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Imaging-Based Prevalence of Superior Labral Anterior-Posterior Tears Significantly Increases in the Aging Shoulder

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Investigation performed at the University of California, San Francisco, San Francisco, California, USA

Background: Superior labral anterior-posterior (SLAP) tears can be associated with pain and shoulder dysfunction. Relatively little is known about the age-related prevalence of SLAP tears.

Purpose: To investigate the age-related prevalence of imaging-diagnosed SLAP tears in a heterogeneous grouping of shoulder conditions in a large cohort at a single institution with multiple blinded reviewers.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: A total of 281 shoulder magnetic resonance imaging (MRI) scans obtained over 8 months were reviewed by a musculoskeletal radiologist and an orthopaedic surgeon. The mean \pm SD age of the group was 49.6 \pm 15.5 years, and 107 of the patients were female (38.1%). Patients were divided into 4 age groups: 35 years or younger, 36 to 50 years, 51 to 65 years, and older than 65 years. Statistical analyses were completed by use of the Fisher exact test to compare proportions of SLAP tears between age groups, odds ratios to determine the likelihood of having a SLAP tear in each age group, and a logistic regression to control for associated abnormalities.

Results: There was a significant difference in the proportion of SLAP tears found on the MRIs for each age group ($P < .001$). Patients were significantly more likely to have SLAP tears if aged 51 to 65 years (66.7%; odds ratio [OR], 2.00; 95% CI, 1.27-3.15) and if older than 65 years (81.2%; OR, 4.31; 95% CI, 2.36-7.88). No increased prevalence was observed in patients aged 35 years or younger (47.5%; OR, 0.91; 95% CI, 0.55-1.50) or 36 to 50 years (51.8%; OR, 1.08; 95% CI, 0.70-1.67). Logistic regression demonstrated that age was the only significant predictor for having a SLAP tear ($P < .001$). Kappa values were 0.46 to 0.65 between reviewers, indicating moderate to substantial agreement.

Conclusion: An increasing prevalence of MRI-based SLAP tears was observed with increasing patient age. Patients older than 50 years were significantly more likely to have superior labral abnormalities regardless of other shoulder injury or disease.

Keywords: shoulder magnetic resonance imaging; superior labral anterior-posterior tears; aging

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Superior labral anterior-posterior (SLAP) tears are associated with pain and shoulder dysfunction. SLAP tears were first described more than 30 years ago in a population of throwing athletes.² The indications for treatment and management of these lesions remain controversial.^{1,3,10,15} Despite this controversy, up to 13% of all shoulder arthroscopic procedures performed in the United States in 2006 were for the primary indication of instability/SLAP tears.⁶

From 2004 to 2009, the incidence of SLAP procedures, including repair and debridement, increased nearly 65%; the incidence of repair in patients older than 40 years nearly matched that of patients younger than 40 years.¹⁵ Provencher et al¹⁰ found that age older than 36 years was an independent risk factor for SLAP repair failure, and SLAP repairs have been performed in patients as old as 85 years.¹⁴

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Although age affects the management and treatment of SLAP lesions, relatively little is known about the age-related nature of SLAP tears. A histological study from more than a decade ago showed an increase in the number of SLAP lesions with increasing age.⁹ Moreover, a recent study showed that up to 75% of asymptomatic shoulders in patients aged between 45 and 60 years had magnetic resonance imaging (MRI)-based evidence of SLAP tears.¹³ Importantly, however, the clinical age-based prevalence of SLAP tears on MRI has not been defined. Patients frequently describe a painful shoulder and have imaging that reveals abnormality at the superior labrum, although the frequency of these imaging findings is not established.

The purpose of this study was to investigate the age-related prevalence of imaging-diagnosed SLAP tears by using a large cohort at a single institution, with multiple blinded reviewers. We hypothesized that an increasing prevalence of SLAP tears would be significantly associated with older age.

METHODS

All consecutive shoulder MRI scans obtained at a single academic medical center in an 8-month period were retrospectively reviewed. A total of 318 shoulder scans were completed. The review included scans for patients 18 years and older and scans ordered for all indications. Patients were excluded for a documented history of prior surgery, for poor image quality, or for absence of clinical evaluation.

All MRIs were obtained on a 3-T scanner (GE Healthcare) with a flex coil. For nonarthrogram studies, sequences obtained included axial proton density, axial fat-saturated T2-weighted, coronal-oblique T1-weighted, coronal-oblique fat-saturated T2-weighted, sagittal-oblique proton density, and sagittal-oblique fat-saturated T2-weighted images. For arthrogram studies, sequences obtained included axial fat-saturated T1-weighted, axial fat-saturated T2-weighted, coronal-oblique fat-saturated T1-weighted, coronal-oblique fat-saturated T2-weighted, sagittal-oblique fat-saturated T1-weighted, and sagittal-oblique fat-saturated T2-weighted sequences. The slice thickness for both nonarthrogram and arthrogram studies was 4 mm.

Each imaging study was reviewed by 1 musculoskeletal radiologist (D.M.) and 1 orthopaedic surgeon (D.A.L.). These readings were completed independently and without knowledge of the clinical findings or radiology reports. The readers evaluated the superior labrum and classified it as intact or torn (Figure 1); a tear was identified by increased signal intensity extending into the labrum on fat-suppressed T2-weighted images or abnormal shape of the superior labrum. Additionally, the supraspinatus, infraspinatus, and subscapularis tendons were evaluated and graded as either intact, partial tear, or full-thickness tear.

The electronic medical record was reviewed for each patient. The final radiology report, which was completed by a fellowship-trained musculoskeletal radiologist, was reviewed, and the description of the labrum was recorded as either intact or torn. For instances with equivocal language, such as "possible fraying," the labrum was classified

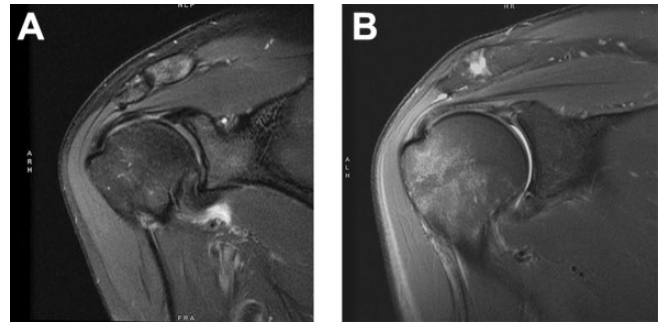


Figure 1. The appearance of the superior labrum on shoulder MRI was evaluated by a musculoskeletal radiologist and an orthopaedic surgeon and classified as either (A) intact or (B) torn. A tear was identified if increased signal was seen within the labrum on fat-suppressed T2-weighted images or if the superior labrum appeared abnormal.

as intact. The status of the rotator cuff tendons was recorded as intact, partial tear, or full-thickness tear for supraspinatus, infraspinatus, and subscapularis. Patient demographic information and history of prior shoulder surgery were recorded from the clinician's notes.

Statistical analyses were performed in Stata 14 (StataCorp). Interrater agreement between the 3 reviewers was determined with kappa statistics. For the status of the superior labrum, a patient was classified as having a labral tear if at least 2 of the 3 reviewers classified the labrum as torn.

Patients were divided into 4 age groups for analysis: 35 years or younger, 36 to 50 years, 51 to 65 years, and older than 65 years. The Fisher exact test was used to determine statistical significance between the proportion of superior labral tears in these 4 groups. Odds ratios (ORs) were determined to calculate the likelihood of having a SLAP tear for each age range.

A logistic regression was then performed to evaluate multiple factors as potential contributors to SLAP tears. The presence or absence of a SLAP tear was used as the dependent variable, with age, sex, body mass index, supraspinatus condition (no tear, partial tear, full-thickness tear), infraspinatus condition, and subscapularis condition as independent variables. For all statistical analyses, significance was defined as alpha less than .05.

RESULTS

A total of 281 MRI scans were included for analyses. From the original 318 scans, the following were excluded: 27 from patients with a documented history of prior shoulder surgery, 6 from patients younger than 18 years, 2 from patients with no clinical documentation, and 2 for pectoralis tendon injuries with poor imaging quality of the glenohumeral joint. The mean age of the full group was 49.6 ± 15.5 years, and the mean body mass index was 26.0 ± 4.7 kg/m² (Table 1). The group consisted of 107 female patients (38.1%) and 174 male patients (61.9%). There were 74

TABLE 1
Demographics of Patients Undergoing Shoulder MRI^a

Characteristic	Value
Age, y, mean ± SD	49.6 ± 15.5
Body mass index, kg/m ² , mean ± SD	26.0 ± 4.7
Sex, n (%)	
Female	107 ± 38.1
Male	174 ± 61.9
Primary shoulder abnormality, n (%)	
Rotator cuff tear/external impingement syndrome	138 ± 46.8
Instability	46 ± 15.6
Biceps/SLAP	32 ± 10.9
Other	79 ± 26.8
Study type, n (%)	
Nonarthrogram MRI	207 ± 73.7
MR arthrogram	74 ± 26.3

^aMR, magnetic resonance; MRI, magnetic resonance imaging; SLAP, superior labral anterior-posterior.

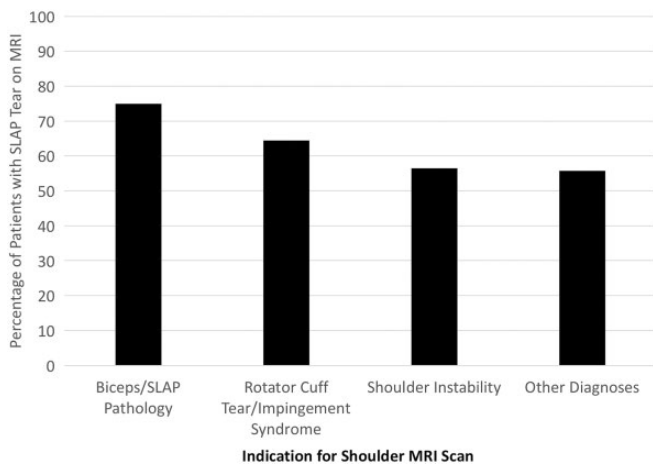


Figure 2. The prevalence of superior labral anterior-posterior (SLAP) tears is displayed according to the indication for obtaining the shoulder magnetic resonance imaging (MRI). SLAP tears were most frequently observed if the MRI was obtained to evaluate for biceps/SLAP abnormality or for rotator cuff tears/external impingement syndrome.

magnetic resonance (MR) arthrograms (26.3%) and 207 nonarthrogram studies (73.7%).

Rotator cuff concerns were the primary indication for the examination (46.8%), with instability (15.6%) and biceps/SLAP concerns (10.9%) as the next most frequent complaints. The remainder of the indications (26.8%) included arthritis, avascular necrosis, oncologic conditions, and recent trauma.

SLAP tears were observed in 169 patients (60.1%). No significant difference was observed in the prevalence between patients with a nonarthrogram study (129/207; 62.3%) versus an MR arthrogram (40/74; 54.1%) ($P = .13$). SLAP injuries were observed most frequently in patients with suspected biceps/SLAP abnormality (75.0%; OR, 3.00; 95% CI, 1.35-6.68) (Figure 2). Patients with rotator cuff

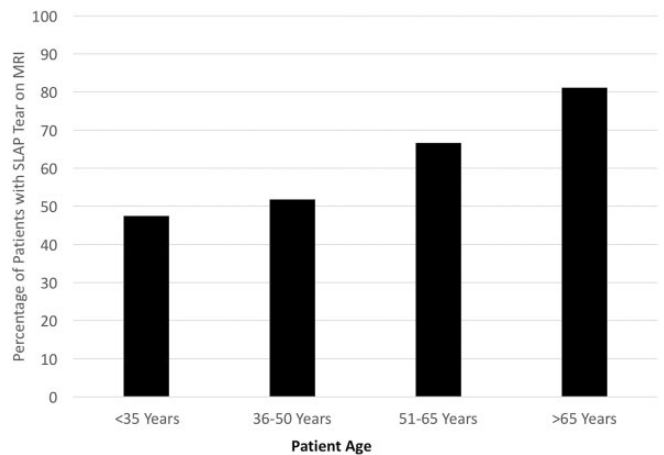


Figure 3. The age-based prevalence of superior labral anterior-posterior (SLAP) tears as detected by shoulder magnetic resonance imaging (MRI) and according to at least 2 of 3 reviewers. The prevalence of SLAP tears is significantly different between age groups, with $P < .001$ by Fisher exact test.

tear/external impingement syndrome as the indication for the imaging study were also more likely to be diagnosed with a SLAP tear (64.5%; OR, 1.82; 95% CI, 1.28-2.57). No significantly increased prevalence was found for patients with instability (56.5%; OR, 1.30; 95% CI, 0.73-2.33) or other diagnoses (55.7%; OR, 1.26; 95% CI, 0.81-1.96). Full-thickness supraspinatus tears were identified in 66 of 281 patients (23.5%), full-thickness infraspinatus tears in 17 patients (6.1%), and full-thickness subscapularis tears in 11 patients (3.9%).

There was a significant difference in the proportion of SLAP tears found on the MRIs for each age group ($P < .001$) (Figure 3). Patients were significantly more likely to have SLAP tears if they were 51 to 65 years old (66.7%; OR, 2.00; 95% CI, 1.27-3.15) and older than 65 years (81.2%; OR, 4.31; 95% CI, 2.36-7.88). No significant increased prevalence was observed in patients 35 years or younger (47.5%; OR, 0.91; 95% CI, 0.55-1.50) or those aged 36 to 50 years (51.8%; OR, 1.08; 95% CI, 0.70-1.67).

The agreement rates for identification of SLAP tears ranged from 73% between the orthopaedic surgeon and the radiology report to 83.1% between the orthopaedic surgeon and the musculoskeletal radiologist (Table 2). The agreement between the musculoskeletal radiologist and the radiology report was 75.4%. The kappa values were moderate between the orthopaedic surgeon and the radiology report (kappa = 0.46) and between the musculoskeletal radiologist and the radiology report (kappa = 0.51).

Substantial agreement was found between the orthopaedic surgeon and the musculoskeletal radiologist (kappa = 0.65). The agreement between all reviewers was higher for patients with an arthrogram compared with a nonarthrogram study.

Logistic regression analysis demonstrated that age was the only significant independent predictor for a patient having a SLAP tear (OR, 1.05; 95% CI, 1.03-1.08; $P < .001$). Relative to other diagnoses, patients were significantly

TABLE 2
Evaluation of Agreement Between Orthopaedic Surgeon, Musculoskeletal Radiologist, and Radiology Report for Diagnosis of Superior Labral Anterior-Posterior Tear on Shoulder MRI^a

Group	Overall		Nonarthrogram		Arthrogram	
	Agreement, %	Kappa	Agreement, %	Kappa	Agreement, %	Kappa
Ortho vs report	73.0	0.46	70.1	0.41	81.1	0.62
MSK vs report	75.4	0.51	69.6	0.39	91.9	0.84
Ortho vs MSK	83.1	0.65	82.8	0.63	83.8	0.68

^aMSK, musculoskeletal radiologist; ortho, orthopaedic surgeon; report, radiology report.

more likely to have a SLAP tear on MRI if the scan was ordered for concern of biceps tendon or SLAP injury (OR, 7.18; 95% CI, 2.57-20.1; $P < .001$), concern for shoulder instability (OR, 3.90; 95% CI, 1.59-9.60; $P = .003$), or concern for rotator cuff injury (OR, 2.05; 95% CI, 1.02-4.14; $P = .044$). Patient sex, body mass index, and status of the supraspinatus, infraspinatus, or subscapularis tendons were not significant independent predictors of having a SLAP tear.

DISCUSSION

A significant association was found between SLAP tears and increasing patient age, consistent with our initial hypothesis. This effect was most pronounced for patients older than 51 years. Additionally, when we controlled for other factors that could affect the condition of the labrum, age remained the only significant predictive variable for SLAP abnormality. This age-related increase in prevalence of superior labral abnormalities is consistent with a prior histopathological report.⁹

The great anatomic detail offered by MRI may lead to the detection of incidental findings of uncertain significance. In a recent study, the MRI-diagnosed prevalence of SLAP tears in 53 asymptomatic patients aged 45 to 60 years was 55% to 72%.¹³ The proportion of patients with SLAP abnormality in the current study is similar to that prior report, with the important distinction that the current cohort had preimaging shoulder symptoms that prompted the treating physician to obtain the study. This distinction helps generalize our findings to the patient with shoulder pain and the concern for potential tearing of the superior labrum, and it especially highlights the need for further research on the contributions SLAP tears may make with regard to shoulder pain.

The high prevalence of SLAP abnormalities on MRI that we observed is similar to findings of prior studies of the hip, knee, and spine. Acetabular labral abnormalities were observed in 69% of asymptomatic hips, with a greater risk of labral abnormality in patients older than 37 years.¹¹ In a study on the cervical spine of asymptomatic patients, Matsumoto et al⁸ found intervertebral disc degeneration in 12% of women and 17% of men in the third decade, compared with 89% of women and 86% of men older than 60. Finally, Englund et al⁵ evaluated knee MRIs in older patients without knee complaints. The prevalence of meniscal tears was 56% for men between the ages of 70 and 90 years.⁵ These prior studies have helped establish the age-related

prevalence of degenerative musculoskeletal conditions as observed on MRI. While these findings may be responsible for painful symptoms, special care must be taken in attributing symptoms to the superior labrum given how common signal abnormalities are at this location.

SLAP abnormality is a challenging entity to understand with regard to its role in shoulder symptoms and implications for treatment. We found that preimaging concern for a biceps tendon injury or SLAP tear was a significant independent predictor of the presence of a SLAP abnormality; however, only a small subset of our population obtained imaging with this concern. Cook et al⁴ reported on the poor diagnostic capabilities of 5 physical examination tests for SLAP injuries: the O'Brien active compression test, biceps load II test, dynamic labral shear test, Speed test, and labral tension test. In a group of patients with heterogeneous shoulder injuries, none of these tests alone or in combination were able to reliably diagnose a SLAP injury. Due to the difficulty in making a clinical diagnosis, advanced imaging may be used for surgical decision making, leading to the high prevalence of surgical treatment of SLAP tears.

Nonarthrogram MRI has been shown to be inconsistent with the diagnosis of SLAP tear, and variability exists between musculoskeletal-trained radiologists and general radiologists in the interpretation of shoulder MRI.¹² Magee and Williams,⁷ however, reported 90% sensitivity and 100% specificity when correlating MRI diagnosis of SLAP tears with arthroscopic evaluation if the MRI was obtained with a 3-T scanner. In the current study, the agreement on the diagnosis of a SLAP tear on MRI was moderate between surgeon and radiologist interpretations, which compares favorably with prior reports.¹³ The agreement in our cohort was higher across all readers for patients with MR arthrograms. Without intra-articular contrast, abnormal signal in the labrum that does not approach fluid signal on MRI can be interpreted differently by different radiologists and reviewers. This discrepancy is less of an issue on MR arthrograms because contrast insinuation defines the tear and those cases are less equivocal. Given the difficulty with a clinical diagnosis and the high prevalence of abnormal findings on MRI, there is a clear need for improved physical examination tests and diagnostic imaging modalities.

This study has multiple strengths. It included a large collection of consecutive imaging studies performed at a single institution. The patient cohort included patients of

a wide age range and with varying shoulder abnormalities. We included the interpretations of both an orthopaedic surgeon and a fellowship-trained musculoskeletal radiologist, in addition to the official radiology interpretation by a fellowship-trained musculoskeletal radiologist.

This retrospective study should be interpreted with an understanding of specific weaknesses. We did not have arthroscopic confirmation of SLAP tears in this cohort and rather relied on an agreement between 2 reviewers on MRI, which is in line with the methods of prior reports.¹¹ Given the difficulty in attributing pain to the superior labrum, we also did not have a gold standard physical examination or history element for SLAP tears. We may have overestimated the true prevalence of SLAP tears, but we believe that our interpretations are similar to those often used in clinical practice. Our agreement between readers was moderate; however, we required a consensus between at least 2 reviewers to categorize an injury as a SLAP tear, which has been used in prior studies of the superior labrum.⁷ The patients had a variety of presenting symptoms, but we believe that this heterogeneity may help make the results more generalizable. We also did not have an asymptomatic control group for comparison. Finally, we did not have specific patient-related information, such as overhead activity level, to determine potential risk factors for imaging-based SLAP tears.

CONCLUSION

The study results show the association of patient age and MR-based changes at the superior labrum. When interpreting imaging studies and reports, both the treating physician and the patient should understand the high prevalence of these findings. This study also highlights the need for further research on examination and imaging findings to clarify when SLAP tears are responsible for a patient's symptoms.

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