

Abnormal Translation in SLAP Lesions on Magnetic Resonance Imaging Abducted Externally Rotated View

Ankur M. Chhadia, M.D., Benjamin A. Goldberg, M.D., and Mark R. Hutchinson, M.D.

Purpose: The purpose of this study was to measure in vivo axial-plane translation of the glenohumeral joint by use of magnetic resonance imaging in patients with and without SLAP lesions between the conventional adducted neutral rotation (AD) view and an abducted externally rotated (ABER) view. **Methods:** Seven patients with an intraoperative SLAP lesion that was unstable and required repair were selected into the SLAP group. Although they did not have normal shoulders, 15 patients were selected into the control or comparison group, most of whom had rotator cuff pathology. The glenohumeral contact point (CP) and humeral head center (HHC) were calculated and compared with the glenoid surface as a relative anterior or posterior translation. The relative posterior translation between the ABER and AD views for each patient was calculated as Δ CP and Δ HHC. These values were compared between the SLAP and control groups. **Results:** There was a significant difference in Δ CP between the SLAP and control groups (3.62 v 0.79 mm of relative posterior translation, $P = .005$). There was not a similar significant difference found in Δ HHC between the SLAP and control groups (3.19 mm v 1.48 mm of relative posterior translation, $P = .14$). There was a significant difference between the mean translations of the SLAP-ABER group and the SLAP-AD group for both CP (-3.65 mm v -0.04 mm, $P = .008$) and HHC (-2.22 mm v $+0.97$ mm, $P = .03$). The difference between the control-ABER group and the control-AD group was not as pronounced. **Conclusions:** The magnetic resonance imaging ABER view in patients with unstable SLAP lesions requiring repair showed in vivo glenohumeral posterior translation relative to the adducted neutral rotation view of greater than 3 mm. **Clinical Relevance:** This finding furthers the understanding of the pathokinematics in SLAP lesions.

The humeral head remains well centered on the glenoid with very minimal translation throughout a large rotational range of motion.¹⁻³ Abnormal translations of the glenohumeral joint can occur with soft-tissue lesions such as anterior-inferior translation with a Bankart lesion or superior translation with rotator cuff tear arthropathy.³ In addition, soft-tissue contracture or capsulorrhaphy procedures can cause obligate

translation.³⁻⁵ SLAP lesions also have been shown in cadaveric models to be associated with pathologic translation and instability.⁶⁻¹² One study found increased instability in vivo in the anterior-to-posterior directions in patients with SLAP tears with external load application.¹³ Further in vivo studies are needed to confirm many of the cadaveric study findings of the pathokinematics in SLAP lesions.

It can be difficult to make an accurate diagnosis of a SLAP lesion because of concurrent shoulder pathology and the lack of high sensitivity and specificity in physical examination and imaging techniques.¹⁴ Arthroscopy is considered the gold standard tool to diagnose SLAP lesions.¹⁴ Magnetic resonance imaging (MRI) with or without arthrography is often obtained preoperatively to substantiate the clinical history and examination findings and to evaluate other potential shoulder lesions.¹⁴ MRI obtained with the shoulder in an abducted externally rotated (ABER) view has been

From the Department of Orthopaedics, University of Illinois at Chicago, Chicago, Illinois, U.S.A.

The authors report no conflict of interest.

Received July 25, 2008; accepted June 27, 2009.

Address correspondence and reprint requests to Ankur M. Chhadia, M.D., Department of Orthopaedics, University of Illinois at Chicago, 835 S Wolcott Ave, M/C 844, Chicago, IL 60612, U.S.A. E-mail: chhadia@gmail.com

© 2010 by the Arthroscopy Association of North America

0749-8063/10/2601-8436\$36.00/0

doi:10.1016/j.arthro.2009.06.028

TABLE 1. Patient Demographics

Patient No.	Group	Age (yr)	Gender	Preoperatively	Postoperatively	Procedure
1	SLAP	27	M	SLAP type II	Same	Repair
2	SLAP	29	M	SLAP type II	Same	Repair
3	SLAP	22	M	SLAP type II	Same	Repair
4	SLAP	19	F	SLAP type II	Same	Repair
5	SLAP	27	M	SLAP type II	Same	Repair
6	SLAP	20	M	SLAP type V	Same	Repair
7	SLAP	46	M	SLAP type II	Same	Repair
8	Control	46	M	SLAP type I, LB	Same + DJD	Debridement
9	Control	23	F	PT-RTC, SLAP type I	Same	Debridement
10	Control	53	M	RTC-SST, SLAP type I	Same	Repair, debridement
11	Control	42	M	SAB, SLAP type I	Same	SAD, debridement
12	Control	49	F	RTC-SST	Same + SLAP type I	Repair, debridement
13	Control	46	M	RTC-SST	Same + SLAP type I	Repair, debridement
14	Control	49	M	RTC-SST	Same	Repair
15	Control	39	M	RTC-SST	Same	Repair
16	Control	39	M	RTC-SST	Same	Repair
17	Control	34	M	RTC-SST	Same	Repair
18	Control	45	M	RTC-SST	Same	Repair
19	Control	19	F	RTC-SST	Same	Repair
20	Control	53	M	RTC-SSC	Same	Repair
21	Control	42	M	RTC-SST	Same	Revision repair
22	Control	28	M	PT-RTC, SAB	Same	Debridement, SAD

Abbreviations: LB, loose body; DJD, degenerative joint disease; PT-RTC, partial-thickness rotator cuff tear; RTC, rotator cuff tear; SST, supraspinatus; SAB, subacromial bursitis; SAD, subacromial decompression; SSC, subscapularis.

used to improve visualization of the undersurface of the rotator cuff for evaluation of internal impingement and in evaluating the anterior labroligamentous complex for instability lesions.¹⁵⁻¹⁷ To our knowledge, there is no study describing the use of MRI ABER views in the assessment of SLAP lesions.

The purpose of this study was to measure in vivo axial-plane translation of the glenohumeral joint by use of MRI in patients with and without SLAP lesions by comparing the conventional adducted neutral rotation (AD) position with an ABER position. We hypothesized that the ABER view would show a posterior translation of the humeral head on the glenoid in the SLAP group only when compared with the traditional arm-at-the-side neutral rotation view.

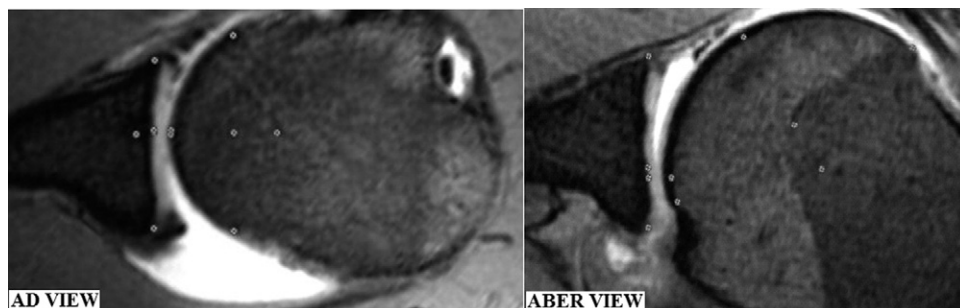
METHODS

All shoulder arthroscopy cases at our institution from January 2005 through August 2006 were retrospectively reviewed. Patients who had preoperative MRI with ABER views available were selected. The ABER view sequences were performed by our radiology department for all shoulder MRI arthrograms during that time period. All patients selected had complaints of pain, weakness, or both. None of the se-

lected patients had preoperative complaints of instability or recurrent dislocation. Patients with a SLAP lesion diagnosed intraoperatively that required repair were selected as the SLAP group (Table 1). The remaining patients had other shoulder pathology (Table 1). Although they did not have normal shoulders, they were used as the control or comparison group.

All of the MRI scans were performed in our institution's radiology department with a GE 3.0-T closed system with a shoulder coil (GE Healthcare, Buckinghamshire, England). An arthrogram technique with a gadolinium injection performed under fluoroscopic guidance was used. The images were obtained in Digital Imaging and Communications in Medicine (DICOM) format (National Electrical Manufacturers Association, Rosslyn, VA) and were evaluated by use of 3D-DOCTOR software (Able Software, Lexington, MA). An axial T1 fat-suppression sequence with the standard arm-at-the-side neutral rotation (AD) view was evaluated. The same axial sequence with the ABER position (shoulder in 90° of abduction and external rotation with the palm of the hand placed behind the head) was evaluated for comparison (Fig 1). The image with the maximum glenoid anterior-to-posterior diameter within each sequence was used for analysis. The resolu-

FIGURE 1. MRI AD and ABER view images at maximal glenoid diameter in axial plane.



tion of the MRI sequences was 0.54×0.54 mm in the axial plane with 3 mm between slices.

The glenohumeral translation in the anterior-to-posterior direction relative to the glenoid face was measured by use of the glenohumeral contact point (CP) and humeral head center (HHC). For each image, points were marked corresponding to the anterior and posterior rim of the glenoid face. A tangential line to the humeral articular surface that was parallel to the glenoid face was used to mark the CP (intersection point of humeral articular surface) (Fig 2). The anterior or posterior translation of the CP relative to the center of the glenoid face was calculated in millimeters. Anterior translation was calculated as a positive value, whereas posterior translation was calculated as a negative value.

To calculate the HHC, it was assumed that the humeral articular surface was spherical.¹⁸ An anterior point and a posterior point were marked on the surface to form an arc. By use of these 2 points, the HHC was calculated with geometry¹⁹ (Fig 3). The anterior or posterior translation of the HHC relative to the center of the glenoid face was calculated in millimeters. Again, anterior translation was calculated as a positive value, whereas posterior translation was calculated as a negative value.

Statistical analysis was performed with the Student *t* test. The significance level was set at $P = .05$. We

performed a power analysis that showed that a sample size of 7 patients per group was needed to detect a difference of 1.5 times the SD between the means of 2 independent samples at 80% power ($\beta = .2$) with $\alpha = .05$. For each patient, the difference between the translation in the AD view and that in the ABER view for the CP and HHC was calculated as relative posterior translation in millimeters. These calculated differences were termed ΔCP and ΔHHC . They were compared between the SLAP and control groups by use of a 2-sample *t* test analysis.

In addition, the images were divided into 4 groups: control-AD view, control-ABER view, SLAP-AD view, and SLAP-ABER view. The mean translations for the CP and HHC for each of the 4 groups were calculated and used to compare differences between them. The control-AD group, was compared with the control-ABER group and the SLAP-AD group was compared with the SLAP-ABER group by use of a paired *t* test analysis. The control-AD group was compared with the SLAP-AD group, and the control-ABER group was compared with the SLAP-ABER group by use of a 2-sample *t* test analysis.

RESULTS

There were 142 shoulder arthroscopy cases at our institution during the time period reviewed. Of these,

FIGURE 2. Glenohumeral CP calculation using a tangential line to humeral articular surface that was also parallel to glenoid face. This shows posterior translation in the ABER view relative to the AD view.

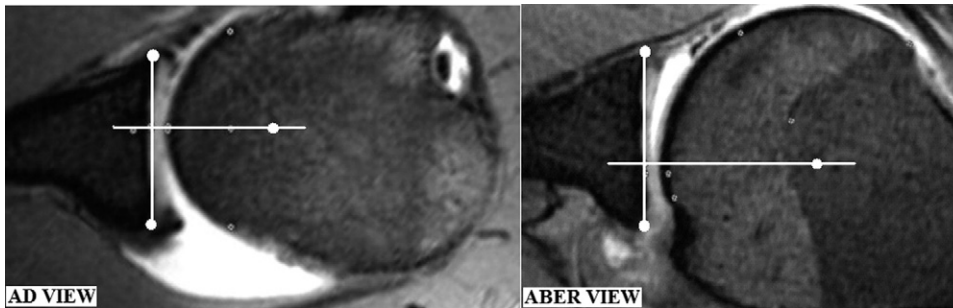


FIGURE 3. HHC calculation using 2 points on arc of spherical articular surface. Data from references^{18,19} This shows posterior translation in the ABER view relative to the AD view.

22 had preoperative MRI with ABER views available. Seven patients were diagnosed intraoperatively with a SLAP lesion that required repair, whereas fifteen were diagnosed with other shoulder pathology and were used as the control or comparison group (Table 1). Within the SLAP group, 6 patients had a type II lesion and 1 had a type V lesion.^{14,20} The patient with the type V lesion who had a SLAP and Bankart repair had a preoperative complaint of only pain and not of any instability. None of the patients in this group had prior same-side surgery. There were 6 men and 1 woman in the SLAP group. The mean age was 27 years, with a range of 19 to 46 years.

Among the 15 patients in the control group, 6 had superior labral fraying consistent with a type I SLAP lesion that was treated with debridement (Table 1). These patients also had other concurrent shoulder pathology. They were not included in the SLAP group because they did not have an unstable labral tear that required repair. The most common shoulder pathology in the control group involved the rotator cuff. Ten supraspinatus tears including one retear after previous repair and one subscapularis tear were repaired. Two partial-thickness articular-sided supraspinatus tears were debrided. Only 1 patient in this group had prior same-side shoulder surgery as previously noted. There were 12 men and 3 women in the control group. The mean age was 40 years, with a range of 19 to 53 years.

There was a significant difference in Δ CP between the SLAP and control groups (3.62 mm ν 0.79 mm of relative posterior translation, $P = .005$) (Fig 4). There was not a similar significant difference found in Δ HHC between the SLAP and control groups (3.19 mm ν 1.48 mm of relative posterior translation, $P = .14$). The control group was divided into the 6 patients with a type I SLAP lesion (control-2 group) and the 9 patients with no SLAP lesion (control-3 group) for subgroup analysis. There were no significant differences between the SLAP and control-2 groups for Δ CP (3.62 mm ν 1.74 mm, $P = .12$) or Δ HHC (3.19

mm ν 1.08 mm, $P = .14$). There was a significant difference between the SLAP and control-3 groups for Δ CP (3.62 mm ν 0.15 mm, $P = .005$) but not for Δ HHC (3.19 mm ν 1.75 mm, $P = .32$). There were no significant differences between the control-2 and control-3 groups for Δ CP (1.74 mm ν 0.15 mm, $P = .08$) or Δ HHC (1.08 mm ν 1.75 mm, $P = .58$).

There was a significant difference between the mean translations of the SLAP-ABER group and the SLAP-AD group for both CP (-3.65 mm ν -0.04 mm, $P = .008$) and HHC (-2.22 mm ν $+0.97$ mm, $P = .03$) (Figs 5 and 6). There was no difference between the control-ABER group and the control-AD group for CP (-1.04 mm ν -0.25 mm, $P = .10$), but there was a small difference for HHC (-0.75 mm ν $+0.73$ mm, $P = .02$). There was a significant difference between the mean translations of the SLAP-ABER group and the control-ABER group for CP (-3.65 mm ν -1.04 mm, $P = .007$) but not for HHC (-2.22 mm ν -0.75 mm, $P = .12$). There was no difference between the SLAP-AD group and the con-

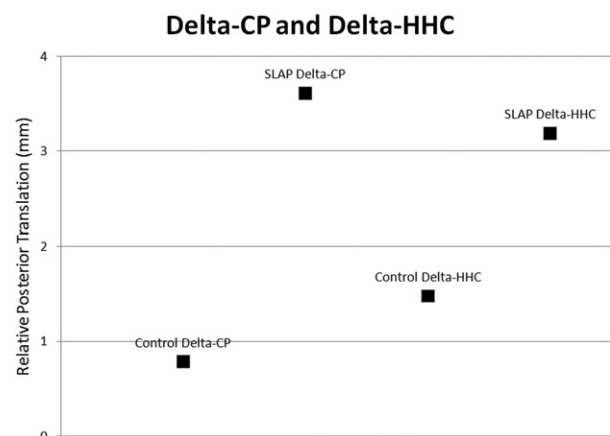


FIGURE 4. The relative posterior translations of Δ CP and Δ HHC were greater in the SLAP group than in the control group. This difference was statistically significant only for Δ CP.

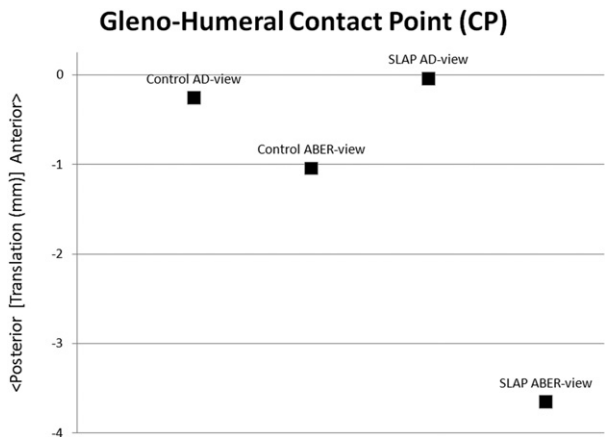


FIGURE 5. Mean translations for glenohumeral CP for each group were compared. There was a statistically significant posterior translation of the SLAP ABER group relative to the SLAP AD group. This was not present in the control group.

trol-AD group for both CP ($-0.04 \text{ mm} \nu -0.25 \text{ mm}$, $P = .78$) and HHC ($+0.97 \text{ mm} \nu +0.73 \text{ mm}$, $P = .74$).

DISCUSSION

The findings of this study confirmed our hypothesis that the humeral head translated posteriorly relative to the glenoid in the ABER view when compared with the AD view in patients with unstable SLAP lesions requiring repair. This finding was more pronounced when using the CP to measure relative translation than when using the HHC. The relative posterior translation consistently measured over 3 mm, which may be clinically relevant given that the mean glenoid diameter measured was $29.4 \pm 0.86 \text{ mm}$ (95% confidence interval) on the axial images studied. This finding furthers the understanding of pathokinematics in SLAP lesions. It could potentially be useful as an extra sign to look for in addition to clinical history, physical examination, MRI appearance, and arthroscopic appearance when evaluating and managing unstable SLAP lesions.

There was not a consistent finding in the control group of posterior translation on the ABER view relative to the AD view. The relative posterior translation measured from under 1 mm up to 1.5 mm. All of the statistical comparisons except for 1 were not significant. Thus the persistent difference found in the SLAP group was not found in the control group between the ABER and AD views. Further analysis of the subgroup of patients in the control group with type I SLAP lesions did find a difference from the SLAP

group of approximately 2 mm of relative posterior translation in the latter, although this was not statistically significant. The subgroup of patients with no SLAP lesions within the control group was significantly different from the SLAP group, with a similar finding of greater than 3 mm of relative posterior translation in the latter.

There could be several potential explanations for this posterior translation measured in the SLAP group. One reason could be that the superior labrum, especially the posterior superior labrum, could provide a centering or stabilizing effect. When this labrum is disrupted and unstable, this effect could be lost, resulting in posterior translation in the ABER position. Another reason could be that a posterior capsule contracture could lead to obligate posterior translation in the ABER position. This contracture can be a pathologic finding in a symptomatic thrower’s shoulder and can be associated with a SLAP lesion, internal impingement, anterior shoulder instability, and scapular dyskinesia.²¹⁻²³ The posterior contracture and resulting posterior translation could be a causative factor of SLAP lesions with this theory.

Many of the cadaveric studies on SLAP lesions also show abnormal motion.⁶⁻¹² Most of these studies used external loading to test for stability of varying anatomic lesions including SLAP lesions and their subsequent repairs.^{6-9,11} Although these studies show glenohumeral instability, they do not evaluate the joint’s pathokinematics with routine motion. In contrast, our study did not evaluate for instability with external loading but, rather, looked at humeral head centering

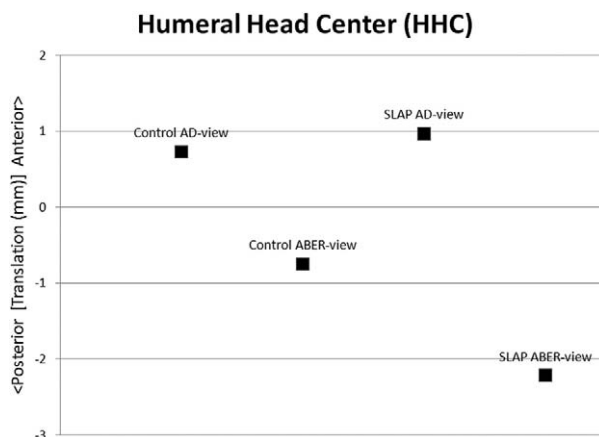


FIGURE 6. Mean translations for HHC for each group were compared. There was a statistically significant posterior translation of the SLAP ABER group relative to the SLAP AD group. There was also a significant difference in the control group, but it was smaller.

with extreme positioning in a static unloaded situation in various patient groups in vivo.

The other 2 cadaveric studies evaluated abnormal translation with varying humeral rotation in simulated throwers' shoulders without an external load to test for stability as part of their experiment.^{10,12} These studies evaluated the effect of simulated posterior capsular contracture and anterior capsular laxity on the pathokinematics of SLAP lesions. They found that in the normal shoulder, translation occurred in a posterior-inferior direction in the cocking position.¹⁰ The cocking position consists of abduction, external rotation, and extension; this is in contrast to our study, in which the flexion-extension positioning was neutral (i.e., in the scapular plane).

We found 1 prior in vivo study of patients with SLAP lesions.¹³ This study, like many of the cadaveric studies discussed earlier, evaluated anterior-to-posterior stability with a load-and-shift type of measurement. It found increased excursion relative to the normal contralateral side and relative to postoperative repairs.

The strengths of our study are that it measures translation in vivo rather than in cadaveric specimens. In addition, we diagnosed the SLAP lesions arthroscopically, rather than relying solely on clinical examination and MRI findings. Furthermore, we measured 2 different points (CP and HHC) on the humeral head for position analysis with routine shoulder rotation, rather than using an external load application to test for instability.

The limitations of our study included a small number of cases. Of the 142 total cases, 26 had arthroscopically diagnosed SLAP lesions but only 13 had the required preoperative MRI scans. Of these, only 7 had unstable SLAP lesions requiring repair. In addition, the control group did not comprise normal asymptomatic contralateral shoulders, which would have been the ideal control group. Most of the patients in the control group had rotator cuff pathology, which could have resulted in a false-negative result showing no difference between the AD and ABER views in the control group. Furthermore, the fluid from the arthrogram could have resulted in a false-positive difference in the SLAP group because the SLAP group likely had increased joint pressure from the contained fluid, resulting in altered joint dynamics, whereas in the control group the fluid could have escaped through the rotator cuff tear. Finally, evaluating coronal-plane translation (i.e., superior or inferior translation), evaluating multiple shoulder positions (i.e., mid-range abduction and a flexed, adducted, and internally rotated

position), and possibly evaluating a dynamic rather than static situation with future improvements in imaging technology could provide further useful information.

CONCLUSIONS

The MRI ABER view in patients with unstable SLAP lesions requiring repair showed in vivo glenohumeral posterior translation relative to the adducted neutral rotation view of greater than 3 mm.

REFERENCES

1. Poppen NK, Walker PS. Normal and abnormal motion of the shoulder. *J Bone Joint Surg Am* 1976;58:195-201.
2. Howell SM, Galinat BJ, Renzi AJ, Marone PJ. Normal and abnormal mechanics of the glenohumeral joint in the horizontal plane. *J Bone Joint Surg Am* 1988;70:227-232.
3. Matsen FA III, Titelman RM, Lippitt SB, Rockwood CA Jr, Wirth MA. Glenohumeral instability. In: Rockwood CA Jr, Matsen FA III, Wirth MA, Lippitt SB, eds. *The Shoulder*. Philadelphia: Saunders, 2004;655-790.
4. Harryman DT II, Sidles JA, Clark JM, McQuade KJ, Gibb TD, Matsen FA III. Translation of the humeral head on the glenoid with passive glenohumeral motion. *J Bone Joint Surg Am* 1990;72:1334-1343.
5. Huffman GR, Tibone JE, McGarry MH, Phipps BM, Lee YS, Lee TQ. Path of glenohumeral articulation throughout the rotational range of motion in a thrower's shoulder model. *Am J Sports Med* 2006;34:1662-1669.
6. Pagnani MJ, Deng XH, Warren RF, Torzilli PA, Altchek DW. Effect of lesions of the superior portion of the glenoid labrum on glenohumeral translation. *J Bone Joint Surg Am* 1995;77:1003-1010.
7. Burkart A, Debski RE, Musahl V, McMahon PJ. Glenohumeral translations are only partially restored after repair of a simulated type II superior labral lesion. *Am J Sports Med* 2003;31:56-63.
8. McMahon PJ, Burkart A, Musahl V, Debski RE. Glenohumeral translations are increased after a type II superior labrum anterior-posterior lesion: A cadaveric study of severity of passive stabilizer injury. *J Shoulder Elbow Surg* 2004;13:39-44.
9. Panossian VR, Mihata T, Tibone JE, Fitzpatrick MJ, McGarry MH, Lee TQ. Biomechanical analysis of isolated type II SLAP lesions and repair. *J Shoulder Elbow Surg* 2005;14:529-534.
10. Grossman MG, Tibone JE, McGarry MH, Schneider DJ, Veneziani S, Lee TQ. A cadaveric model of the throwing shoulder: A possible etiology of superior labrum anterior-to-posterior lesions. *J Bone Joint Surg Am* 2005;87:824-831.
11. Youm T, Tibone JE, ElAttrache NS, McGarry MH, Lee TQ. Simulated type II superior labral anterior posterior lesions do not alter the path of glenohumeral articulation: A cadaveric biomechanical study. *Am J Sports Med* 2008;36:767-774.
12. Mihata T, McGarry MH, Tibone JE, Fitzpatrick MJ, Kinoshita M, Lee TQ. Biomechanical assessment of type II superior labral anterior-posterior (SLAP) lesions associated with anterior shoulder capsular laxity as seen in throwers: A cadaveric study. *Am J Sports Med* 2008;36:1604-1610.
13. Magit D, Tibone JE, Lee TQ. In vivo comparison of glenohumeral translation after arthroscopic superior labral (SLAP) repairs. Poster presented at the American Academy of Ortho-

- paedic Surgeons Annual Meeting, San Francisco, CA, March 5-9, 2008.
14. Mileski RA, Snyder SJ. Superior labral lesions in the shoulder: Pathoanatomy and surgical management. *J Am Acad Orthop Surg* 1998;6:121-131.
 15. Tirman PF, Bost FW, Steinbach LS, et al. MR arthrographic depiction of tears of the rotator cuff: Benefit of abduction and external rotation of the arm. *Radiology* 1994;192:851-856.
 16. Cvitanic O, Tirman PF, Feller JF, Bost FW, Minter J, Carroll KW. Using abduction and external rotation of the shoulder to increase the sensitivity of MR arthrography in revealing tears of the anterior glenoid labrum. *AJR Am J Roentgenol* 1997; 169:837-844.
 17. Kwak SM, Brown RR, Trudell D, Resnick D. Glenohumeral joint: Comparison of shoulder positions at MR arthrography. *Radiology* 1998;208:375-380.
 18. Itoi E, Morrey BF, An K. Biomechanics of the shoulder. In: Rockwood CA Jr, Matsen FA III, Wirth MA, Lippitt SB, eds. *The Shoulder*. Philadelphia: Saunders, 2004:223-268.
 19. Book 3. Proposition 25. Given a segment of a circle, to describe the complete circle of which it is a segment. In: Euclid, Heath TL (translator), Aberdein A (introduction). *The Elements: Books I-XIII, Complete and Unabridged*. New York: Barnes & Noble, 2006.
 20. Maffet MW, Gartsman GM, Moseley B. Superior labrum-biceps tendon complex lesions of the shoulder. *Am J Sports Med* 1995;23:93-98.
 21. Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: Spectrum of pathology. Part I: Pathoanatomy and biomechanics. *Arthroscopy* 2003;19:404-420.
 22. Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: Spectrum of pathology. Part II: Evaluation and treatment of SLAP lesions in throwers. *Arthroscopy* 2003;19:531-539.
 23. Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: Spectrum of pathology. Part III: The SICK scapula, scapular dyskinesis, the kinetic chain, and rehabilitation. *Arthroscopy* 2003;19:641-661.

Have you ever thought of reviewing for *Arthroscopy*?

Be part of our peer-review process. It's rewarding, enlightening, and a great service to your profession. It's also an important commitment of time and effort.

Do you have what it takes to volunteer? Think about it.

Visit <http://ees.elsevier.com/arth/> and click on the links found in the Reviewer Information box.