The Resisted Supination External Rotation Test

A New Test for the Diagnosis of Superior Labral Anterior Posterior Lesions

Thomas H. Myers,† MD, Jason R. Zemanovic,‡ MD, and James R. Andrews,‡ MD
From the †Atlanta Sports Medicine and Orthopaedic Center, Atlanta, Georgia, and the ‡American Sports Medicine Institute, Birmingham, Alabama

Purpose: To evaluate a new clinical test, the resisted supination external rotation test, for the diagnosis of superior labral anterior posterior lesions of the shoulder.

Study Design: Cohort study (diagnosis); Level of evidence, 2.

Methods: Forty athletes (average age, 23.9 years) with activity-related shoulder pain were enrolled in the study. The patients underwent 3 different tests designed specifically to detect superior labral anterior posterior lesions (the resisted supination external rotation test, the crank test, and the active compression test); the tests were performed in a random order on the affected shoulder. The results of the tests were compared with arthroscopic findings.

Results: Out of 40 athletes, 29 (72.5%) had superior labral anterior posterior tears. The resisted supination external rotation test had the highest sensitivity (82.8%), specificity (81.8%), positive predictive value (92.3%), negative predictive value (64.3%), and diagnostic accuracy (82.5%) of all tests performed.

Conclusion: By re-creating the peel-back mechanism, the resisted supination external rotation test is more accurate than 2 other commonly used physical examination tests designed to diagnose superior labral anterior posterior tears in overhead-throwing athletes. By using this test in the context of a thorough clinical history and physical examination, lesions of the superior labrum can be more reliably diagnosed.

Keywords: superior labral anterior posterior (SLAP) lesion; superior labral anterior posterior (SLAP) test; physical examination; peel-back mechanism; superior labrum; overhead-throwing athletes

Injury to the biceps–superior labral complex in athletes was first described by Andrews et al2 in 1985. In their review of 73 overhead-throwing athletes, most injuries to the biceps anchor were seen as detachments of the anterosuperior labrum from the glenoid. In a later study, Snyder et al24 categorized these superior labral anterior posterior (SLAP) lesions into 4 discrete types. A type I SLAP lesion involved degenerative fraying of the superior labrum, whereas types II to IV described abnormal detachment of the biceps anchor, bucket-handle tear of the superior labrum, and vertical superior labral tear extending into the biceps tendon, respectively.24

Since the first description of SLAP tears, numerous clinical examinations and provocative maneuvers have been described to aid in the preoperative diagnosis of superior labral injuries.3,10-12,16,19,26 Despite initial reports of high diagnostic reliability, follow-up studies on some of these maneuvers have failed to reproduce the diagnostic sensitivity and specificity of the original reports.8,14,25 The lack of a reliable test for SLAP tears therefore makes preoperative diagnosis difficult.

A new diagnostic test for lesions of the superior labrum was developed at the institution of the senior author (J.R.A.). Named the resisted supination external rotation (supination/ER) test, this examination attempts to re-create the "peel-back" mechanism of the superior labrum, thought to be a cause of unstable SLAP tears.7 We hypothesized that this test would have higher sensitivity, specificity, and diagnostic accuracy for the evaluation of unstable superior labral injuries than currently accepted diagnostic examinations.

*Address correspondence to Thomas H. Myers, MD, Atlanta Sports Medicine and Orthopaedic Center, 3200 Downwood Circle, Suite 500, Atlanta, GA 30327 (email: tmyers12@bellsouth.net).

No potential conflict of interest declared.

The American Journal of Sports Medicine, Vol. 33, No. 9
DOI: 10.1177/0363546504273250
© 2005 American Orthopaedic Society for Sports Medicine
MATERIALS AND METHODS

A prospective study of 40 athletes with activity-related shoulder pain was performed at our institutions. The study group was composed of 39 men and 1 woman, with an average age of 23.9 years (range, 17-50 years). Patients older than 50 years, those with shoulder pain that was not the result of athletic injury, and those who did not undergo arthroscopic evaluation were excluded from the study. The majority of the patients were baseball players (34), with the remainder participating in football (4), volleyball (1), and skiing (1). There were 4 recreational athletes, 7 high school athletes, 16 collegiate athletes, and 13 professionals. The dominant arm was affected in 38 patients (95%). All patients had failed a course of nonoperative treatment, including physical therapy, cessation of aggravating activities, and anti-inflammatory medications, before surgical intervention.

The patients enrolled in the study were observed by the senior author and 1 of 12 orthopaedic sports medicine fellows. A thorough clinical history and physical examination were performed by the orthopaedic fellow. When clinical history was consistent with activity-related shoulder pain in an athlete, the orthopaedic sports medicine fellow performed 3 provocative tests specifically for the detection of SLAP lesions: the active compression test,\textsuperscript{19} the crank test,\textsuperscript{12} and the supination/ER test, in addition to other physical examination maneuvers appropriate for overhead-throwing athletes. As part of the randomization, each fellow used a worksheet that listed 8 SLAP-specific tests in random order. The first 6 tests were performed on each patient at the end of the physical examination process (mostly because of time constraints and the fact that the athletes were sore after 6 maneuvers). The results were recorded separately. This procedure ensured that one specific test did not irritate the shoulder and bias the results for the subsequent tests. We chose as our study subjects 40 patients who had the supination/ER test performed and included as comparison those patients who also had the crank test and active compression test performed. Our study is therefore not a cohort of consecutive patients evaluated for sport-related shoulder pain, as some of the patients were randomly not tested with the supination/ER test and thus not included. This point is a source of bias, as the supination/ER test could have biased the results of the crank and active compression tests, despite being done in random order. The results of these tests were correlated to findings from the arthroscopic examination by the senior author within 1 week of the clinical examination. The senior author was blinded to the results of the clinical examinations until after the arthroscopy. Type I SLAP lesions, consisting of degenerative fraying of the superior labrum, were considered a normal variant; types II to IV were considered abnormal. The clinical reliability of each test was then established by the calculation of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy of detecting SLAP lesions.

RESULTS

Of the 40 athletes involved in this study, 29 (72.5%) were noted to have SLAP lesions at arthroscopy. There were 26 type II, 1 type III, and 2 type IV lesions. Statistical analysis of the supination/ER test, the active compression test, and the crank test revealed that the supination/ER test had the highest sensitivity (82.8%), specificity (81.8%), PPV (92.3%), NPV (64.3%), and diagnostic accuracy (82.5%) (Table 1). Additional intra-articular lesions were noted in 79% of the shoulders with SLAP tears. The most commonly occur-
ring associated injury was a partial rotator cuff tear, seen in 18 patients (62%). Other injuries included glenohumeral chondromalacia (n = 5), posterior labral injury (n = 4), Bankart lesion (n = 2), Hill-Sachs lesion (n = 1), and posterior thrower’s exostosis (n = 1). In 11 patients who did not have SLAP tears, there were 3 patients with Bankart lesions (1 patient also had a partial rotator cuff tear), 2 with posterior labral fraying and partial rotator cuff tears, 1 with a type I SLAP lesion and partial rotator cuff tear, 2 with isolated partial rotator cuff tears, 1 with a full-thickness rotator cuff tear, and 2 shoulders with no obvious lesions.

**DISCUSSION**

Since their first description by Andrews et al.\(^2\) and later classification by Snyder et al.\(^24\) injuries to the biceps–superior labrum complex have become increasingly recognized as a significant source of shoulder pain in athletes. However, the exact mechanism responsible for the creation of SLAP lesions remains a source of controversy. Andrews et al.\(^3\) initially hypothesized that the superior labrum became detached from the glenoid during the deceleration phase of throwing. The eccentric contraction of the biceps during the follow-through motion of a pitch overloaded the biceps anchor and avulsed its intra-articular attachment. It has alternatively been proposed that a direct blow to the shoulder or a fall on an outstretched arm may cause compressive loading of the affected glenohumeral joint, resulting in a superior subluxation of the humeral head. Detachment of the labrum may occur as it is pinched between the glenoid and humerus.\(^24\) Excessive traction on the biceps (such as when lifting a heavy object) has also been implicated as a possible cause of SLAP lesions.\(^5,13,24\)

In an evaluation of overhead-throwing athletes, Burkhart and Morgan\(^7\) described the peel-back mechanism of SLAP-tear generation. By placing the arm in an abducted, externally rotated position (throwing position), the biceps tendon transferred a torsional force to the superior labrum. At arthroscopy, the authors noted that this torsional force caused a rotation of the posterior superior labrum medially off of the superior glenoid, producing a SLAP lesion. Previously described physical examination tests designed to diagnose SLAP lesions do not reproduce this peel-back mechanism and do not appear to place maximum load on the biceps anchor. Thus, despite the development of numerous provocative maneuvers, the preoperative diagnosis of SLAP lesions has proven to be difficult.\(^5,14,15,17,25\)

Initial reports of previously described diagnostic tests for detection of labral injuries have been almost uniformly favorable. Kibler\(^10\) described his anterior slide test as having a sensitivity of 78.4% and a specificity of 91.5% in the detection of superior labral injuries. Mimori et al.\(^16\) noted

---

**TABLE 1**

<table>
<thead>
<tr>
<th>Test</th>
<th>Patients Tested, n</th>
<th>Sensitivity, %</th>
<th>Specificity, %</th>
<th>PPV, %</th>
<th>NPV, %</th>
<th>Diagnostic Accuracy, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resisted supination external rotation test</td>
<td>40</td>
<td>82.8</td>
<td>81.8</td>
<td>92.3</td>
<td>64.3</td>
<td>82.5</td>
</tr>
<tr>
<td>Active compression test</td>
<td>37</td>
<td>77.8</td>
<td>11.1</td>
<td>70.0</td>
<td>14.3</td>
<td>59.5</td>
</tr>
<tr>
<td>Crank test</td>
<td>36</td>
<td>34.6</td>
<td>70.0</td>
<td>75.0</td>
<td>29.2</td>
<td>44.4</td>
</tr>
</tbody>
</table>

\(^a\)PPV, positive predictive value; NPV, negative predictive value.
that their pain provocation test had a sensitivity of 100%, a specificity of 90%, and a diagnostic accuracy of 97%. The active compression test was noted to detect labral abnormalities with a sensitivity of 100%, a specificity of 98.5%, a PPV of 94.6%, and an NPV of 100%. The initial report on the crank test yielded impressive results: sensitivity of 91%, specificity of 93%, PPV of 94%, and NPV of 90%. The evaluation by Kim and coworkers of the biceps load test II on 127 patients with shoulder pain revealed a sensitivity of 89.7%, a specificity of 96.6%, a PPV of 92.1%, and an NPV of 95.5% for the detection of type II SLAP tears.11

Follow-up studies on the accuracy of SLAP-specific diagnostic tests, however, have not reproduced the same results as these initial reports. In their evaluation of 59 patients with activity-related shoulder pain, Guanche and Jones8 noted that the active compression test (sensitivity = 54%, specificity = 47%) and the crank test (sensitivity = 39%, specificity = 67%) were unreliable for the detection of SLAP tears. Similar results were reported by Stetson and Templin,25 who noted that the active compression test (sensitivity = 54%, specificity = 31%) and the crank test (sensitivity = 46%, specificity = 56%) were poor indicators of unstable SLAP lesions. McFarland et al14 also noted low diagnostic reliability for the active compression test (sensitivity = 47%, specificity = 55%) and the compression rotation test (sensitivity = 24%, specificity = 76%).

To increase the diagnostic accuracy of a test to detect injuries of the superior labrum, we believe that the affected shoulder should be placed in a position that maximally loads the biceps anchor while reproducing the torsional loads on the superior labrum. Our goals in the development of the resisted supination external rotation test were 2-fold: (1) to eccentrically resist the muscles in the arm through a simulated throwing motion, and (2) to place maximum load on the long head of the biceps in a position that reproduces the suspected mechanism of injury in throwers.

The effectiveness of the resisted supination external rotation test lies in its ability to re-create the mechanism of injury to the superior labrum in the overhead-throwing athlete (the peel-back mechanism). As described previously, abduction and external rotation of the humeral head displace the unstable biceps–superior labral complex away from the glenoid. We believe that patients experience pain from this unstable biceps-labral complex when there is traction on the long head of the biceps in a position where the orientation of the force vector is oblique to fiber orientation of the biceps tendon and the posterior-superior labrum. Placing the shoulder at 90° of abduction and rotating the shoulder into maximal external rotation with the scapula stabilized on the examination table should cause the superior labral complex to displace medially off of the superior glenoid, reproducing the patient’s symptoms. In addition, maximal contraction of the long head of the biceps with resisted supination during this maneuver should increase the posteriorly directed force vector and re-create the mechanism of injury.

The biceps load test II of Kim et al11 resists elbow flexion at 90° and full forearm supination. We believe that the long head of the biceps should be resisted against active supination of the forearm in the neutral or semiprone position. In a study of elbow biomechanics, Basmajian and Latif4 described the function of the biceps, in detail, using EMG analysis. They concluded that maximum activity of the biceps occurred with as little as 2 lb of supination resistance on the semiprone forearm. They also showed no activity of the long head of the biceps in more than half of the subjects with the elbow at 90° of flexion and the forearm in the prone position. Further work by Buchanan et al5 demonstrated that the biceps is most active for supination loads and, for a broad range of conditions, the brachialis and brachioradialis were the chief elbow flexors. Thus, we chose resisted supination, rather than resisted elbow flexion, to place maximal load on the biceps anchor.

With regard to the optimal degree of elbow flexion, a number of studies confirm a position of maximum force and torque about the elbow for the 3 chief elbow flexors.1,18,21,22 For the biceps, the peak forces were highly variable but occurred between 20% and 44% of the total range of motion (ROM) of the elbow. Peak torques were less variable and occurred between 46% and 60% of the elbow ROM. We therefore chose to resist the elbow at 45% of the total ROM to maximize load on the tendon of the long head of the biceps. Given an average elbow ROM of 140° to 145°, resisted supination with the elbow at 60° to 70° of flexion should generate a maximum contraction.

When performing the resisted supination external rotation test, care should be taken to differentiate pain from apprehension; patients with anterior instability may experience apprehension with this maneuver. The examiner should ask the patient to describe the sensation at maximal shoulder external rotation (ie, late cocking). The patient should describe anterior or deep pain in the shoulder or describe the same symptoms that occur during throwing. If the patient has apprehension sensations or posterior shoulder pain, a diagnosis of anterior instability or internal impingement may be entertained. The relocation test of Jobe may be helpful in making the correct diagnosis.

One reason for the difficulty in preoperative diagnosis of SLAP lesions is the fact that they rarely occur in isolation. In this study, 73% of SLAP tears were observed in combination with other shoulder lesions. The most commonly occurring concomitant injury was a partial rotator cuff tear, present in 60% of our cases. McFarland et al14 noted that 77% of patients had associated shoulder injuries, with 64% having an injury to the supraspinatus tendon. Snyder et al23 and Maffet et al11 also noted a preponderance of rotator cuff injuries, with occurrences of 40% and 48% in their respective studies of SLAP lesions. Other disorders described in association with SLAP tears include Bankart injury, subacromial impingement, acromioclavicular arthrosis, Hill-Sachs lesion, and glenohumeral chondromalacia/osteoarthritis.4 Overlapping symptoms from these commonly occurring simultaneous injuries have made the development of a SLAP-specific diagnostic examination exceedingly difficult, and this overlap may have been a confounding factor in our study.

In the current study, the resisted supination external rotation test was superior to 2 other maneuvers tested for...
the detection of unstable SLAP lesions. With a sensitivity of 82.8%, a specificity of 81.8%, and a diagnostic accuracy of 82.5%, the resisted supination external rotation test was more accurate than both the active compression test and the crank test. We believe that the re-creation of the peel-back mechanism is central to this test’s ability to detect SLAP lesions reliably.

Although we believe the resisted supination external rotation test is highly useful in the diagnosis of SLAP lesions, there are some flaws with this study that may bias the results. First, our patient population consisted almost exclusively of high-level overhead-throwing athletes, thus accounting for our high incidence of SLAP tears (72.5%) observed at arthroscopy. The high incidence of positive findings at arthroscopy can bias the results, particularly when calculating NPV and specificity. In this population, the peel-back motion is thought to account for most of the observed injuries. Furthermore, this motion is primarily thought to cause type II SLAP lesions and possibly primarily posterior type II SLAP lesions. We did not differentiate whether the test results were positive or negative based on the location of the labral injury or type of SLAP lesion. Also, whether this test is as accurate in detecting unstable superior labral injuries caused by other mechanisms (eg, direct falls onto the shoulder, sudden traction on the biceps) in a more generalized population (in which SLAP tears are less prevalent than in this study) should be the focus of further studies with larger numbers of patients.

It has been argued that, in the hands of an experienced orthopaedic surgeon, nearly any test may have high sensitivity and specificity for SLAP-tear detection. In this study, therefore, we used only the results of examinations performed by orthopaedic fellows, correlated with arthroscopic findings confirmed by the senior author. We believe that the high sensitivity and specificity, despite the use of multiple examiners, actually strengthens the argument that this test is simple enough to be used by any orthopaedic surgeon. We did not track intraobserver variability in this study, but doing so may be useful in the future to prove reproducibility.

Lastly, as mentioned earlier, there are multiple examination maneuvers currently used to diagnose SLAP lesions, yet only 2 of these tests were compared to the resisted supination external rotation test in this study. The tests chosen for comparison (the crank test and active compression test) have both been subjects of follow-up studies that have revealed difficulties in replicating the high diagnostic accuracy of the initial reports. Certainly, a comparison of all SLAP tests currently available would be beneficial as a topic of further study. This is a preliminary report from an ongoing study that attempts to determine the accuracy of multiple other SLAP tests (including the biceps active test, the biceps load test II,11 the new pain provocation test,18 and the clunk test3) at our institutions.

CONCLUSION

The preoperative detection of SLAP lesions has proven to be a diagnostic challenge. By re-creating the peel-back mechanism, the resisted supination external rotation test offers higher sensitivity, specificity, PPV, NPV, and diagnostic accuracy than 2 other commonly utilized tests for the diagnosis of SLAP tears. By implementing this test in the context of a thorough clinical history and physical examination, clinicians may be able to more accurately diagnose lesions of the superior labrum.