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Asymptomatic rotator cuff tears: Patient demographics and baseline shoulder function

Jay D. Keener, MD^{*,^}, Karen Steger-May, MA⁺, Georgia Stobbs, RN[^], and Ken Yamaguchi, MD[^]

[^]Department of Orthopaedic Surgery, Washington University, 660 S Euclid Ave, Campus Box 8233, St. Louis, MO 63017

⁺Washington University School of Medicine, Division of Biostatistics, St. Louis, MO 63110

Abstract

Background—The purpose of this study is to characterize the demographic features and physical function of subjects with asymptomatic rotator cuff tears and to compare their shoulder function to controls with an intact rotator cuff.

Materials and Methods—196 subjects with an asymptomatic rotator cuff tear and 54 subjects with an intact rotator cuff presenting with a painful rotator cuff tear in the contralateral shoulder were enrolled. Various demographic features, shoulder function (ASES score and SST score), range of motion and strength were compared.

Results—The demographic features of the study and control groups were similar. Hand dominance was associated with the presence of shoulder pain ($p < .05$). Subjects with an intact rotator cuff had greater but clinically insignificant ASES ($p < .05$) and SST scores ($p < .05$) than those with an asymptomatic tear.

No differences in functional scores, range of motion or strength were seen between partial ($n=61$) and full-thickness tears ($n=135$). Of the full-thickness tears, 36 (27%) were classified as small, 85 (63%) as medium and 14 (10%) as large tears. No differences were seen in functional scores between full-thickness tears of various sizes.

Conclusions—When asymptomatic, a rotator cuff tear is associated with a clinically insignificant loss of shoulder function compared to those with an intact rotator cuff. Therefore, a clinically detectable decline in shoulder function may indicate an “at-risk” asymptomatic tear. The presence of pain is important in cuff deficient shoulders for creating a measurable loss of shoulder function. Hand dominance appears to be an important risk factor for pain.

Keywords

Rotator cuff tear; asymptomatic; shoulder function; strength; normal shoulder; ultrasound

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*Corresponding author: Jay D Keener, MD, Assistant Professor, Shoulder and Elbow Service, 314 747-2639, Fax: 314 747-2599, keenerj@wustl.edu.

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Introduction

Asymptomatic rotator cuff tears are relatively common in older individuals.^{5,6,8,12} These types of tears have become an increasingly important clinical entity given the high probability of occurrence in individuals presenting with unilateral shoulder pain. A previous study has shown that 50 percent of individuals 66 years of age or older with a painful rotator cuff tear will have an asymptomatic cuff tear in the opposite shoulder.¹³ These tears are clinically important as they likely represent the early stages of degenerative rotator cuff disease and may progress to symptomatic tears over time.¹⁵ The potential burden of asymptomatic rotator cuff tears to our society is tremendous given the ageing population and the drive to remain physically active in these individuals. To this point, few studies have attempted to characterize the demographic features and physical function of individuals with asymptomatic rotator cuff tears.^{6,7,13,15} Previous studies were limited in their ability to determine the potential clinical impact of asymptomatic cuff tears given the lack of a specific control group with an intact rotator cuff and a contralateral tear. The baseline functional assessment of a cohort of asymptomatic rotator cuff tears is fundamental to understanding the natural history of degenerative rotator cuff tears by serving as a baseline for the evaluation of the clinical effect of these tears and the risk of symptom progression over time.

The purpose of the present study were to characterize the baseline demographic features and physical function of subjects with asymptomatic rotator cuff tears identified when presenting with contralateral symptomatic cuff disease. We also compared the function of these individuals to controls with an intact rotator cuff.

Materials and Methods

The present study was approved by the Washington University Institutional Review Board (#05-0347) prior to initiation.

The subjects of the present study represent the baseline enrollment for a prospective cohort study in which standardized bilateral assessment of shoulder function and shoulder ultrasonography and radiography are performed every 12 months to study the natural history of asymptomatic rotator cuff tears. This cohort of patients was assembled to study the risk of symptomatic progression of asymptomatic rotator cuff tears over time and to examine factors related to the onset of symptoms. Inclusion criteria were patients who: 1) presented for bilateral shoulder ultrasonography at our institution to investigate unilateral shoulder pain without a history of shoulder injury, 2) were discovered to have a rotator cuff tear in the painful shoulder, 3) were discovered to also have a rotator cuff tear (either full or partial thickness) in the “asymptomatic” contralateral shoulder, 4) were verified as persistently asymptomatic at the time of study initiation, and 5) had no history of trauma to either shoulder and remained injury free during the duration of the study. Exclusion criteria were: 1) any past or current “significant pain” in the asymptomatic shoulder, 2) continuous use of narcotic pain medication or anti-inflammatory medication for longer than three months from the study enrollment, 3) a traumatic episode to the asymptomatic shoulder, 4) inflammatory arthropathy, 5) history of seeking medical attention for other problems in the asymptomatic shoulder (e.g., instability, arthritis, trauma, etc), 6) tear of the subscapularis tendon 7) use of the upper extremity for weight bearing, and 8) a very small partial-thickness tear smaller than 5 mm in the asymptomatic shoulder. “Significant pain” was defined as: 1) any pain greater than or equal to 3/10 on the visual analog pain scale (VAS pain) that lasted longer than six weeks, 2) any pain considered to be greater than that normally experienced as part of daily living, 3) any pain requiring the use of medications such as narcotics or non-steroidal anti-inflammatories, or 4) any pain that prompted a physician visit for evaluation.

A VAS pain score of 3 was chosen as the minimal pain level for distinction of “significant pain” as our clinical experience demonstrates that patients seeking medical evaluation for a painful shoulder generally report pain VAS scores of 5 or greater.

A control group was assembled from the same population and consisted of subjects with an asymptomatic shoulder and an intact rotator cuff by ultrasound examination. These subjects, otherwise, met all above inclusion and exclusion criteria including the presence of a painful rotator cuff tear in the contralateral shoulder.

Clinical assessment

Clinical evaluation included assessment of patient gender, occupation, hand-dominance, smoking status and ethnic background. Shoulder function was assessed with use of validated shoulder outcome tools and objective functional instruments. The assessment of subjective shoulder function included questionnaires pertaining to the American Shoulder and Elbow Surgeons (ASES) Score⁴ and the Simple Shoulder Test.³ The self assessment domain of the ASES Score includes a VAS pain scale and a summary score for various activities of daily living. The Simple Shoulder test is a validated scale consisting of 12 self- assessed questions of shoulder function. For purposes of statistical analysis, the SST score was converted to a 0 to 100 scale by dividing the raw score by the maximal score and multiplying by 100.

The assessment of objective shoulder function included physical examination with goniometric measurement of active range of motion of the shoulder including forward elevation, external rotation at the side, external rotation and internal rotation at 90° abduction, and internal rotation in extension. The range of internal rotation in extension was categorized in such a way that the least internal rotation (i.e., the hand on one’s side) was given a grade of 6 and the greatest internal rotation (i.e., the thumb up to the level of the fifth thoracic spine) a grade of 1. Isometric external rotation strength was measured at 0° abduction and 45° internal rotation of the shoulder with the subject in a sitting position. Strength measurement was repeated three times for each shoulder with use of an Isobex dynamometer (Cursor AG, Bern, Switzerland), and the average of the three measurements was obtained and used for analysis. All physical examinations were performed by either a dedicated research nurse or a research fellow (medical doctor).

Shoulder ultrasonography

Shoulder ultrasonography was performed in real time with use of a Siemens Elegra and Antares scanners (Siemens Medical Systems, Mountainview, California) and a variable high-frequency linear array transducer (7.5 to 13 megahertz) by one of three radiologists with extensive experience in musculoskeletal ultrasonography. Each subject had standardized ultrasonography of bilateral shoulders as previously described.^{10,11} The accuracy of ultrasonography for identifying and quantifying the size of full-thickness and partial-thickness cuff tears has been shown to be comparable to that of MRI with an overall accuracy of 87% in our institution.¹¹ The maximum anteroposterior dimension of a tear was measured in transverse views (i.e., perpendicular to the long axis of the cuff) and designated as the width of the tear. The maximum degree of retraction was measured in longitudinal views (i.e., parallel to the long axis of the cuff) and designated as the length of the tear. Full-thickness tears were then classified by size (based on tear width or length, whichever was larger) as small (<10 mm), medium (10 to 30 mm) or large (>30 mm).

Statistical Analysis

Data for the asymptomatic shoulder are reported for patients with an intact rotator cuff compared to patients with a partial tear and patients with a full tear. For continuous variables, statistical comparisons across the three groups (i.e., control, partial tear, full tear)

were performed using analysis of variance (ANOVA) with Tukey-adjusted least square means for all pairwise between-group comparisons. Within the ANOVA model, a statistical contrast was used to assess an a priori hypothesis regarding the equivalence of the control and study samples. Comparisons of categorical variables were performed using chi-square tests with Bonferroni-adjusted p-values for pairwise between-group comparisons. Tear size variables were compared for partial and full tears using unpaired t-tests (for continuous measures) or the chi-square test (for tear size classification). Due to violations of the assumptions required for the statistical method used, some variables required log or rank transformation prior to analysis.

Unless otherwise noted, mean $\pm$ standard deviation or number and percents are reported by group. For variables that required transformation prior to analysis, the median and interquartile range (IQR, 25th and 75th percentiles) are reported. The data analysis was generated using SAS software, version 9.1.3 of the SAS System for Linux (SAS Institute Inc., Cary, NC, USA).

Results

Subject Demographics

Over a period of three years, a total of 250 subjects were identified as eligible and enrolled in the study. This group was comprised of 196 study subjects with an asymptomatic rotator cuff tear and 54 control subjects with an intact rotator cuff (Table 1). Within the study group there were 135 full-thickness and 61 partial-thickness rotator cuff tears. There was no significant difference in the mean age between the control group (60.2 years) and the entire study group (62.1 years, $p = 0.44$). Within the study group, the mean age of those with full-thickness tears (63.3 years) was greater than those with partial-thickness tears (59.5 years, $p < 0.05$). The study group was comprised of 40% females compared to 44% of the control group ($p = 0.59$).

The presence of shoulder pain was associated with hand dominance, with 159 of the 250 (64%) control and study subjects experiencing pain in the dominant shoulder ($p < 0.05$). Therefore, only 36% of the cohort (91 subjects) were asymptomatic in the dominant shoulder. There was no difference in hand dominance in the asymptomatic shoulder between the study (38% dominant, 75/196) and control groups (30% dominant, 16/54 ($p = 0.24$)) (Table 1). A greater percentage (44%, 59/135) of asymptomatic full-thickness tears involved the dominant shoulder compared to those with partial-thickness tears (26%, 16/61 ($p = 0.05$)).

Forty-three percent (85/196) of the study subjects reported a past history of tobacco use compared to 44% (24/54) of controls ($p = 0.89$). However, a significantly greater percentage of control subjects (15%, 8/54) were currently smoking compared to the study population (6%, 11/196 ($p < 0.05$)). Likewise, a greater percentage of control subjects (15%) were currently using tobacco compared to those with full-thickness tears (4%, 5/135 ($p < 0.05$)). However, there was no difference in current tobacco use between the control group (15%) and those with partial-thickness tears (10%, 6/61 ($p = 1.0$)) or for full-thickness (4%) compared to partial-thickness tears (10% ($p = 0.23$)).

Rotator cuff tear characteristics

The median tear width, length and area of the study subjects with full-thickness rotator cuff tears in were 10.5 mm, 11.0 mm and 111 mm², respectively (Table 2). The median tear width, length and area of the study subjects with partial thickness cuff tears were 9.0 mm, 6.0 mm and 64.0 mm², respectively. The width, length and area of the full-thickness tears were significantly greater than the partial-thickness tears, $p < 0.05$. Regarding the size of the

full-thickness tears, 36 (27%) were classified as small tears, 85 (63%) as medium sized tears and 14 (10%) as large tears.

Shoulder function

The data pertaining to shoulder function is presented in Table 3. There were no clinically significant differences in shoulder function between the control and study groups although some statistical differences were seen. The median ASES score for the entire study group and those subjects with partial-thickness and full-thickness tears were 96.7, 100 and 95.6, respectively. There was no difference in ASES scores between partial and full-thickness tears ($p = 0.08$). The median ASES score for the control group was 100, which was significantly greater than the study group as a whole as well as for full-thickness ($p < 0.05$) but not partial-thickness tears ($p = 0.12$).

The median SST score for the entire study group and those subjects with partial-thickness and full-thickness tears was 91.7, 91.7 and 90.9, respectively. There was no difference in SST scores between partial and full-thickness tears ($p = 0.50$). The median SST score for the control group was 100, which was significantly greater than the study group as a whole as well as both partial and full-thickness cuff tears ($p < 0.05$).

Complete values for active range of motion of the shoulders are presented in Table 3. There were no clinically significant differences in shoulder range of motion between the control and study groups. However, the range of active range of forward elevation motion was statistically greater in the study group (median 160 degrees) compared to the control group (median 150 degrees, $p < 0.05$). There was no difference in active external rotation of the shoulder with the arm at the side in the study group (median 70.9 degrees) compared the control group (median 65.0 degrees, $p = 0.06$), however, full-thickness tears when analyzed individually showed greater external rotation (median 72.1 degrees) than the control group, $p < 0.05$. There were no statistically significant differences in active shoulder motion in other directions between the study and control groups or between partial and full-thickness tears.

The median external rotation strength of the entire study group and those subjects with partial-thickness and full-thickness rotator cuff tears was 6.3 kg, 6.9 kg and 6.0 kg, respectively. The median external rotation strength of the control group was 7.7 kg. There was no significant difference in external rotation strength between the control and study groups ($p = 0.26$) or between partial and full-thickness tears ($p = 0.17$).

Shoulder functional scores were analyzed according to tear size classification for the full-thickness asymptomatic tears (Table 4). There were no significant differences in the median ASES score for small (94.2), medium (95.0) and large tears (97.5, $p = 0.86$). Likewise, there were no significant differences in the median SST scores for small (91.7), medium (90.9) and large tears (83.3, $p = 0.50$). No differences were seen between tear size groups with all measures of shoulder active ROM with the exception of external rotation at 90 degrees abduction which was greater in small tears (90.0 degrees, IQR=90-100) compared to medium and large tears collectively (90.0 degrees, IQR=80-95, $p < .05$). No differences were seen in external rotation strength between small (5.5 kg), medium (6.4 kg) and large tears (4.8 kg, $p = 0.72$).

The power of this study to detect MCIDs in SST and ASES scores among patients with no tear, partial tears, and full tears is 1.0. In fact, the sample size has 0.80 power to detect between group differences as small as 7.5 points for the SST and 3 points for the ASES. The power to detect a MCID among patients with full tears classified as small, medium, and large is 0.58 for the SST; however the comparison did have adequate power (0.80) to

detect a difference of at least 22 points. Comparisons of these tear size groups achieved power of 0.97 to detect a MCID for the ASES score, with adequate power to detect differences as small as 9 points.

Discussion

The natural history of asymptomatic rotator cuff tears is unknown. Although age has been identified as a primary risk factor for the development of degenerative rotator cuff tears, 2,5,6,8,13 the factors associated with tear progression and the onset of clinical symptoms are unknown. Fundamental to the understanding of the natural history of rotator cuff disease is the identification of a cohort of individuals with asymptomatic tears that can be studied longitudinally in a systematic manner. We sought to define such a population and compare them to a control group with an intact cuff to better understand the potential effect of these tears upon shoulder function as a baseline. In this context, our cohort represents an “at-risk” population given both the presence of an asymptomatic cuff tear and the presence of painful cuff tear in the opposite shoulder. The control group for this study was similar to the study group for all measured demographic variables: age, gender, ethnicity and hand dominance. We, therefore, feel that valid comparisons regarding shoulder functional outcomes can be made between groups. One demographic difference between the study and control groups is noteworthy. Although there was no difference in age between the study and control groups, the age of patients with partial thickness tears (59.5 years) was younger than those with full-thickness tears (63.3 years) suggesting that age is an important factor relating to the severity of degenerative cuff disease.

Our results suggest that there is a small and clinically insignificant effect of the presence of an asymptomatic tear on shoulder function as evidenced by the slightly lower SST and ASES scores of the study group compared to the control group. The statistically significant differences in ASES and SST scores between the control and study groups are not clinically relevant. One recent study has shown the minimum clinically important difference (MCID) using the ASES and SST scores for conservatively treated rotator cuff disease are 12-17 points and 2.05-2.33 points (17-19 points using a 0 to 100 scale), respectively.⁹ We also found no clinically significant difference in active range of motion of the shoulder or external rotation strength between these groups. It is important to recognize the preserved shoulder function, range of motion and strength of the full-thickness asymptomatic tears compared to controls despite the presence of a mean tear size compatible with complete disruption of the supraspinatus tendon. Previous studies, similarly, have shown preserved shoulder range of motion in patients with asymptomatic tears,¹⁵ however, decreased elevation strength has been reported in shoulders with asymptomatic full-thickness supraspinatus tears.^{6,7}

Separate analysis of the study population with full-thickness asymptomatic tears failed to show significant differences in any measure of function between shoulders based on tear size category. Subjects with both medium and large size full-thickness tears maintained similar function with every outcome variable to those with small tears (<10 mm). The reasons for this remain unclear; however, it seems that full-thickness tears of all sizes are well tolerated in the absence of shoulder pain. Previous studies have reported altered glenohumeral kinematics in patients with asymptomatic rotator cuff tears.^{1,14} One study examining glenohumeral kinematics in patients with rotator cuff tears noted that larger tears, with extension into the infraspinatus tendon, were associated with increased proximal humeral migration compared to isolated supraspinatus tears in both symptomatic and asymptomatic shoulders.¹ The presence of an intact rotator cuff force couple (subscapularis and teres minor) likely explains the preserved range of motion and function seen within the study population, even with the larger full-thickness tears.

We found no significant difference in external rotation strength between the control and study groups and within the subgroup analysis of full-thickness tears of various sizes. These findings are similar to Kim et al who noted preserved external rotation strength but diminished abduction strength in asymptomatic shoulders with large/massive full-thickness rotator cuff tears compared to the contralateral shoulder.² It is possible that our subjects with full-thickness tears may have some loss of abduction/elevation torque which was not measured in this study.

The association of shoulder pain and hand-dominance seen in this study is noteworthy. Our study population is comprised of patients with rotator cuff tears in both shoulders; however, only one side is symptomatic. In our population, we noted a strong association between pain and hand-dominance with 70% of the control group and 62% of the study group having pain in the dominant shoulder. The results suggest that activity level (reflected in hand dominance) is a risk factor for the development of pain. This is an especially important consideration for patients with a contralateral shoulder pain who may experience increased activity of the non-dominant shoulders following treatment of the symptomatic side. A previous report by Milgrom, showed no relationship between hand dominance and the incidence of asymptomatic cuff disease, including Stage 3 lesions (partial or full-thickness tears) in subjects without pain in either shoulder, however, quantification of tear size was not reported.⁵

The results of this study must be considered after review of its' inherent limitations. The subjects of this study represent a cohort of patients with symptomatic cuff disease in the contralateral shoulder. These subjects likely have a predisposition towards symptom progression or tear progression over time. Our population, therefore, may have a different natural history than those with a unilateral tear or those with tears related to a traumatic event. However, the study group is representative of the most common clinical scenario where an asymptomatic tear is most likely to be identified. Although ultrasound has been validated as an accurate means of assessing cuff pathology, widespread use of this modality is limited by availability and the need for experienced radiologists for accurate assessment. The lack of measurement of abduction strength is a weakness, yet we feel that the functional outcome measures used in this study allowed a meaningful comparison between groups and will be sensitive to detect deterioration in function in this cohort over time. No analysis of rotator cuff muscle atrophy and fatty infiltration was performed in this study. Given the minimal difference in shoulder function observed between control shoulders and those with asymptomatic tears and the lack of difference in function and strength in asymptomatic full-thickness tears of various sizes, it is doubtful that analysis of muscle atrophy and fatty infiltration would have yielded significant findings. Data regarding rotator cuff tear size in the symptomatic shoulder may have been an interesting baseline comparison; however, the primary purpose of the present study was to establish a baseline assessment of shoulder function in shoulders with asymptomatic cuff tears compared to a control group with no tears. Lastly, some data points regarding shoulder motion and function were excluded early in the data collection process due to uncertainty of the asymptomatic side when reviewing the data forms. This resulted in a small amount of data attrition and allowed for clarification of the evaluation forms to prevent further problems in data collection in the future.

Conclusions

In conclusion, the presence of an asymptomatic rotator cuff tear is associated with a small and, likely, clinically insignificant loss of shoulder function compared to shoulders an intact rotator cuff. Shoulders with asymptomatic tears appear to be truly asymptomatic using conventional means of assessing shoulders function. Therefore, clinically detectable differences in shoulder function may indicate an "at-risk" asymptomatic tear. Findings from

this study suggest that the presence of pain is likely important in cuff deficient shoulders in producing a measurable loss of shoulder function. Hand dominance (activity level) appears to be an important risk factor for pain. This may be an important consideration for patients undergoing treatment of a painful cuff tear in the presence of an asymptomatic tear in the opposite shoulder.

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Table 1

Sample demographics of eligible patients that were enrolled (n=250)

Variable	Control (n=54)	Study sample with tears			p-values (control vs study sample)
		Partial (n=61)	Full (n=135)	Study sample (n=196)	
Gender, female	24 (44%)	27 (44%)	52 (39%)	79 (40%)	= 0.59
Age at enrollment (years)	60.2 +/- 10	59.5 +/- 10	63.3 +/- 10	62.1 +/- 10	= 0.44 (Partial vs full, < .05)
Ethnicity, Caucasian	50 (93%)	52 (85%)	122 (90%)	174 (89%)	= 0.42
Study side, dominant	16 (30%)	16 (26%)	59 (44%)	75 (38%)	= 0.24 (Partial vs full, = .05)
Smoking, current	8 (15%)	6 (10%)	5 (4%)	11 (6%)	< .05 (Control vs. full, < .05) (Control vs. partial, = 1.0) (partial vs. full, = 0.23)
Smoking, ever	24 (44%)	28 (46%)	57 (42%)	85 (43%)	= 0.89

Data are number of patients (% of group) or mean +/- standard deviation.

P-values compare controls to the study sample by statistical contrast within a model comparing controls to partials to fulls. For continuous variables, an ANOVA model was used with Tukey-adjusted p-values reported for significant pairwise between-group comparisons. For categorical variables, a chi-square test was used with Bonferroni-adjusted p-values reported for significant pairwise between-group comparisons.

Table 2

Tear characteristics for the asymptomatic side for patients with a tear (n=196)

Variable	Partial (n=61)	Full (n=135)	p-value *
Tear width (mm)	9.0 (7.0-12.0)	10.5 (.0-16.0)	< 0.05 ^
Tear length (mm)	6.0 (5.6-8.0)	11.0 (8.0-18.0)	< 0.05 ^
Tear area (mm ²)	64.0 (40.0-91.0)	111 (56.0-234)	< 0.05 ^
Tear classification ^^			
Small (<10 mm)	31 (51%)	36 (27%)	< 0.05
Medium (10-30 mm)	30 (49%)	85 (63%)	
Large (>30 mm)	0	14 (10%)	

Data are median (IQR) or # of patients (% of group).

* p-value compares partial to full tears by unpaired t-test or chi-square test (for tear size classification).

^ Data log-transformed prior to analysis.

^^ Based on tear width or length, whichever is larger.

Table 3

Function, strength and range of motion for the asymptomatic side

Variable	Control (n=54)	Study sample with tears		p-values *	
		Partial (n=61)	Full (n=135)	Study sample (n=196)	Control vs. study sample
ASES score	100 (100-100) Missing 1	100 (91.7-100)	95.6 (88.3-100) Missing 1	96.7 (88.9-100) Missing 1	Control vs. full, < 0.05 Control vs. partial, = 0.12 Partial vs. full, = 0.08
SST score	100 (100-100) Missing 2	91.7 (66.7-100) Missing 1	90.9 (66.7-100) Missing 4	91.7 (66.7-100) Missing 5	Control vs. full, < 0.05 Control vs. partial, < 0.05 Partial vs. full, = 0.50
External rotation strength (kg)	7.7 (5.1-9.4) Missing 2	6.9 (4.8-9.4) Missing 2	6.0 (4.3-8.6) Missing 1	6.3 (4.5-8.7) Missing 3	Control vs. full, = 0.12 Control vs. partial, = 0.98 Partial vs. full, = 0.17
Forward elevation (degrees)	150 (145-155) Missing 1	160 (145-160) Missing 1	160 (145-165)	160 (145-160) Missing 1	Control vs. full, < 0.05 Control vs. partial, < 0.05 Partial vs. full, = 0.97
External rotation at side (degrees)	65.0 +/- 17 Missing 1	68.3 +/- 16 Missing 1	72.1 +/- 18	70.9 +/- 17 Missing 1	Control vs. full, < 0.05 Control vs. partial, = 0.58 Partial vs. full, = 0.31
External rotation at 90 abduction (degrees)	90.0 (80.0-95.0) Missing 1	90.0 (90.0-95.0) Missing 1	90.0 (80.0-100)	90.0 (80.0-100) Missing 1	Control vs. full, = 0.99 Control vs. partial, = 0.76 Partial vs. full, = 0.75
Internal rotation behind back (level)					
Midthoracic	26 (49%)	31 (52%)	58 (43%)	89 (46%)	NA
Thoracolumbar	21 (40%)	24 (40%)	60 (44%)	84 (43%)	
Belt	6 (11%)	5 (8%)	16 (12%)	21 (11%)	
Buttock	0	0	1 (1%)	1 (1%)	
Side	0 Missing 1	0 Missing 1	0	0 Missing 1	
Internal rotation at	68.0 +/- 17	68.7 +/- 18	66.5 +/- 19	67.2 +/- 19	Control vs. full, = 0.87
					0.89

Variable	Control (n=54)	Study sample with tears			p-values *	
		Partial (n=61)	Full (n=135)	Study sample (n=196)	Control vs. partial vs. full	Control vs. study sample
90 abduction (degrees)	Missing 1	Missing 1	Missing 1	Missing 2	Control vs. partial, = 0.98 Partial vs. full, = 0.74	

Data are median (IQR), mean +/- standard deviation, or number of patients (% of group) .
NA = not applicable.

* P-value compares controls to partials to fulls by Tukey-adjusted least square means for all pairwise comparisons from the ANOVA. Within the ANOVA model, a statistical contrast was used to assess the a priori hypothesis that the control and study samples are equivalent.

[^] data rank-transformed prior to analysis.

Table 4

Function, strength, and ROM for the asymptomatic side of **full-thickness tears** (n=135)

Variable	Tear size classification +				p-values*	
	small (<10mm) (n=36)	medium (10 to 30mm) (n=85)	large (30mm or more) (n=14)	small vs. medium vs. large	small vs. 10mm or larger	
ASES score	94.2 (88.3-100)	95.0 (88.3-100)	97.5 (86.7-100)	0.50 ^	0.29 ^	
SST score	91.7 (72.7-100)	90.9 (66.7-100)	83.3 (58.3-91.7)	0.86 ^	0.65 ^	
External rotation strength (kg)	5.5 (4.2-8.7)	6.4 (4.2-8.6)	4.8 (4.3-7.7)	0.72 ^	0.94 ^	
Forward elevation (degrees)	160 (150-160)	160 (145-165)	155 (145-165)	0.91 ^	0.72 ^	
External rotation at side (degrees)	70.7 ± 15	73.5 ± 18	67.9 ± 23	0.47	0.99	
External rotation at 90 abduction (degrees)	90.0 (90.0-100)	90.0 (80.0-100)	87.5 (70.0-90.0)	0.09 ^	< 0.05 ^	
Internal rotation behind back (level):						
Midthoracic	19 (53%)	34 (40%)	5 (36%)	NA	NA	
Thoracolumbar	14 (39%)	39 (46%)	7 (50%)			
Belt	3 (8%)	12 (14%)	1 (7%)			
Buttock	0	0	1 (7%)			
Side	0	0	0			
Internal rotation at 90 abducted (degrees)	63.5 ± 20	68.2 ± 19	64.3 ± 16	0.42	0.51	

Data are median (IQR), mean ± standard deviation, or # of patients (% of group).

NA = not applicable.

* P-value compares small to medium to large tears by ANOVA. Within the ANOVA model, a statistical contrast was used to assess the a priori hypothesis that the small tears and the medium/large tears are equivalent.

^Δ Data rank-transformed prior to analysis.

[‡] Based on tear length or width, whichever is larger.