

The Subscapularis Footprint: An Anatomic Study of the Subscapularis Tendon Insertion

Leonard L. D'Addesi, M.D., M.S., Ammar Anbari, M.D., Matthew W. Reish, M.D., Shyam Brahmabhatt, M.D., and John D. Kelly, M.D.

Purpose: Arthroscopic repair of the subscapularis tendon has become more prevalent in recent years. Tears of the subscapularis insertion can be measured arthroscopically when the size of the average subscapularis tendon insertion is known. This anatomic study was performed to measure the dimensions and describe the anatomy of the subscapularis footprint. **Methods:** A total of 6 male and 6 female shoulders were dissected down to the insertion of the subscapularis tendon. The insertion was demarcated, the tendon was detached, and the dimensions of the insertion site were measured. **Results:** The footprint is the insertion of the subscapularis tendon onto the lesser tubercle. The shape of the footprint was characterized as resembling a human ear. The insertion is broad proximally and tapered distally and has a straight medial border that is almost parallel to the longitudinal axis of the humerus. The total average cephalocaudal height of the footprint was 25.8 mm (± 3.2 mm). The total average width was 18.1 mm (± 1.6 mm). Average male cephalocaudal height was 26.7 mm (range, 22 to 32 mm), and width was 18.3 mm (range, 16 to 21 mm). Average female cephalocaudal height was 24.8 mm (range, 22 to 29 mm), and width was 17.8 mm (range, 15 to 19 mm). Although the male footprint was slightly larger than the female footprint, differences were not statistically significant ($P = .18$ and $.31$ for height and width, respectively). **Conclusions:** An anatomic study was performed to determine the size of the footprint of the subscapularis tendon. We found that the average cephalocaudal height of the footprint was 25.8 mm, and the average width was 18.1 mm. **Clinical Relevance:** Subscapularis tears are now more frequently addressed arthroscopically. This anatomic study was performed to characterize the anatomy of the subscapularis footprint so that the surgeon can achieve a more anatomic repair. **Key Words:** Subscapularis insertion—Subscapularis footprint—Arthroscopy—Rotator cuff.

Tears of the subscapularis tendon are becoming increasingly recognized as surgeons gain proficiency in arthroscopic shoulder surgery. Subscapularis tears have been repaired with the use of open techniques,¹⁻⁶ and recently, much interest has been expressed in arthroscopic visualization techniques and repair.^{3,7-15}

Subscapularis tears have been classified as partial-thickness/partial-length, full-thickness/partial-length, full-thickness/complete-length with no retraction, and full-thickness/complete-length with retraction.^{8,11} The optimal critical tear size for surgical repair has yet to be determined.¹⁵ Comparative studies of tears of various sizes are lacking.⁶ Full-thickness and partial-thickness tears of isolated and combined subscapularis tears have been reported.^{1-6,8,10-12,15} The size of the tear, as a percentage of the overall cephalocaudal height of the insertion of the subscapularis tendon, has not been well described. Some reports of open repairs have quantified the size of the tear in thirds^{3,5,6}; however, arthroscopic measurements of the size of the tear are lacking.

The size of the subscapularis tear can be calculated during arthroscopy according to a mathematical

From the Department of Orthopaedic Surgery, Temple University Hospital, Philadelphia, Pennsylvania, U.S.A.

The authors report no conflict of interest.

Address correspondence and reprint requests to Leonard L. D'Addesi, M.D., M.S., Department of Orthopaedic Surgery, Temple University Hospital, 3401 North Broad St, Philadelphia, PA 19140 U.S.A. E-mail: ldaddes@temple.edu

© 2006 by the Arthroscopy Association of North America

0749-8063/06/2209-x588\$32.00/0

doi:10.1016/j.arthro.2006.04.101

model,^{9,13} which is based on the known size of the footprint. A limited description of the average size of the footprint is provided in the literature. Tierney et al.¹⁶ (abstract publication) measured the average height of the subscapularis insertion as 40.35 mm. Burkhart and Tehrani⁹ (unpublished data) reported an average size of 2.5 cm. Pearsall et al.¹⁷ found the overall height of the tendinous insertion to be 31.3 mm.

We performed this anatomic study to better describe the detailed anatomy of the subscapularis footprint. It is hoped that this investigation will aid surgeons in calculating during arthroscopy the percentage of the subscapularis that is torn. The goal of this study is to characterize the anatomy of the tendon insertion, including its dimensions and shape, so that the surgeon can achieve a more anatomic repair.

METHODS

We examined the subscapularis footprint in 14 embalmed cadaveric shoulders. Two were discarded because a subscapularis tear was noted. Of the remaining 12, 6 were male and 6 were female shoulders. Average age of male shoulders was 76 years (range, 63 to 83 years) and of female shoulders, 84 years (range, 74 to 92 years). All female shoulders were left-sided. Male shoulders were left-sided (3) and right-sided (3). Shoulders were dissected grossly down to the conjoint tendon, with the elbow flexor musculature and anterior deltoid excised. The conjoint tendon was detached from the coracoid, and the subscapularis muscle was identified. The biceps tendon lying in the bicipital groove was identified as a guide to the lateral border of the lesser tubercle (Fig 1). The perimeter of the tendinous insertion of the subscapularis tendon was determined on the lesser tubercle and demarcated. The subscapularis tendon was then detached sharply from the lesser tubercle, so that the footprint could be measured. Measurements consisted of the cephalocaudal distance (height) of the tendinous portion of the insertion and the maximum mediolateral distance (width) of the footprint. Maximum width corresponded to an area in the proximal two thirds of the footprint.

RESULTS

Total average height of the footprint was 25.8 mm. Total average width was 18.1 mm. Average male height was 26.7 mm (range, 22 to 32 mm), and width was 18.3 mm (range, 16 to 21 mm). Average female height was 24.8 mm (range, 22 to 29 mm), and width was 17.8 mm (range, 15 to 19 mm). Although the

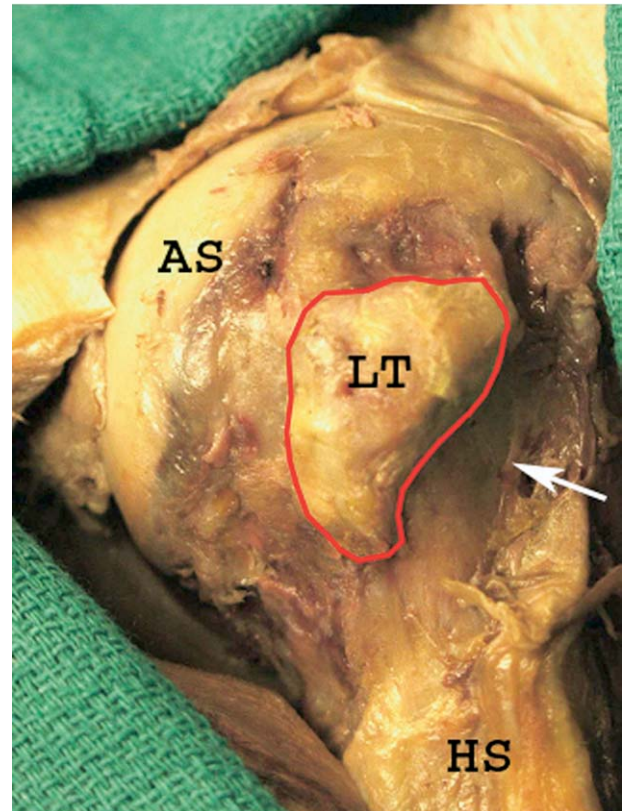


FIGURE 1. The lesser tubercle of the proximal humerus is the site of insertion of the subscapularis tendon. The footprint was defined as the grossly tendinous insertion of the subscapularis tendon (red line). The arrow denotes the bicipital groove, which abuts the lateral border of the lesser tubercle. The insertion was broad proximally and tapered distally. The shape resembles that of a human ear. Measurements were taken of this tendinous portion of the insertion, which averaged 25.8 mm in height and 18.1 mm at maximum width. AS, articular surface of the humeral head; LT, lesser tubercle; HS, humeral shaft.

male footprint was slightly larger than the female footprint, differences were not statistically significant ($P = .18$ and $.31$ for height and width, respectively). The shape of the footprint was inspected as well (Fig 1). The medial border was found to be a straight edge that was aligned almost parallel to the longitudinal axis of the humeral shaft. Overall shape resembled that of a human ear. The footprint was broad proximally and tapered distally.

DISCUSSION

The subscapularis tendon inserts into the lesser tubercle. The subscapularis footprint is the description of the tendon insertion into the lesser tubercle.

The subscapularis can be injured during falls on an outstretched arm, with forceful hyperextension or external rotation with the arm adducted, during anterior dislocation of the shoulder, and as the result of coracoid impingement.^{1,18-20} Repairs have been performed with the use of open¹⁻⁶ and arthroscopic techniques.^{3,9-12,15} Isolated, complete tears of the subscapularis insertion have been studied.¹⁻³ Partial-thickness, incomplete tears are increasingly recognized arthroscopically because partial tears are articular sided and may not be visualized with traditional open techniques.^{9,15} The prevalence of partial-thickness tears has been found to be between 13% and 19%.^{8,12}

The literature provides little information on partial tears. Several reports describe the length of the tear by separating the height of the tendon into thirds, but these have used mainly open techniques.^{3,5,6} Deutsch et al.³ arthroscopically debrided one patient with a partial-thickness tear; Kim et al.¹⁵ arthroscopically repaired isolated, articular sided partial-thickness tears of the subscapularis that were at least 5 mm in width, and they debrided smaller lesions. It is unclear what percentage of the height of the tendon insertion these tears represented. Other arthroscopic studies classified tears as partial-thickness, full-thickness, or complete,^{5,8,10-12} without reporting the size of the tear. The description of an incomplete tear is meaningful when one knows how much of the overall height of the tendon insertion the tear represents. An optimal critical tear size for surgery may exist,¹⁵ but this has not been determined because studies on tears of various sizes are lacking.⁶

A mathematical model can be used to calculate the size of the tear during arthroscopy. The bare area of the footprint, as would be seen in full-thickness tears, is measured and divided by the known average height of the footprint.^{9,13} Quantification of the percentage of the subscapularis tear can be achieved only with information on the overall height dimension of the footprint. Our goal was to measure the total height of the subscapularis footprint (insertion of the tendinous portion of the subscapularis) to aid the surgeon in calculating the size of the tear during arthroscopy. The average height of the tendinous insertion of the subscapularis in this study was 25.8 mm. Thus, 13 mm of exposed footprint roughly correlates with a 50% tear of the subscapularis tendon.

Studies describing the height of the subscapularis footprint are lacking. Tierney et al.¹⁶ (abstract publication) measured 20 fresh-frozen cadaver shoulders and found the average height of the footprint to be 40.35 mm (range, 35 to 55 mm) and the width to be

19.58 mm (range, 15 to 25 mm). The authors do not report whether these measurements are of the entire insertion, including the muscular portion, or only of the tendinous portion. Comparison is difficult because this report lacks detail. Burkhart and Tehrani⁹ briefly reported unpublished data on the height of the footprint. Nineteen cadaver shoulders were used. The superior-to-inferior height of the subscapularis footprint was found to be 2.5 cm (range, 1.5 to 3 cm). The authors did not give a description of what was measured, so again, comparison is difficult. Pearsall et al.¹⁷ measured 10 cadaver shoulders and found the total cephalad-caudad height of the tendinous insertion to average 31.3 mm (± 9.6 mm). Assessing the causes of differences in average values is difficult because Pearsall's study focused on the dimensions of the intra-articular subscapularis tendon. It is unclear why this study shows about a 5-mm difference in average height from our results.

Our study had several limitations. First, our cadaver population was older than the average patient with rotator cuff injuries. We do not believe this affected our results because all study shoulders had no subscapularis tears, and their respective footprints were intact. Secondly, our sample size was small but was within the range of specimens used in other studies.^{9,16,17}

Future research should be aimed at expanding the number of specimens measured while a biomechanical analysis of subscapularis tears of various sizes is performed to determine whether a critical size of tear is necessary for repair. Physical examination, magnetic resonance imaging, and arthroscopic findings should be correlated with patient outcomes upon repair of tears of various sizes.

CONCLUSIONS

We performed an anatomic study to determine the dimensions of the footprint of the subscapularis tendon. We found the average height of the footprint to be 25.8 mm and average width to be 18.1 mm. The shape of the footprint was characterized as resembling a human ear. The medial border of the tendinous insertion is almost parallel to the longitudinal axis of the humerus. This insertion is broad proximally and tapered distally.

REFERENCES

1. Gerber C, Krushell RJ. Isolated rupture of the tendon of the subscapularis muscle. *J Bone Joint Surg Br* 1991;73:389-394.

2. Gerber C, Hersche O, Farron A. Isolated rupture of the subscapularis tendon: Results of operative repair. *J Bone Joint Surg Am* 1996;78:1015-1023.
3. Deutsch A, Altchek DW, Veltri DM, Potter HG, Warren RF. Traumatic tears of the subscapularis tendon: Clinical diagnosis, magnetic resonance imaging, and operative treatment. *Am J Sports Med* 1997;25:13-22.
4. Sakurai G, Ozaki J, Tomita Y, Kondo T, Tamai S. Incomplete tears of the subscapularis tendon associated with tears of the supraspinatus tendon: Cadaveric and clinical studies. *J Shoulder Elbow Surg* 1998;7:510-515.
5. Edwards TB, Walch G, Sirveaux F, et al. Repairs of the subscapularis. *J Bone Joint Surg Am* 2005;87:725-730.
6. Kreuz PC, Remiger A, Erggelet C, Hinterwimmer S, Niemeyer P, Gachter A. Isolated and combined tears of the subscapularis tendon. *Am J Sports Med* 2005;33:1831-1837.
7. Bennett WF. Visualization of the anatomy of the rotator interval and bicipital sheath. *Arthroscopy* 2001;17:107-111.
8. Bennett WF. Subscapularis, medial, and lateral head coracohumeral ligament insertion anatomy: Arthroscopic appearance and incidence of "hidden" rotator interval lesion. *Arthroscopy* 2001;17:173-180.
9. Burkhart SS, Tehrany AM. Arthroscopic subscapularis tendon repair: Technique and preliminary results. *Arthroscopy* 2002;18:454-463.
10. Bennett WF. Arthroscopic repair of anterosuperior (supraspinatus/subscapularis) rotator cuff tears: A prospective cohort with 2- to 4-year follow-up. Classification of biceps subluxation/instability. *Arthroscopy* 2003;19:21-33.
11. Bennett WF. Arthroscopic repair of isolated subscapularis tears: A prospective cohort with 2- to 4-year follow-up. *Arthroscopy* 2003;19:131-143.
12. Kim TK, Rauh PB, McFarland EG. Partial tears of the subscapularis tendon found during arthroscopic procedures on the shoulder: A statistical analysis of sixty cases. *Am J Sports Med* 2003;31:744-750.
13. Richards DP, Burkhart SS, Lo IK. Subscapularis tears: Arthroscopic repair techniques. *Orthop Clin North Am* 2003;34:485-498.
14. Esch JC, Bynum CK. Arthroscopic repair of subscapularis tendon ruptures. *Sports Med Arthrosc Rev* 2004;12:99-103.
15. Kim S, Oh I, Park J, Shin S, Jeong W. Intra-articular repair of an isolated partial articular-surface tear of the subscapularis tendon. *Am J Sports Med* 2005;33:1825-1830.
16. Tierney JJ, Curtis AS, Kowalk DL, Scheller AD. The footprint of the rotator cuff. Abstract from the Eighteenth Annual Meeting of the Arthroscopy Association of North America, Vancouver, British Columbia, Canada, April 15-18, 1999;556-557.
17. Pearsall AW, Holovac TF, Speer KP. The intra-articular component of the subscapularis tendon: Anatomic and histological correlation in reference to surgical release in patients with frozen-shoulder syndrome. *Arthroscopy* 2000;16:236-242.
18. Delee JC, Drez D, Miller MD, eds. *Orthopaedic sports medicine: Principles and practice*. Ed 2. Philadelphia: WB Saunders, 2003.
19. Lo IK, Burkhart SS. The etiology and assessment of subscapularis tendon tears: A case for subcoracoid impingement, the roller-wringer effect, and tuff lesions of the subscapularis. *Arthroscopy* 2003;19:1142-1150.
20. Ticker BT, Warner JJP. Single tendon tears of the rotator cuff: Evaluation and treatment of subscapularis tears and principles of treatment for supraspinatus tears. *Orthop Clin North Am* 1997;28:99-116.