

A New SLAP Test: The Supine Flexion Resistance Test

Nina Ebinger, M.D., Petra Magosch, M.D., Sven Lichtenberg, M.D., and Peter Habermeyer, M.D., Ph.D.

Purpose: This study describes a new test to detect SLAP lesions. The sensitivity, specificity, and positive and negative predictive values with respect to the diagnosis of a SLAP lesion were determined in comparison to Speed's test and the O'Brien test. **Methods:** One hundred fifty patients presenting for arthroscopic surgery with persisting pain or functional disability of the shoulder underwent a complete shoulder examination. All patients underwent Speed's test, the O'Brien test, and the new supine flexion resistance test. The clinical results of the tests were correlated with the presence of a SLAP lesion by direct arthroscopic visualization. **Results:** The supine flexion resistance test had a sensitivity of 80% and a specificity of 69%, whereas Speed's test and the O'Brien test had sensitivities of 60% and 94%, respectively, and specificities of 38% and 28%, respectively. Regarding isolated SLAP lesions, the supine flexion resistance test was highly sensitive, with a sensitivity of 92% (58% for Speed's test and 75% for the O'Brien test). For isolated tears of the supraspinatus, the specificity of the supine flexion resistance test was 75% (14% for Speed's test and 17% for the O'Brien test). **Conclusions:** Compared with the O'Brien test and Speed's test, the supine flexion resistance test proves to be more specific, with a specificity of 69% for the whole study population (28% for the O'Brien test and 38% for Speed's test) and with a specificity of 75% for the group of patients with isolated supraspinatus lesions (17% for the O'Brien test and 14% for Speed's test). The new test is a useful and effective test for detecting type II SLAP lesions. The high specificity enables the elimination of false-positive results of other clinical tests that are more sensitive but not specific. **Level of Evidence:** Level II, development of diagnostic criteria with consecutive patients and universally applied gold standard. **Key Words:** SLAP lesion—Arthroscopy—SLAP test—Speed's test—O'Brien test—Shoulder.

There are many standard tests to evaluate the shoulder function and to differentiate between the wide variety of functional and structural disorders of the shoulder. Pathologies such as rotator cuff tears, acromioclavicular (AC) joint arthritis, or instability can be distinguished reliably. The accuracy of the functional tests regarding pathology of the biceps–superior labrum complex, however, has been ques-

tioned in the literature,¹⁻⁸ because the significance of the established tests assessed by analyzing sensitivity and specificity is still disappointingly low. Snyder et al.⁹ first described the SLAP (superior labrum anterior-posterior) lesion and marked the importance of the biceps–superior labrum complex in clinical disorders of the shoulder. Since then, a few clinical tests have been described. When first published and evaluated for their efficacy, the results seemed promising,¹⁰⁻¹² but the comparatively high sensitivity and specificity of the tests were not reproducible in further studies.¹⁻⁸ To achieve more reliable results in recognizing a SLAP lesion only by clinical examination with less need for expensive and extensive diagnostic investigations such as magnetic resonance imaging (MRI), the senior author has developed a new SLAP test. The purpose of this study is to present the supine flexion resistance test and to evaluate the test for its

From the Department of Shoulder and Elbow Surgery, ATOS Clinic, Heidelberg, Germany.

The authors report no conflict of interest.

Address correspondence and reprints requests to Nina Ebinger, M.D., Diakoniekrankenhaus Annastift, Klinik III, PD Dr. Med. Frank Gossé, Anna-von-Borries-Strasse 1-7, 30625 Hanover, Germany. E-mail: nina.ebinger@annastift.de

© 2008 by the Arthroscopy Association of North America
0749-8063/08/2405-7299\$34.00/0

doi:10.1016/j.arthro.2007.11.017

sensitivity, specificity, and positive and negative predictive values compared with the 2 most common tests,¹³ Speed's test¹⁴ and the active compression test (i.e., O'Brien test).¹² The new supine flexion resistance test is expected to diagnose a SLAP lesion with a higher accuracy than the established tests.

METHODS

A prospective diagnostic protocol was applied to 150 consecutive patients (150 shoulders, 42 female and 108 male patients) presenting for arthroscopic surgery of the shoulder for a wide variety of complaints. All patients had undergone conservative treatment previously and presented with persisting nonresponsive pain and functional disability for a complete physical examination before being admitted to the hospital undergo surgery. They all provided plain radiographs as well as MRI scans of the shoulder. Patients were included in the study only if a complete range of motion of the involved shoulder could be obtained. Thus 37 patients had to be excluded, leaving a study population of 113 shoulders. Of the 113 patients, 84 were male and 29 were female, with a mean age of 48.8 years (range, 14 to 79 years). There were 69 right and 44 left shoulders involved.

One day before surgery, all patients were evaluated with a complete shoulder examination according to a standard protocol. For assessment of a SLAP lesion, the 2 most common provocative maneuvers, Speed's test and the O'Brien test, as well as the supine flexion resistance test, were performed by 1 independent physician. The supine flexion resistance test is performed with the patient in the supine position. The patient is asked to rest the arm above the head in full elevation, with the forearm resting on a pallet with the palm facing upward (Fig 1). The examiner is positioned adjacent to the patient on the same side as the examined shoulder and grasps the patient's arm just distal to the elbow. Then the patient is asked to perform a

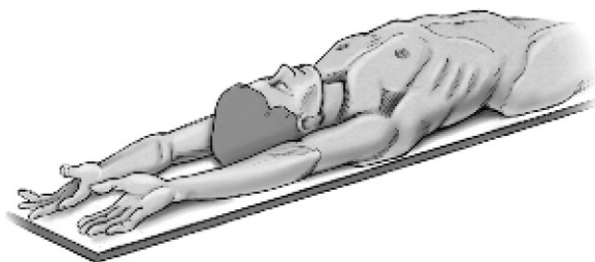


FIGURE 1. Supine flexion resistance test: Starting position.

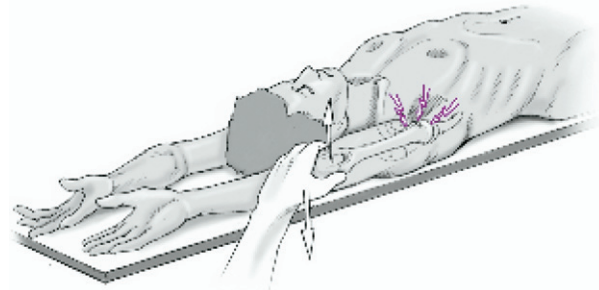


FIGURE 2. Supine flexion resistance test: The patient performs a throwing motion against resistance. The test is considered positive if pain is elicited deep inside the shoulder joint or at the dorsal aspect of the shoulder.

forward flexion of the arm as if simulating a throwing motion (Fig 2). The test is considered positive only if pain is elicited deep inside the shoulder joint or at the dorsal aspect of the shoulder along the joint line during the resisted movement. Performing the test on the nonaffected shoulder should not elicit any pain. With the patient in the beach-chair position, standardized arthroscopy was performed by 2 surgeons (the senior author and his partner), both different from the person who performed the examination. The glenohumeral joint and the subacromial space were evaluated and the pathology surgically addressed as appropriate. Type II SLAP lesions were considered to be present when the probe could completely detach the superior labrum from the glenoid rim and when a peel-back mechanism¹⁵ could be shown by putting the arm in the overhead position. All type II SLAP lesions were arthroscopically repaired. All surgical findings were recorded.

An analysis of the outcome of the clinical tests and their correlation with the arthroscopic examination was undertaken afterward to determine the sensitivity (frequency of the test being positive if a pathology is present), specificity (frequency of the test being negative if a pathology is not present), positive predictive value (probability of a pathology being present if the test is positive), and negative predictive value (probability of a pathology not being present if the test is negative) of each of the 3 tests with respect to the intraoperative diagnosis of a type II SLAP lesion. Type I SLAP lesions were not included for evaluation of the correlation between the clinical tests and the arthroscopic findings. The analysis was first performed for the whole study population including all pathologic conditions ranging from AC joint arthritis to rotator cuff tears and instability. Afterward, the analysis was done for patients divided into subgroups according to

TABLE 1. Preoperative Clinical Examination (*n* = 113)

	No. of Patients With Positive Results
Supine flexion resistance test	46
O'Brien test	83
Speed's test	70
Impingement (Neer, Hawkins)	87
Instability	32
Hyperlaxity	30
Tests for supraspinatus (Jobe, Patte's)	65
Tests for subscapularis (lift-off, belly off)	8

specific pathologic conditions: (1) isolated type II SLAP lesion, (2) isolated partial tear of the supraspinatus, (3) isolated full tear of the supraspinatus, and (4) combined type II SLAP lesion and supraspinatus lesion. Statistical analyses were performed by use of SPSS software (version 13.0 for Windows; SPSS, Chicago, IL).

RESULTS

The results of the clinical examination are summarized in Table 1 (online only, available at www.arthroscopyjournal.org). Among the 113 patients, the supine flexion resistance test was positive in 46 and negative in 67. Speed's test was positive in 70 shoulders and negative in 43, and the O'Brien test was positive in 83 shoulders and negative in 30. The Neer test was positive in 87 shoulders, and the hyperangulation test was positive in 58. Of the patients, 30 showed clinical signs of hyperlaxity and 32 had positive signs of shoulder instability. The Jobe test and Patte's test were positive in 65 and 62 shoulders, respectively. Eight patients tested positive clinically for a subscapularis lesion.

The arthroscopic examination revealed type II SLAP lesions in 21 shoulders (Table 2, online only, available at www.arthroscopyjournal.org). Type I SLAP lesions were found in 11 shoulders, and a type III SLAP lesion was found in 1 case. Of the patients, 22 had a partial tear of the supraspinatus and 37 had a full tear. Lesions of the infraspinatus were found in 6 patients and lesions of the subscapularis in 12. The AC joint was affected in 23 shoulders, and instability of the glenohumeral joint was revealed in 29. There was a wide conjunction of the different pathologic findings. Regarding isolated pathologies, 12 type II SLAP lesions, 25 complete tears of the supraspinatus, and 11 partial tears of the supraspinatus were detected.

Arthroscopy revealed 6 shoulders with a type II SLAP lesion in association with a supraspinatus lesion.

For the whole study population, the sensitivity and specificity of the supine flexion resistance test were 80% and 69%, respectively, and the positive predictive value and negative predictive value were 36% and 94%, respectively. The sensitivity, specificity, positive predictive value, and negative predictive value were 60%, 38%, 18%, and 81%, respectively, for Speed's test and 94%, 28%, 55%, and 83%, respectively, for the O'Brien test. Regarding the isolated type II SLAP lesions, the supine flexion resistance test was highly sensitive, with a sensitivity of 92% (58% for Speed's test and 75% for the O'Brien test). The sensitivity of the supine flexion resistance test for the combined SLAP and supraspinatus lesions decreased to 60% (83% for both Speed's test and the O'Brien test). For isolated partial tears of the supraspinatus, the specificity of the supine flexion resistance test was 73% (18% for both Speed's test and the O'Brien test), and for isolated complete tears of the supraspinatus, the specificity of the supine flexion resistance test was 76% (12% for Speed's test and 16% for the O'Brien test) (Table 3).

DISCUSSION

The clinical diagnosis of a SLAP lesion remains difficult because previous studies could not reproducibly prove that the sensitivity and specificity were satisfactory.¹⁻⁸ O'Brien et al.¹² described the O'Brien test as being 100% sensitive and 98.5% specific, although they included all kinds of labral lesions and did not apply the test only to SLAP lesions. Stetson and Templin¹⁶ showed a sensitivity of 67% and a speci-

TABLE 2. Pathologies Found Intraoperatively (*n* = 113)

	No. of Patients
Type I SLAP lesion	11
Type II SLAP lesion	21
Isolated type II SLAP lesion	12
Type III SLAP lesion	1
Partial tear supraspinatus	22
Isolated partial tear supraspinatus	11
Full tear supraspinatus	37
Isolated full tear supraspinatus	25
Type II SLAP and supraspinatus lesions	6
Infraspinatus lesion	6
Subscapularis lesion	12
Instability	29
AC joint arthritis	23

TABLE 3. Utility of Several Examination Maneuvers for Diagnosis of SLAP Lesion

Maneuver	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value
Study population				
SFRT	80%	69%	36%	94%
Speed's test	60%	38%	18%	81%
O'Brien test	94%	28%	55%	83%
SLAP lesion				
SFRT	92%	—	100%	—
Speed's test	58%	—	100%	—
O'Brien test	75%	—	100%	—
SLAP and supraspinatus lesions				
SFRT	60%	—	100%	—
Speed's test	83%	—	100%	—
O'Brien test	83%	—	100%	—
Full tear of supraspinatus				
SFRT	—	76%	—	100%
Speed's test	—	12%	—	100%
O'Brien test	—	16%	—	100%
Partial tear of supraspinatus				
SFRT	—	73%	—	100%
Speed's test	—	18%	—	100%
O'Brien test	—	18%	—	100%
Supraspinatus lesion (full or partial tear)				
SFRT	—	75%	—	100%
Speed's test	—	14%	—	100%
O'Brien test	—	17%	—	100%

Abbreviation: SFRT, supine flexion resistance test.

ficiency of 41% for the O'Brien test, focusing on SLAP lesions. In 2002 they reported an even lower sensitivity and specificity for the O'Brien test (54% and 31%, respectively).⁶ Morgan et al.¹³ found Speed's test and the O'Brien test as standard tests for SLAP lesions to be very useful in predicting anteriorly located SLAP lesions. They did not indicate the specificity or sensitivity, however, and they eliminated patients with rotator cuff tears from their study group. Liu et al.¹¹ described the crank test and reported a sensitivity of 91% in detecting labral tears, but they did not specify the validity for detecting a SLAP lesion. A similar sensitivity for Speed's test was reported by Bennett,¹ but again, the study included not only SLAP lesions but also biceps inflammation and biceps avulsion. Holtby and Razmjou³ found a sensitivity and specificity of 32% and 75%, respectively, for Speed's test. Guanche and Jones² compared 7 clinical tests for

lesions of the biceps–superior labrum complex with arthroscopic findings and could not find a statistical significance for 1 test alone or for several tests in conjunction. In a similar study Parentis et al.⁴ evaluated the validity of several clinical tests to detect a SLAP lesion and did not find any of the tests to be sensitive or specific. The 2 most recently published studies, by Hegedus et al.⁷ and Jones and Galluch,⁸ are based on a literature review concerning the diagnostic accuracy of individual physical examination tests including several SLAP tests. Both groups found only limited diagnostic value for SLAP-specific physical examination results. Given the lack of reliable clinical tests, predicting a SLAP lesion before surgical intervention still requires MRI or magnetic resonance arthrography, which is expensive and inconvenient.⁶ Therefore a reliable clinical test for detecting SLAP lesions would provide great benefit.

The idea to develop the new SLAP test began when several patients complained about pain in overhead positions while at the same time the only pathologic clinical finding was pain in the dorsal aspect of the shoulder in full arm elevation, which was provoked by trying to bring the arm back into a neutral position against the resistance of the examiner. When arthroscopic surgery was performed on those patients, an isolated SLAP lesion was detected in many cases. The test was modified by placing the patient in a supine position to achieve optimal muscle relaxation. A biomechanical examination showed the origin of a type II SLAP lesion in throwers not in the late-cocking position as often reported^{17,18} but instead in the acceleration and especially in the early deceleration position.^{19,20} Some tests are designed to diagnose a SLAP lesion by simulating this pathomechanism. The supine flexion resistance test simulates the peel-back mechanism, which was detected arthroscopically and described by Burkhart and Morgan.¹⁵ During the provocative maneuver, the SLAP complex is exposed to maximal stress: trying to bring the arm from hyperflexion into resisted extension leads to traction on the biceps–superior labrum complex.²¹

In this study Speed's test and the O'Brien test did not prove sufficiently reliable in detecting a type II SLAP lesion, given that they only provided a specificity of 38% and 28%, respectively, for the whole study population. For the group of supraspinatus lesions, it was even lower, at 14% and 17%, respectively. The supine flexion resistance test proved to be less sensitive than the O'Brien test (80% compared with 94% for the whole study population) but had a higher sensitivity in the group of isolated SLAP le-

sions, at 92% compared with a sensitivity of 83% for the O'Brien test and only 58% for Speed's test. The specificity of the supine flexion resistance test was higher than that of the other tests in all study groups, as was the negative predictive value. Those results show that the supine flexion resistance test, applied separately, might not be sufficiently valid to detect a SLAP lesion reliably by means of sensitivity. Yet, with a high specificity, it proves to be very useful in combination with other clinical tests to diagnose a SLAP lesion, especially by eliminating the false-positive results of other diagnostic maneuvers. Many patients with a supraspinatus tear, for instance, show positive O'Brien and Speed's tests. If the supine flexion resistance test is negative in those patients, the presence of a SLAP lesion is very unlikely. For patients who report no other complaints than pain in the overhead position and who present no pathologic clinical finding other than a positive supine flexion resistance test, the existence of a SLAP lesion is very likely.

One weakness of this study is that because of its design, it was not possible to establish a control group. Surgery had to be performed on all of the patients because it was the means to verify the existence of a SLAP lesion. To reduce potential bias, the physician performing the examination was not involved in the surgery whereas the 2 surgeons did not know the results of the clinical examination tests. It is true, however, that by talking to the patients, the examiner might have guessed which patients were most likely to have SLAP tears. The supine flexion resistance test can only be used in patients with a free range of motion of the involved shoulder because patients with partial shoulder stiffness experience pain just by trying to reach the full flexion examination position as a result of the capsular adhesions. As another limitation of the study, this might unfortunately lead to excluding patients with a SLAP lesion associated with a glenohumeral internal rotation deficit. Also, patients with a positive hourglass test according to Boileau et al.²² who did not achieve full passive elevation of the arm were excluded from the study. Patients with severe instability who were not able to reach the full flexion position therefore had to be excluded as well. Another weakness is that the study did not include diagnostic tests other than the O'Brien test and Speed's test to detect SLAP lesions, either because the diagnostic value was low according to several publications (i.e., Yergason's test,²³ crank test,¹¹ and forced abduction test²⁴) or because they were not established as standardized examination

methods in our clinic (i.e., biceps load test II,¹⁰ SLAP-prehension test,²⁵ and resisted supination external rotation test²⁶). Unfortunately, a type II SLAP lesion was found only in 21 patients. The study, however, was designed for 150 consecutive patients without preselecting those who were expected to present with a SLAP lesion. The correlation between clinical tests and intraoperative findings regarding a SLAP lesion included only type II SLAP lesions. No type IV, V, VI, or VII SLAP lesions and only 1 type III SLAP lesion were found in the study population. Type I SLAP lesions have been described as degenerative changes at the superior labrum without severe instability of the biceps–superior labrum complex. In the whole study population all type I SLAP lesions were associated with other pathologies and were not addressed surgically. Therefore they were not included in the statistical analysis.

CONCLUSIONS

Compared with the O'Brien test and Speed's test, the supine flexion resistance test proved to be more specific, with a specificity of 69% for the whole study population (28% for the O'Brien test and 38% for Speed's test) and a specificity of 75% for the group of patients with isolated supraspinatus lesions (17% for the O'Brien test and 14% for Speed's test). The supine flexion resistance test is a useful and effective test for detecting type II SLAP lesions. The high specificity allows, to a great extent, the elimination of false-positive results of other clinical tests that are more sensitive but not specific. Thus there can be differentiation between SLAP lesions and other pathologies such as additional injuries to the labrum or rotator cuff tears.

REFERENCES

1. Bennett WF. Specificity of the Speed's test: Arthroscopic technique for evaluating the biceps tendon at the level of the bicipital groove. *Arthroscopy* 1998;14:789-796.
2. Guancho CA, Jones DC. Clinical testing for tears of the glenoid labrum. *Arthroscopy* 2003;19:517-523.
3. Holtby R, Razmjou H. Accuracy of the Speed's and Yergason's tests in detecting biceps pathology and SLAP lesions: Comparison with arthroscopic findings. *Arthroscopy* 2004;20:231-236.
4. Parentis MA, Mohr KJ, ElAttrache NS. Disorders of the superior labrum: Review and treatment guidelines. *Clin Orthop Relat Res* 2002;77-87.
5. Snyder SJ, Banas MP, Karzel RP. An analysis of 140 injuries to the superior glenoid labrum. *J Shoulder Elbow Surg* 1995;4:243-248.
6. Stetson WB, Templin K. The crank test, the O'Brien test, and

- routine magnetic resonance imaging scans in the diagnosis of labral tears. *Am J Sports Med* 2002;30:806-809.
7. Hegedus EJ, Goode A, Campbell S, et al. Physical examination tests of the shoulder: A systematic review with meta-analysis of individual tests. *Br J Sports Med* in press, available online 24 August, 2007.
 8. Jones GL, Galluch DB. Clinical assessment of superior glenoid labral lesions: A systematic review. *Clin Orthop Relat Res* 2007;455:45-51.
 9. Snyder SJ, Karzel RP, Del Pizzo W, Ferkel RD, Friedman MJ. SLAP lesions of the shoulder. *Arthroscopy* 1990;6:274-279.
 10. Kim SH, Ha KI, Ahn JH, Kim SH, Choi HJ. Biceps load test II: A clinical test for SLAP lesions of the shoulder. *Arthroscopy* 2001;17:160-164.
 11. Liu SH, Henry MH, Nuccio SL. A prospective evaluation of a new physical examination in predicting glenoid labral tears. *Am J Sports Med* 1996;24:721-725.
 12. O'Brien SJ, Pagnani MJ, Fealy S, McGlynn SR, Wilson JB. The active compression test: A new and effective test for diagnosing labral tears and acromioclavicular joint abnormality. *Am J Sports Med* 1998;26:610-613.
 13. Morgan CD, Burkhart SS, Palmeri M, Gillespie M. Type II SLAP lesions: Three subtypes and their relationships to superior instability and rotator cuff tears. *Arthroscopy* 1998;14:553-565.
 14. Gilcreest EL. The common syndrome of rupture, dislocation and elongation of the long head of the biceps brachii. An analysis of 100 cases. *Surg Gynecol Obstet* 1934;58:322-339.
 15. Burkhart SS, Morgan CD. The peel-back mechanism: Its role in producing and extending type II SLAP lesions and its effect on SLAP repair rehabilitation. *Arthroscopy* 1998;14:637-640.
 16. Stetson WB, Templin KT. Sensitivity of the crank test vs. the O'Brien test in detecting SLAP lesions of the shoulder. Presented at the American Shoulder and Elbow Surgeon's Specialty Day; Anaheim, CA; February 1999.
 17. Jobe FW, Giangarra CE, Kvitne RS, Glousman RE. Anterior capsulolabral reconstruction of the shoulder in athletes in overhand sports. *Am J Sports Med* 1991;19:428-434.
 18. Kuhn JE, Lindholm SR, Huston LJ. Failure of the biceps superior labral complex: A cadaveric biomechanical investigation comparing the late cocking and early deceleration positions of throwing. *Arthroscopy* 2003;19:373-379.
 19. Fleisig GS, Andrews JR, Dillman CJ, Escamilla RF. Kinetics of baseball pitching with implications about injury mechanisms. *Am J Sports Med* 1995;23:233-239.
 20. Vaitl T, Burkart A, Steinhauser E, Hohmann E, Imhoff A. Biomechanical investigations for the development of a SLAP-II-lesion. *Orthopade* 2003;32:608-615 (in German).
 21. Andrews JR, Carson WG Jr, McLeod WD. Glenoid labrum tears related to the long head of the biceps. *Am J Sports Med* 1985;13:337-341.
 22. Boileau P, Ahrens PM, Hatzidakis AM. Entrapment of the long head of the biceps tendon: The hourglass biceps—A cause of pain and locking of the shoulder. *J Shoulder Elbow Surg* 2004;13:249-257.
 23. Hawkins RJ, Bokor DJ. Clinical evaluation of shoulder problems. In: Rockwood CA, Matsen FA, eds. *The shoulder*. Philadelphia: WB Saunders, 1990;149-177.
 24. Nakagawa S, Yoneda M, Hayashida K, Obata M, Fukushima S, Miyazaki Y. Forced shoulder abduction and elbow flexion test: A new simple clinical test to detect superior labral injury in the throwing shoulder. *Arthroscopy* 2005;21:1290-1295.
 25. Berg EE, Ciullo JV. A clinical test for superior glenoid labral or 'SLAP' lesions. *Clin J Sport Med* 1998;8:121-123.
 26. Myers TH, Zemanovic JR, Andrews JR. The resisted supination external rotation test: A new test for the diagnosis of superior labral anterior posterior lesions. *Am J Sports Med* 2005;33:1315-1320.