10% in a series.[21,25]

An outside-in, trans–pectoralis major arthroscopic portal originating medial to the level of the coracoid process was described by Boileau et al.[11,12] to ease graft passage and screw placement. The medial portal was used initially as a working portal to expose the coracoid and detach the pectoralis minor from the medial side and then to retract the osteotomized coracoid bone block medially. This portal creates a medial position that allows for an appropriate trajectory of screw insertion and flush placement of the bone block against the articular surface of the glenoid. However, if this medial portal is established too far lateral, improper screw trajectory, bone block overhang, and nonunion of the coracoid to the glenoid have been reported.[11,12]

Traditional arthroscopic teaching discourages the creation of any arthroscopic portal medial to the level of the coracoid for fear of damage to vital neurovascular structures.[26] The purpose of this study was to assess the proximity of neurovascular structures in a layered approach during medial portal placement and determine standardized measurements for establishing a portal medial to the coracoid used in arthroscopic Latarjet-type procedures. It was hypothesized that creation of the medial portal would avoid neurovascular structures and provide safer, functional access for the Latarjet procedure.

Materials and Methods

Twelve shoulders (6 right and 6 left) in 6 decapitated, eviscerated, fresh frozen cadaveric torsos (5 female and 1 male cadaver; 5 white and 1 African American), sectioned from the shoulders to T10, were used in this study. The average specimen age was 73.2 years (range, 51-87 years) and the average body mass index was 25.4 (range, 22.3-27.4). Once thawed, the specimens were mounted on a custom-designed apparatus in the modified beach-chair position at approximately 30° of elevation. The humerus was positioned in 25° of forward flexion with neutral abduction and external rotation.

Anatomic landmarks including the acromion, coracoid, acromioclavicular joint, clavicle, and axillary fold were identified and marked with a marking pen. Once the surface anatomy was identified, portal-site locations were identified and marked. The arthroscopic Bankart-Bristow-Latarjet procedure involves the creation of a posterior portal and 5 anterior portals (central, proximal, distal, lateral, and medial portals) as described by Boileau et al.[11,12] The central portal was described to be located just lateral to the tip of the coracoid. The proximal portal was described to be located above the coracoid process, just anterior to the acromioclavicular joint. The distal portal was described to be located in the axillary fold, 3 fingerbreadths distal to the coracoid tip. The lateral portal was described to be located 2 fingerbreadths lateral to the coracoid tip. The medial trans–pectoralis major portal was described to be located 3 to 4 fingerbreadths medial to the level of the coracoid and in line with the level of the distal portal[2,11] (Fig 1). Once the medial portal location was identified and marked, the distance medial and distal to the coracoid tip was measured and recorded with a digital caliper (UltraTECH; New York, NY) accurate to one-tenth of a millimeter.

For the purposes of this study, only the posterior, central, lateral, and medial portals were used. To best re-create the surgical view, the posterior portal was established through the "soft spot" in the raphe of the infraspinatus, located 2 cm inferior and 2 cm medial to the posterolateral corner of the acromion.[27] After joint insufflation, a 30° arthroscope (HD 3CCD; ConMed Linvatec, Utica, NY) was inserted into the glenohumeral joint. Under direct visualization, by use of an outside-in technique, the central portal was then localized with a spinal needle inserted 1 cm lateral to the palpable tip of

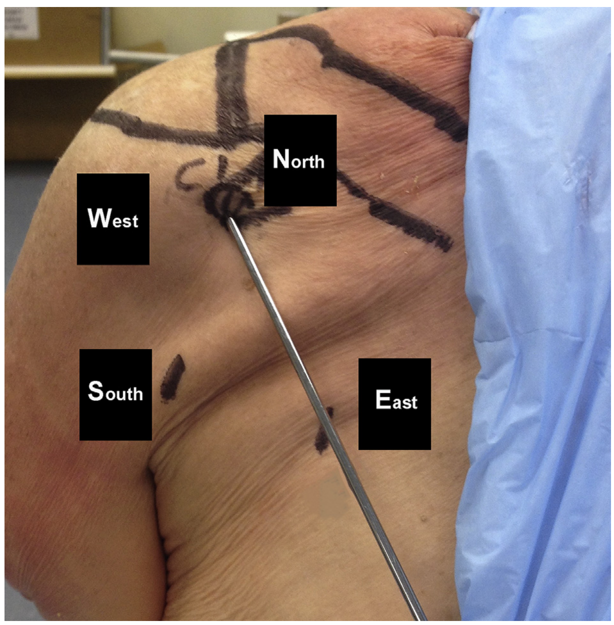

Fig 1. A cadaveric specimen, before dissection, showing the central portal located just lateral to the tip of the coracoid; the proximal portal located above the coracoid process, just anterior to the acromioclavicular joint; the distal portal located in the axillary fold, 3 fingerbreadths distal to the coracoid tip; the lateral portal located 2 fingerbreadths lateral to the coracoid tip; and the medial trans–pectoralis major portal located 3 to 4 fingerbreadths medial to the level of the coracoid and in line with the level of the distal portal.

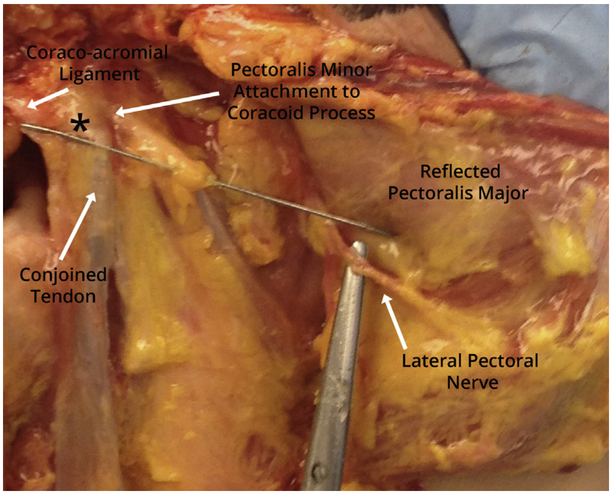

Fig 2. A cadaveric specimen, before dissection, showing an altered trajectory from the medial trans−pectoral major (trans-Pec) portal starting point toward the medial base of the coracoid process (X). The chain of arrows indicates the path of the deltopectoral interval. (AC, acromion; DEL, deltoid; PM, pectoralis major muscle.)

the coracoid process in the midsubstance of the rotator interval.[28]

While viewing intra-articularly from the posterior portal, the surgeon placed a 4.2-mm arthroscopic shaver (ERGO Shaver with Great White Straight Shaver Blade; ConMed Linvatec) through the central portal. The rotator interval was opened until the coracoid process became visible. A spinal needle was then introduced to localize the lateral portal approximately 2 cm lateral to the coracoid, just off the palpable, anterolateral acromion, following the path of the long head of the biceps through the rotator interval. With the use of a switching stick, the arthroscope was then placed in the anterior subdeltoid space via the lateral portal. While viewing the coracoid and subscapularis, the surgeon introduced a long spinal needle through the medial portal and directed it toward the lateral tip of the coracoid process.

With the spinal needle in view and placed appropriately, a second spinal needle directed toward the medial base of the coracoid was placed, penetrating the pectoralis minor (Fig 2). At this time, meticulous dissection was performed circumferentially around the path of the needles in a layered approach. Superficial plane dissection was performed down to the coracoid along the needle placed toward the lateral tip of the coracoid. Further deep plane dissections were performed along the medially positioned needle, deep to the pectoralis minor and conjoined tendon. The humerus was stabilized within the glenoid to avoid subluxation of the humerus and distortion of the anatomic relations. Careful dissection was performed around the needle to identify the relevant structures and to ensure anatomic relations were not disrupted during dissection for accurate measurements.

Neurovascular and other anatomic structures were identified, including the cephalic vein, lateral pectoral nerve, axillary nerve, lateral cord of the brachial plexus, axillary artery, and musculocutaneous nerve. Superficial plane dissection involved measurements from the portal tract to the cephalic vein and lateral pectoral nerve. Deep plane dissection involved measurements from the portal tract to the axillary nerve, lateral cord of the brachial plexus, axillary artery, and musculocutaneous nerve. The shortest distance from the path of the spinal needle to each structure was measured with the digital caliper (UltraTECH, New York, NY) accurate to one-tenth of a millimeter.

Statistical Analysis

All values are reported as mean ± standard deviation. Statistical analysis was performed using SPSS software (version 11.0; SPSS, Chicago, IL).

Results

The medial portal was established at a maximum distance of 50.0 mm distal and 35.0 mm medial to the lateral tip of the coracoid because these measurements ensured a minimum of 10.0 mm of separation from the portal tract to the lateral pectoral nerve, the closest pertinent neurovascular structure at risk with creation of this portal. Superficial plane measurements are presented in Table 1. The medial trans−pectoralis major portal was 49.9 ± 4.5 mm distal and 36.4 ± 3.6 mm medial to the lateral tip of the coracoid. The portal starting point consistently corresponded with the level of the third rib costal angle in all specimens (Fig 3).

The closest neurovascular structures to the course of the medial portal were the cutaneous intercostal nerves of T2 and T3. These nerves were intimately related to the skin incision of the medial portal. Their presence and location were inconsistent among specimens, as well as between left and right sides.

The cephalic vein was located 4.6 ± 1.9 mm anterior to the spinal needle at the level of the lateral tip of the coracoid in the deltopectoral interval (Fig 4). The lateral pectoral nerve was located 9.4 ± 2.6 mm medial to the medial portal site (Fig 5).

All other neurovascular structures were located in a deeper plane protected by the conjoined tendon and

Table 1. Superficial Plane Anatomy: Distance From Needle Directed Toward Lateral Coracoid Tip

Structure	Mean ± SD, mm	Range, mm
Cephalic vein	4.6 ± 1.9	2.0-7.4
Lateral pectoral nerve	9.4 ± 2.6	6.0-14.4

SD, standard deviation.

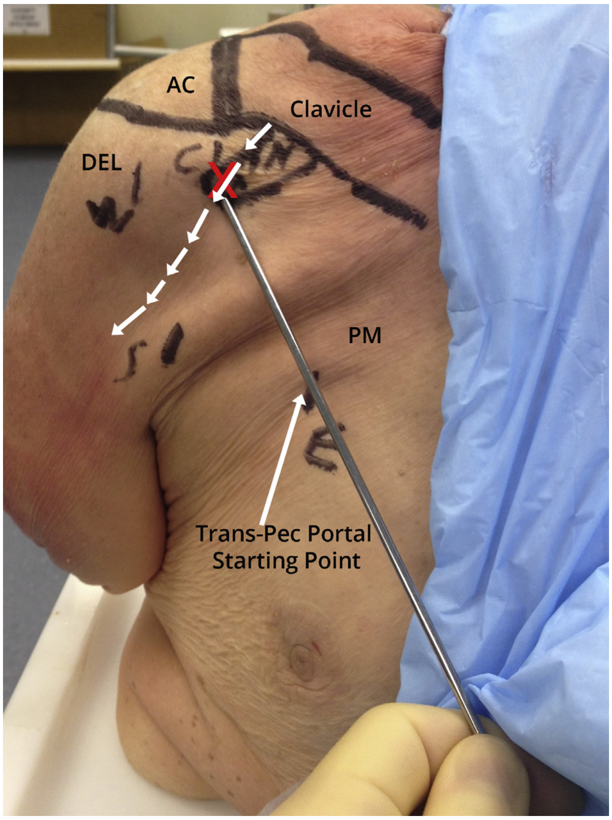

Fig 3. Artistic representation of a right shoulder showing the functional safe zone of the medial trans−pectoralis major portal starting point. The portal should be made 45 to 50 mm distal to the palpable tip of the coracoid process and 30 to 35 mm medial, consistent with the costal angle of the third rib. A 3-mm switching stick is depicted establishing the portal tract.

pectoralis minor (thickness, 7.5 ± 0.7 mm). As referenced as the shortest distance to the medially directed needle, the axillary nerve was located 24.9 ± 7.4 mm medial; the lateral cord of the brachial plexus, 25.5 ± 8.1 mm medial; the axillary artery, 34.1 ± 6.0 mm medial; and the musculocutaneous nerve, 42.2 ± 9.2 mm medial. Deep-plane measurements are presented in Table 2.

Discussion

A medial trans−pectoralis major portal placed under direct visualization 45.0 to 50.0 mm distal and 30.0 to 35.0 mm medial to the lateral tip of the coracoid process avoids major neurovascular structures and serves as a standardized zone for portal placement. This identified zone can serve as an alternative to the traditional use of finger placements when establishing the medial portal for use in the arthroscopic Bankart-Bristow-Latarjet procedure for shoulder instability in the presence of large bone defects (e.g., >25%). The cephalic vein and the lateral pectoral nerve were the only 2 neurovascular structures in close proximity to the portal tract; however, neither structure was violated during placement of the medial portal. All other neurovascular structures were located in a deeper plane protected by the pectoralis minor and conjoined tendon.

The accuracy of portal placement in routine shoulder arthroscopy is known to be paramount for a successful surgical procedure, particularly with more advanced techniques such as the all-arthroscopic Bristow-Latarjet procedure. Inaccurate placement or angulation of a

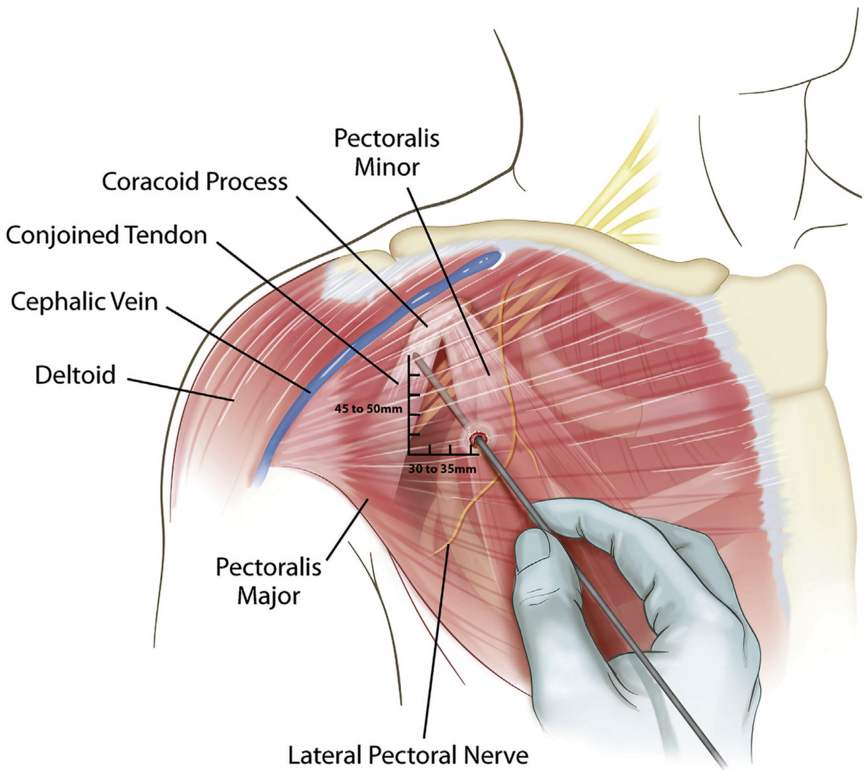

Fig 4. A cadaveric specimen (left shoulder) with the deltopectoral interval dissected, showing the location of the cephalic vein relative to needle placement along the path of the medial trans−pectoralis major portal. It should be noted that more extensive dissection was performed on this specimen to aid in showing this relation. The asterisk indicates the palpable tip of the coracoid process.

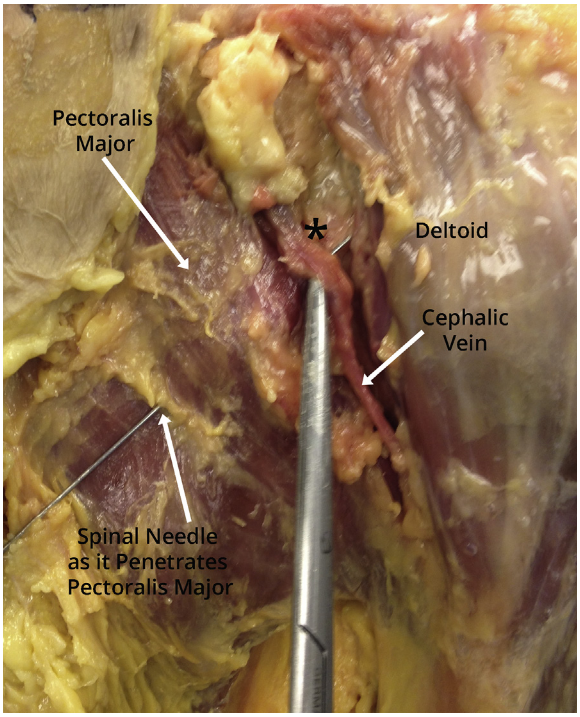

Fig 5. A cadaveric specimen (right shoulder) with the pectoralis major muscle reflected, showing the location of the lateral pectoral nerve relative to needle placement through the pectoralis major along the path of the medial trans–pectoralis major portal. It should be noted that more extensive dissection was performed on this specimen to aid in showing this relation. The asterisk indicates the tip of the coracoid process.

portal's trajectory can result in a nerve or vascular injury and potentially catastrophic results. This is especially true when creating a portal medial to the coracoid; a medial portal is important to the success of the arthroscopic Bankart-Bristow-Latarjet procedure.[29] An alternative portal for the arthroscopic Latarjet procedure as originally described by Lafosse and Boyle[9] is the "I" portal, which is placed inferior to the coracoid process just above the axillary fold. Although still used by some surgeons, this trajectory often yields nonflush placement of the bone block on the glenoid and thus was modified to the medial portal as described by Boileau et al.[11,12]

Anatomic studies commonly use different techniques, which can lead to variability in the results. Lo et al.[26] previously described the relations of the axillary nerve, musculocutaneous nerve, lateral cord of the brachial plexus, and axillary artery relative to the anteromedial base of the coracoid. Average distances were reported to be 29.3 ± 5.6 mm, 36.5 ± 6.1 mm, 36.6 ± 6.2 mm, and 42.7 ± 7.3 mm, respectively.[26] Differences compared with our study's measurements can be explained by differences in the reference points used. The use of a fixed osseous landmark, as in the study by Lo et al., makes it difficult to extrapolate these data to the use of a medial portal for the arthroscopic Bankart-Bristow-Latarjet procedure. Measurements were taken as the shortest distance to a needle passed along a portal tract, not to a fixed anatomic reference point, to provide clinical value. Additionally, the measurement of the musculocutaneous nerve was taken at the insertion of the main trunk into the musculature of the coracobrachialis. In comparison, Lo et al. used the shortest distance to the musculocutaneous nerve as it exited the lateral cord of the brachial plexus. Flatow et al.[30] previously reported the mean distance of the main branch of the musculocutaneous nerve as it enters the coracobrachialis muscle belly in relation to the coracoid as being 56 mm (range, 31-81 mm). The musculocutaneous nerve was 42.2 ± 9.2 mm away from the portal tract in our study. Again, the proximal reference points used for measurement can explain the differences in results. Finally, the cephalic vein also has been previously found to be the closest structure to a far-medial arthroscopic portal,[31] confirming the results of our study.

Table 2. Deep-Plane Anatomy: Distance From Needle Directed Through Conjoined Tendon Toward Medial Coracoid Base to Neurovascular Structures

Structure	Mean ± SD, mm	Range, mm
Axillary nerve	24.9 ± 7.4	15.0-38.0
Lateral cord	25.5 ± 8.1	12.4-37.1
Axillary artery	34.1 ± 6.0	20.5-41.5
Musculocutaneous nerve	42.2 ± 9.2	22.6-58.0

SD, standard deviation.

The initial description of the medial portal, as previously reported by multiple authors, involves the use of finger widths as a measurement tool.[11,12,32,33] Finger width is highly variable, resulting in lack of standardization for medial portal placement. Establishing measurements is important for the reproducibility of this technique and potentially for a reduction in the incidence of neurovascular complications with this procedure. A standard reference point for the medial portal was located 30.0 to 35.0 mm medial and 45.0 to 50.0 mm distal to the lateral tip of the coracoid. This working zone avoids neurovascular structures and provides a minimum of 10.0 mm of clearance between the portal and the lateral pectoral nerve. Additionally, portals are created through dilation; therefore, there will be 10 mm of soft tissue between the neurovascular structures and the portal. The appropriate trajectory required for screw placement can also be achieved using these measurements.

Changes in neurovascular anatomy can occur with the Latarjet procedure, as previously described by Freehill et al.[34] with the open Latarjet procedure. They noted that both the musculocutaneous and axillary nerves moved distally and laterally with the transfer of the coracoid process and conjoined tendon to the glenoid neck.[34] Similar changes in neurovascular anatomy were found when performing the full arthroscopic Bankart-Bristow-Latarjet procedure in 1 specimen. To measure this change, 2 long spinal needles were placed along the previously described paths after transferring the coracoid process to the glenoid neck. Dissection showed a shift in the anatomic location of the axillary nerve, moving toward the needle path from a distance of 25.1 mm to 11.9 mm. Measurement of the musculocutaneous nerve remained within the previously described range at 31.9 mm from the needle path. This finding is of importance either in the revision setting or if arthroscopic screw removal is required because the native anatomy has been changed with a primary arthroscopic Bankart-Bristow-Latarjet procedure. Future research is necessary to assess the risk to the neurovascular structures in the revision setting after arthroscopic Bankart-Bristow-Latarjet procedures.

With appreciation of the geometric shape medial to the coracoid, switching sticks are routinely used when changing portals. The use of a blunt-tipped, 3-mm switching stick, which may be steered into position, for creation of the portal tract is recommended because this allows for easy direction toward the lateral tip of the coracoid process, passing obliquely through the pectoralis major muscle belly and superficial to the conjoined tendon and pectoralis minor.

Limitations

One of the limitations of this study was the age of the specimens, with a mean age of 73.2 years. It is rare to find a candidate for the Latarjet procedure of this age. Theoretically, degenerative changes can lead to limited mobility and contracture of surrounding soft tissues, altering the anatomy from what would be encountered in a younger patient requiring a Latarjet procedure. The specimens in this study had only minimal degenerative changes; therefore, age-related degenerative changes did not confound any findings in this study. Moreover, torsos were used rather than shoulder specimens to preserve native anatomic relations to avoid disruption of the native anatomy. Second, a spinal needle was used to create the portal tract in this study rather than a 6-mm rod. The use of a spinal needle ensured that no structures were pushed out of the way; rather, if any structure fell in the path of the spinal needle, the structure would be speared in line with the portal. On the other hand, the use of a spinal needle to establish portal placement proved to be a more challenging surgical technique because one loses the ability to steer the instrument and must pass the needle in line with the planned portal without redirection. Because of this technical challenge, a second needle was placed along a different trajectory to simulate steering of a sturdier device such as a shaver or radiofrequency device to the medial aspect of the coracoid process. Use of a blunt-tipped switching stick, as is routine in shoulder arthroscopy, will also cause less damage by pushing structures out of the way, rather than spearing them straight on. Although not assessed in our study, future research should investigate the role of coracoid shape and angulation when establishing the medial trans–pectoralis major portal, given that the shape of the coracoid would likely dictate the angulation required to create the portal tract aiming toward the lateral coracoid tip.

Conclusions

In a cadaveric model, the creation of a medial trans–pectoralis major portal used in the arthroscopic Bankart-Bristow-Latarjet procedure can avoid compromise of vital neurovascular structures, alleviating concerns of creating a portal medial to the coracoid. Portal placement 45.0 to 50.0 mm distal and 30.0 to 35.0 mm medial to the palpable tip of the coracoid process may be a safe approach to perform the arthroscopic Bankart-Bristow-Latarjet procedure.

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