Poor Agreement on Classification and Treatment of Subscapularis Tendon Tears

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Purpose: To assess the inter- and intraobserver agreement for classification and management of subscapularis tendon pathology based on arthroscopy and magnetic resonance imaging (MRI). **Methods:** Twenty-two orthopaedic surgeons from the Multicenter Orthopaedic Outcomes Network (MOON) shoulder group reviewed still arthroscopic and MRI images of the subscapularis tendon from patients with a random assortment of subscapularis morphology. The surgeons were asked to classify the pathology based on 2 systems (Lafosse and Lyons) and choose whether they would repair the tendon and, if so, the method of repair (open or arthroscopic). The survey was administered 3 times to each surgeon. Inter- and intraobserver reliability between testing rounds was determined by kappa analysis. **Results:** Interobserver reliability on classification of tears was poor based on MRI ($k = 0.18$ to 0.19) and fair based on arthroscopy ($k = 0.26$ to 0.29). Interobserver agreement on whether surgical treatment was indicated was fair for both MRI ($k = 0.28$) and arthroscopy ($k = 0.38$), while the agreement for type of surgery was poor based on MRI ($k = 0.18$) and fair based on arthroscopy ($k = 0.28$). Interobserver agreement did not improve when both MRI and arthroscopy were provided simultaneously ($k = 0.24$ to 0.30). Intraobserver reliability for classification and treatment was fair to moderate for both MRI ($k = 0.32$ to 0.50) and arthroscopic imaging ($k = 0.39$ to 0.56). When considering just those patients with normal tendons, surgeon agreement improved. For all questions, the arthroscopic images had a higher level of agreement among surgeons than the MRI ($P < .001$). **Conclusions:** Although surgeons tended to have higher reliability when presented with arthroscopic images compared with MRI, there was very little agreement on the classification and management of subscapularis tendon tears. **Level of Evidence:** Diagnostic Level III.

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The subscapularis tendon is the largest rotator cuff muscle-tendon unit of the shoulder, functioning as an important static and dynamic stabilizer. Subscapularis tears have been reported in up to 27% to 43% of patients undergoing shoulder arthroscopy.[1] Unfortunately, it can be difficult to assess the severity of subscapularis tendon injuries during preoperative evaluation. Magnetic resonance imaging (MRI) may not provide adequate preoperative information, even when arthrogram is performed.[2,3] A systematic approach to evaluating MRI may improve our ability to evaluate subscapularis tears, but MRI remains an imperfect diagnostic tool, especially with tears involving less than half the cephalad-to-caudal width of the tendon.[2,4]

Arthroscopy remains the gold standard for identifying subscapularis tears.[2,3,5] The use of arthroscopy has enabled surgeons to recognize even subtle pathology of the tendon, including intra-articular longitudinal tears of the superior-most intramuscular tendon, which may be difficult to detect through open surgery.[6] However, an inadequate evaluation and difficulties in determining what constitutes a tear that requires fixation may lead to missed diagnosis and treatment of subscapularis pathology. Standard arthroscopic portals leave the majority of the subscapularis veiled by the middle and inferior glenohumeral ligaments, whereas the entire articular surface of the supraspinatus and infraspinatus can be visualized via glenohumeral arthroscopy.[7] Unrecognized subscapularis tears can lead to compromise of normal biomechanical shoulder function and have been theorized to compromise repair of concurrent supraspinatus and posterosuperior rotator cuff tears.[8]

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With the reported difficulty in evaluating the subscapularis tendon, the purpose of this study was to assess the inter- and intraobserver agreement for classification and management of subscapularis tendon pathology based on arthroscopy and MRI. Our hypothesis was that there would be poor agreement on the classification and subsequent treatment decisions of these tears.

Methods

Both MRI and arthroscopic images were collected from 30 patients with a variety of shoulder pathologies, from normal to complete tears of the subscapularis tendon as determined by the operative report (please refer to the Appendix for details on each case). We chose patients from the case logs of the 2 senior authors (M.S., E.C.S.) from 2007 to 2013 and purposely selected a breadth of tendon pathology. Cases were excluded if they did not show the subscapularis tendon clearly or if they did not have clear 3-tesla MRI with appropriate sequencing. Four T2-weighted fat-suppressed, sequential, axial cuts of the subscapularis tendon were selected for each patient (Fig 1A). The arthroscopic images were taken intraoperatively with a 30° arthroscope through a standard posterior portal, with the patient in the beach chair position. Four representative images were chosen, evaluating the visible tendon, lesser tuberosity footprint, and biceps when present (Fig 1B). All images were agreed upon by 3 of the authors to best highlight the tendon and any pathology.

A survey was administered in 3 rounds, with over 4 weeks between surveys. The first survey contained 60 question blocks. Each question block was based on a set of either 4 MRI or 4 arthroscopic images derived from 30 patients. From these images, the surgeon was asked a series of 4 multiple-choice questions: (1) how to classify the tendon based on the Lafosse classification, (2) how to classify the tendon based on the Lyons classification, (3) whether the surgeon would fix the tendon ("no", "yes"), and (4) how they would fix the tendon ("would not fix", "arthroscopic", "open", "other").[9,10] The Lafosse and Lyons classification systems (Table 1) were selected for this study because they tend to be the most commonly used and they do not require evaluation of the supraspinatus.

The second survey contained the same 60 question blocks as the first, but in a different order. In the third survey, the 60 questions blocks were condensed into 30 blocks, with each block containing MRI with matching arthroscopic images, for a total of 8 images per question block. This third survey was created to more closely mimic the clinical experience, where both MRI and intraoperative information are available. Institutional Review Board approval for this study was obtained from the University of California, San Francisco.

Surgeon Population

The surgeons surveyed were from the Multicenter Orthopaedic Outcomes Network (MOON) Shoulder Group, which is a collection of sports medicine or

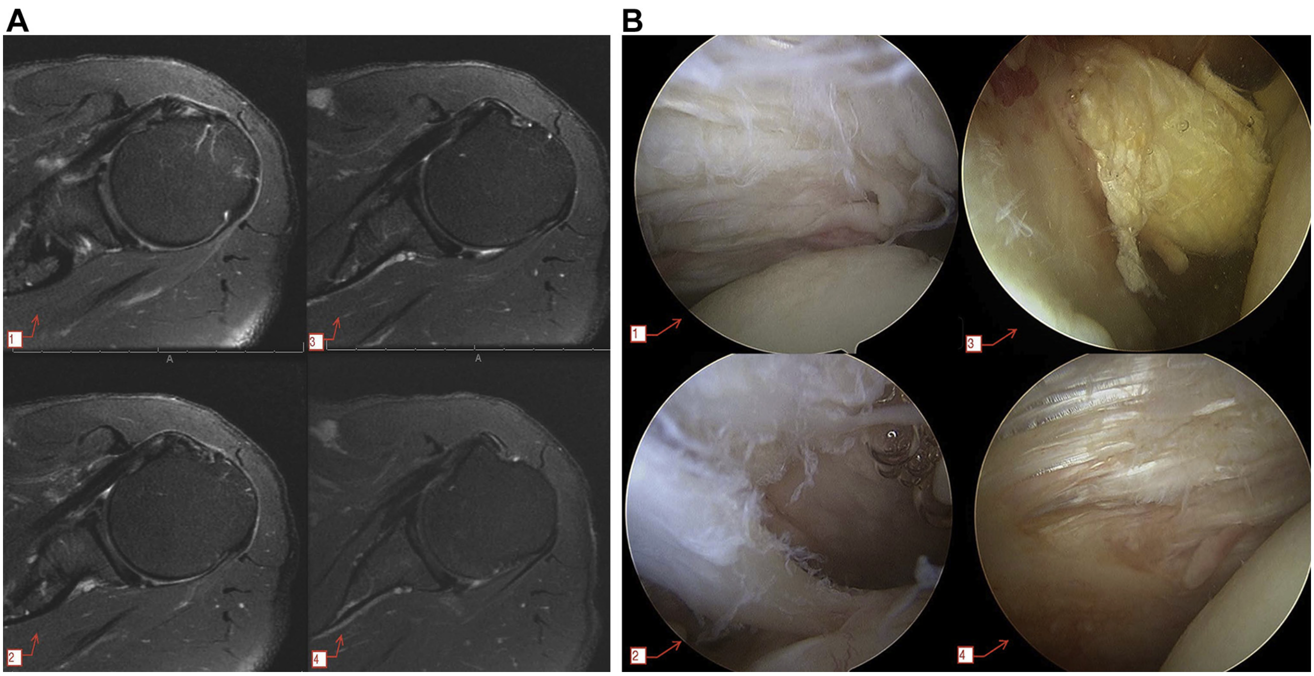

Fig 1. For each patient in the survey, 4 representative axial T2-weighted fat-suppressed (A) magnetic resonance imaging (MRI) and (B) arthroscopic images were selected. Arthroscopic images were taken with a 30° arthroscope through a standard posterior portal, with the patient in the beach chair position. The sample MRI and arthroscopic images displayed are from the same patient and show a lesion of the subscapularis tendon.

Table 1. Lafosse[9] and Lyons[10] Classification Systems

Classification	Lafosse Definition	Lyons Definition
0	No subscapularis tear	No subscapularis tear
I	Partial lesion of superior 1/3 of subscapularis	Partial thickness + partial length
II	Complete lesion of superior 1/3 of subscapularis	Full thickness + partial length
III	Complete lesion of superior 2/3 of subscapularis	Full thickness + complete length without retraction
IV	Complete lesion of subscapularis	Full thickness + complete length with retraction

shoulder fellowship–trained orthopaedic surgeons from across the United States. All surgeons perform a significant amount of shoulder surgery, in academic centers or private practice. The group of 32 surgeons represents a broad range of experience, from recent fellowship graduates to those who have been in practice for over 20 years.

Statistical Methods

The surveys were created and distributed through REDCap, a HIPAA-compliant, secure, web-based application for building and managing online surveys and databases.[11] Once the data were collected, they were analyzed using SAS statistical software (SAS Institute, Cary, NC, U.S.A.). Nonweighted kappa analysis was used to assess inter- and intraobserver reliability between round 1 and round 2, as well as interobserver reliability in round 3.[12,13] By convention, a kappa value of 0 to 0.19 is considered poor agreement, 0.20 to 0.39 is fair, 0.40 to 0.59 is moderate, 0.60 to 0.79 is good, and 0.80 to 1.00 is excellent.[14] To compare kappa values between arthroscopic images and MRI, we used the 2-tailed *t*-test (interobserver values) and the paired *t*-test (intraobserver values). A subgroup reliability analysis was performed for each round, dividing the cases into those with normal subscapularis tendons and those with pathology (based on the operative report findings), to assess whether agreement depends on the presence or absence of pathology. A second subgroup analysis was performed among high-volume surgeons (>10 rotator cuff repairs per month, with >25% of these involving the subscapularis), to assess whether there was improved agreement in this population.

Results

Inter- and intraobserver reliability between rounds 1 and 2 are presented in Table 2. Table 3 shows the interobserver reliability for the third survey, where MRI and arthroscopy were combined for each question. As the tables demonstrate, inter- and intraobserver agreement was poor to moderate for both the classification and management of subscapularis tears. For all questions, the arthroscopic images had a higher level of agreement among surgeons than the MRI images ($P < .001$).

Subgroup analysis for normal and partial/complete tears was calculated next, with inter- and intraobserver reliability from rounds 1 and 2 shown in Table 4. Interobserver reliability on classification of tears was slightly better for normal tendons than for tendons with pathology. Subgroup analysis when MRI and arthroscopy were provided simultaneously had the following results. For normal tendons, the interobserver agreement on classification of tears was poor to fair ($k = 0.19$ for Lafosse, 0.21 for Lyons) and fair for abnormal tendons ($k = 0.26$, 0.26). Agreement on need for surgery was moderate for normal tendons ($k = 0.40$) and fair for abnormal tendons ($k = 0.27$). Agreement on type of surgery was fair for both normal tendons ($k = 0.29$) and abnormal ($k = 0.23$) tendons.

A separate subgroup analysis was also performed to evaluate the responses of those surgeons who perform a high volume of subscapularis repairs. When presented

Table 2. Inter- and Intraobserver Reliability From Survey Rounds 1 and 2

	Interobserver		Intraobserver	
	Kappa (95% CI)	Rating	Kappa (95% CI)	Rating
Magnetic Resonance Imaging:				
Lafosse classification	0.19 (0.18-0.20)	Poor	0.34 (0.30-0.38)	Fair
Lyons classification	0.18 (0.17-0.19)	Poor	0.32 (0.28-0.36)	Fair
Surgery: yes or no	0.28 (0.27-0.29)	Fair	0.50 (0.46-0.54)	Moderate
Surgery: open or arthroscopic	0.18 (0.17-0.19)	Poor	0.38 (0.33-0.43)	Fair
Arthroscopy:				
Lafosse classification	0.26 (0.25-0.27)	Fair	0.39 (0.35-0.43)	Fair
Lyons classification	0.29 (0.28-0.30)	Fair	0.43 (0.39-0.47)	Moderate
Surgery: yes or no	0.38 (0.37-0.39)	Fair	0.56 (0.50-0.62)	Moderate
Surgery: open or arthroscopic	0.28 (0.27-0.29)	Fair	0.50 (0.44-0.56)	Moderate

CI, confidence interval.

Table 3. Interobserver Reliability With Simultaneous Magnetic Resonance Imaging (MRI) and Arthroscopy (Survey Round 3)

MRI and Arthroscopy	Kappa (95% CI)	Rating
Lafosse classification	0.24 (0.23-0.25)	Fair
Lyons classification	0.25 (0.24-0.26)	Fair
Surgery: yes or no	0.30 (0.29-0.31)	Fair
Surgery: open or arthroscopic	0.25 (0.24-0.26)	Fair

with both MRI and arthroscopic images (survey round 3), intersurgeon agreement was fair for both Lafosse ($k = 0.33$) and Lyons ($k = 0.31$) classifications, moderate for decision to operate ($k = 0.45$), and moderate for operative technique ($k = 0.43$). A total of 22 surgeons completed all 3 rounds of the survey (response rate 68.8%). The surgeons responded that they performed anywhere from one to over 25 rotator cuff repairs per month (14 surgeons performed one to 10 per month, 6 performed 10 to 25, and 2 performed over 25 rotator cuff repairs per month). Of these repairs, 16 surgeons responded that 1% to 25% of rotator cuff repairs include subscapularis tendon repairs, while 6 surgeons reported that 26% to 50% involved the subscapularis.

Discussion

As hypothesized, the results show that there was very little inter- and intraobserver agreement on the classification of subscapularis tendon tears. There was significantly higher agreement based on arthroscopic images than MRI. This matches the consensus that arthroscopy is the gold standard for the diagnosis of subscapularis tendon injuries.[2] MRI—with or without arthrogram—has been found to have a sensitivity of 31% to 91% and a specificity of 79% to 100%, with increasing sensitivity for larger tears.[2,3,10] This is in contrast to MRI of the supraspinatus, which has an overall sensitivity of 80% to 100% and specificity of 79% to 100%.[15] The low sensitivity for MRI for detection of subscapularis tears is largely because lesions of the superior portion of the tendon insertion are visualized obliquely on transverse MRI cuts and parallel to oblique MRI cuts, which leads to distortion from a partial-volume effect.[16]

Given the low sensitivity of MRI in detecting subscapularis injury, it is understandable that inter- and intrasurgeon agreement from MRI would be low, especially when asked to specify the degree of tendon damage. It was interesting, however, that there was only fair to moderate agreement on subscapularis pathology classification based on the arthroscopic images. This may be because these were still images, which are inferior to video or real-time operation with manipulation. However, the poor agreement may also be representative of our limited understanding of the subscapularis tendon, especially in the setting of partial tears. Only in the past 10 years have there been studies to improve diagnosis of subscapularis injury and increased attempts to describe the pathology.[9,16-19]

For both MRI and arthroscopy, there also was only poor to moderate agreement on whether or not to repair the subscapularis tendon. This may be due to (1) disagreement on the presence of a tear based on the MRI or arthroscopic images or (2) disagreement on the need for repair of partial tears. In contrast to the supraspinatus, open repair of the subscapularis was not popularized until the 1990s.[8] Arthroscopic repair of the subscapularis was not described until 2002.[20] Only recently has there been an emphasis on the importance of the subscapularis tendon for normal biomechanical shoulder function and to increase the viability of concurrent supraspinatus and posterosuperior rotator cuff repairs.[8]

The relative infancy of arthroscopic subscapularis repair may also account for the disparity in agreement on whether to manage the tendon tears arthroscopically or with an open procedure. As the surgeons surveyed have a wide breadth of years in practice, there may be considerable variation in their approach to repair of the subscapularis, and thus their responses may be related more to surgical experience or opinion than to the type of pathology present.

Table 4. Subgroup Analysis of Inter- and Intraobserver Reliability From Survey Rounds 1 and 2, According to Tendon Pathology

	Interobserver				Intraobserver			
	Normal		Torn		Normal		Torn	
	Kappa	Rating	Kappa	Rating	Kappa	Rating	Kappa	Rating
Magnetic Resonance Imaging								
Lafosse classification	0.21	Fair	0.17	Poor	0.33	Fair	0.30	Fair
Lyons classification	0.22	Fair	0.16	Poor	0.30	Fair	0.29	Fair
Surgery: yes or no	0.26	Fair	0.28	Fair	0.40	Moderate	0.50	Moderate
Surgery: open or arthroscopic	0.19	Poor	0.17	Poor	0.30	Fair	0.40	Moderate
Arthroscopy								
Lafosse classification	0.30	Fair	0.18	Poor	0.47	Moderate	0.30	Fair
Lyons classification	0.30	Fair	0.20	Fair	0.49	Moderate	0.34	Fair
Surgery: yes or no	0.42	Moderate	0.33	Fair	0.52	Moderate	0.50	Moderate
Surgery: open or arthroscopic	0.32	Fair	0.22	Fair	0.48	Moderate	0.42	Moderate

There was improved agreement when higher volume surgeons were evaluated apart from the rest of the survey cohort, but the highest agreement was still at the moderate level. Thus, a portion of the poor level of agreement seen in the entire surgeon group may be a reflection of overall inexperience; but even in experienced surgeons, the agreement never approaches the “good” or “excellent” levels.

Surgeon agreement did not improve when both MRI and arthroscopic images were provided simultaneously; in fact, there tended to be less agreement than compared with arthroscopic images alone. The insensitivity of MRI may confuse surgeons and influence their opinions on the pathology presented in the arthroscopic photographs.

The overall poor agreement on identification and management of subscapularis tears is in contrast to recent studies published by the MOON shoulder group on agreement of supraspinatus tears. When presented with arthroscopic video of supraspinatus tears, as opposed to photographs used in the current study, surgeons had excellent agreement ($k = 0.85$) on distinguishing partial from full-thickness tears and determining side of involvement.[21] When presented with MRI, there was good agreement ($k = 0.77$) in distinguishing partial and full-thickness supraspinatus tears.[22] Again, the differences between these studies and the present investigation may be due to poor sensitivity of MRI in detecting subscapularis tears, use of arthroscopic video versus static images, or the inconsistency with classifications of subscapularis pathology.

There was improvement in both inter- and intraobserver agreement, for both MRI and arthroscopy, when normal subscapularis tendons alone were considered. And again, arthroscopy was superior to MRI. These findings suggest that surgeons are better at discerning the presence of pathology than classifying the specific type of pathology and may pinpoint a weakness in the current classification systems.

Limitations

The major limitation of this study was the use of arthroscopic photographs instead of video. Video would more closely simulate the operative experience and thus better represent the gold standard of arthroscopy. The images selected were agreed upon by 3 surgeons, but there may have been better angles or views that were not photographed that would have more clearly shown the insertion of the subscapularis. Similarly, only 4 MRI axial images were selected per patient; the survey would more closely mimic the clinical environment if it contained full MRI, with the ability to scroll through all images. Furthermore, physical exam was not provided in the survey. While exam findings would have provided more information to the surgeons, they intentionally were omitted to prevent bias in interpretation of the imaging. Inter- and intraobserver agreement may have been improved if video, full MRI, and physical exam had been provided.

Conclusions

Although surgeons tended to have higher reliability when presented with arthroscopic images compared with MRI, there was very little agreement on the classification and management of subscapularis tendon tears.

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Appendix

Details on the survey cases are displayed. Age indicates age at time of operation. All procedures are arthroscopic unless otherwise noted, and the Lafosse[9] and Lyons[10] classifications are given based upon the operative report.

Patient	Age	Sex	Side	Lafosse	Lyons	Other Intraoperative Findings	Procedure
1	33	F	R	I	I	Labral tear	Subscap repair, labral debridement
2	48	F	R	IV	IV	Impingement, labral tear	Subscap repair, SAD, labral debridement
3	64	M	R	I	I	Infra tear, impingement, biceps fraying	Infra repair, SAD, biceps debridement
4	64	F	R	I	I	Impingement, biceps fraying	Subscap debridement, SAD, biceps debridement
5	40	M	R	IV	III	Biceps dislocation	Open subscap repair, biceps tenodesis
6	68	M	L	0	0	Supra tear, impingement, biceps fraying	Supra repair, SAD, biceps debridement
7	67	F	R	III	II	Supra tear, impingement	Subscap and supra repair, SAD
8	68	F	R	0	0	Supra tear, impingement, biceps fraying	Supra repair, SAD, biceps debridement
9	61	M	L	III	II	Impingement, biceps subluxation	Subscap repair, SAD, biceps tenotomy
10	55	M	R	III	II	Coracoid impingement, biceps tear	Subscap repair, coracoidplasty, biceps debridement
11	58	M	L	III	II	Coracoid impingement, biceps subluxation	Subscap repair, coracoidplasty
12	34	M	L	0	0	Impingement	SAD
13	53	F	R	III	II	Supra tear, impingement, biceps tear	Subscap and supra repair, SAD, biceps debridement
14	67	M	L	III	II	Supra tear, impingement	Subscap and supra repair, SAD
15	77	M	L	0	0	Supra tear, impingement	Revision supra and infra repair, SAD
16	67	F	R	0	0	Supra tear, impingement	Supra repair, SAD
17	58	F	L	II	II	Impingement	Subscap repair, SAD
18	45	M	R	II	II	—	Subscap repair
19	51	M	R	III	II	Coracoid impingement	Subscap repair, coracoidplasty
20	64	M	R	III	II	Supra tear, impingement, biceps fraying	Subscap and supra repair, SAD, biceps debridement
21	54	F	R	IV	III	Biceps tear	Subscap repair, SAD, biceps debridement
22	72	M	L	II	II	Supra tear, impingement, biceps fraying	Subscap and supra repair, SAD, biceps tenodesis
23	55	F	R	III	II	Supra tear, impingement, labral tear	Subscap and supra repair, SAD, labral debridement
24	60	M	R	IV	III	Supra tear	Subscap and supra repair
25	58	F	L	I	I	Supra tear, impingement	Subscap debridement, supra repair, SAD
26	74	M	L	I	I	Impingement, biceps fraying	Subscap repair, SAD, open biceps tenodesis
27	72	M	L	0	0	Supra tear, impingement, biceps fraying	Supra repair, SAD, biceps debridement
28	62	M	R	0	0	Supra tear, impingement	Supra repair, SAD
29	39	F	R	0	0	Supra fraying, impingement	Supra debridement, SAD
30	56	F	L	IV	IV	Supra fraying, biceps dislocation	Subscap repair, supra debridement, biceps tenodesis

F, female; Infra, infraspinatus; L, left; M, male; R, right; SAD, subacromial decompression; subscap, subscapularis; supra, supraspinatus.