Internal rotation resistance strength test: A new diagnostic test to differentiate intra-articular pathology from outlet (Neer) impingement syndrome in the shoulder

Kenneth R. Zaslav, MD, Richmond, Va

This prospective study introduces a new sign to differentiate between outlet impingement and non-outlet (intra-articular) causes of shoulder pain in patients with positive impingement sign: the internal rotation resistance strength test (IRRST). It was hypothesized that positive test results are predictive of non-outlet impingement, whereas negative test results confirm outlet impingement. A prospective comparison between IRRST and arthroscopic findings of 115 consecutive patients showed the test to be highly accurate in differentiating between these two diagnoses (positive predictive value 88%, negative predictive value 96%, specificity 96%, and accuracy 94.5%). The IRRST, in conjunction with impingement and apprehension signs, adds to our armamentarium of tests that distinguish between subacromial outlet impingement and intra-articular forms of pathology. (J Shoulder Elbow Surg 2001;10:23-7.)

INTRODUCTION

Differentiating between outlet impingement, as originally described by Neer, and intra-articular causes of pain in the shoulder remains a challenge to physicians treating patients with overhead shoulder pain. When surgery is indicated, this differential diagnosis is essential in choosing the correct procedure to produce a lasting return to high-level activities. Since 1972, impingement has been categorized into grades I through III (Neer) with subacromial decompression as the mainstay of surgical treatment. With the advent of arthroscopy and the treatment of younger athletes, early reports suggested that patients younger than 50 years may not have true impingement but suffer from secondary impingement caused by underlying instability. Outlet decompression had been indicated only rarely in the younger patient. In this decade, we have come to realize that the pathology is more complex. Both primary and secondary impingement can be present in younger patients, and other forms of non-outlet or internal impingement also exist. The differential diagnosis of pain in the overhead athlete and worker has become more diverse. This differential includes outlet or subacromial impingement as well as several causes of pain resulting from intra-articular pathologic conditions, such as internal posterosuperior glenoid impingement, secondary impingement as a result of underlying instability and/or the loss of the normal obligate posterior translation with maximum external rotation, and superior labrum anteroposterior (SLAP) or chondral lesions. Our hypothesis is that this new test will help to diagnose intra-articular causes of painful impingement and differentiate these from pure outlet impingement.

Although diagnostic arthroscopic findings associated with both outlet impingement as well as instability and internal impingement have been well documented in the literature, preoperative differential diagnosis is essential to enable appropriate counseling of the patient about postoperative restrictions and prognosis. This preoperative differential is especially important for surgeons who routinely perform open acromioplasty or cuff repair and who may not adequately visualize the glenohumeral components without the presence of a large rotator cuff tear.

A sign of apparent weakness of internal versus external rotation of the arm, when held in 90° of abduction and 80° to 85° of external rotation, was developed and named the internal rotation resistance strength test (IRRST). It was thought that the test would be a helpful way to distinguish patients with a positive impingement sign in whom symptoms were due to subacromial pathology from those who had an intra-articular pathologic condition or microinstability with secondary impingement.
The purpose of this prospective study was to examine the actual predictive values and the accuracy of this test in a population of consecutive patients with a positive impingement sign who had failed conservative treatment and were now undergoing arthroscopy of the shoulder. This article reports the accuracy of the test but does not address the success of the surgical intervention.

MATERIALS AND METHODS

One hundred fifteen consecutive patients (67 male, 48 female) who underwent arthroscopic shoulder surgery by a single surgeon were evaluated in the study. The criterion for inclusion was the presence of a positive Neer overhead impingement sign. Five patients in the consecutive cohort were removed from the study group before analysis: 4 because they had apprehension and relocation signs only with a negative impingement sign, and 1 because of a primary diagnosis of avascular necrosis made by radiograph and confirmed by magnetic resonance imaging.

Before arthroscopy, a standard shoulder physical examination form was completed by an assistant, either by direct physical examination at the time of surgery or by review of the surgeon’s patient preoperative evaluation.

Patients had failed an average trial of 16 weeks of conservative treatment (range 2 to 25 months). This conservative program consisted of a single injection of cortisone followed by formal physical therapy, which included progressive resistance exercises for the rotator cuff and the scapular stabilizers as well as proprioceptive neuromuscular facilitation and sport-specific exercises when appropriate. Oral anti-inflammatory medications were used for pain relief.

The presence or absence of the index test was then compared with the intra-operative findings. Findings that were considered evidence of outlet impingement included a thickened and inflamed subacromial bursa, erosions on the coracoacromial ligament and undersurface of the acromion, and bursal side partial- or full-thickness tearing of the rotator cuff. Evidence of non-outlet impingement included anterior glenoid erosions or labral tears, middle glenohumeral ligament tearing, undersurface rotator cuff partial tears, posterosuperior labral lesions, or SLAP lesions. In addition, the excursion of the humeral head on abduction/external rotation testing or inferior sulcus testing in the beach chair position was also noted and classified as grade I, II, or III, according to Warren’s scale. The presence of grade II or III subluxation in a shoulder with a pristine subacromial space was considered positive for secondary impingement, even if no other intra-articular pathologic condition was found. Positive predictive value (PPV), negative predictive value (NPV), sensitivity, specificity, and accuracy were evaluated for statistical significance at the end of the study.

The IRRST is performed in the standing position with the examiner positioned behind the patient. The arm is positioned in 90° of abduction in the coronal plane and approximately 80° of external rotation. A manual isometric muscle test is performed for external rotation and then compared with one for internal rotation in the same position (Figure 1). If a patient with a positive impingement sign has good strength in external rotation in this position and apparent weakness in internal rotation, the IRRST result is considered positive. Because this is a test of relative weakness in a pathologic shoulder, strength is not compared with the contralateral normal arm.

It was hypothesized that a positive IRRST in a patient with a positive impingement sign would be predictive of internal (non-outlet) impingement, whereas a negative test (more weakness in external rotation) would suggest classic outlet impingement.

RESULTS

One hundred ten patients (65 male, 45 female) met the criteria for study. Ages ranged from 17 to 76 years (mean 44 years), and the average duration of symptoms was 10.9 months (range 2 months to 4 years). The patients were categorized into 2 clinical groups for statistical analysis. Group 1 consisted of all patients who had outlet impingement with or without concomitant acromioclavicular joint pathology. No internal or glenohumeral lesions were noted. Group 2 consisted of patients who had significant intra-articular findings associated with non-outlet impingement as defined previously (Table I).
Group 1 comprised 84 patients (48 male, 36 female). The age range in this group was 18 to 76 years (mean 47 years). Outlet impingement was noted in patients of various ages; however, far more were 50 years or older. Specifically, 52 were 50 years or older, and 32 were younger than 50 years. Of the group 1 patients (N = 84), 81 had a negative IRRST result. Three patients in this group exhibited a positive IRRST or a false positive result. Specificity, defined as the percentage of patients with arthroscopic findings of outlet impingement only who exhibited a negative IRRST result, was 96% (81/84).

Group 2 comprised 26 patients (17 male, 9 female) with evidence of internal impingement, as defined above. The ages of these patients ranged from 16 to 59 years (mean 33 years). As expected, the mean age of group 2 was lower than that of group 1. In fact, only 2 patients in group 2 were 50 years or older. Both patients (aged 57 and 59 years) had a positive test result because of type II or III SLAP lesions, along with concomitant outlet impingement signs in the subacromial space. Both underwent arthroscopic treatment for these lesions.

Of group 2 patients (N = 26), 23 had a positive IRRST result, and only 3 exhibited a false-negative result. Sensitivity, defined as the percentage of patients with diagnostic findings of internal impingement and a positive IRRST, was 88% (23/26).

Two subjects were of particular interest in relation to the validity of this test because they had both had previous open rotator cuff repairs for documented supraspinatus tears by other surgeons. Both had effective repairs with good return of external rotation and supraspinatus strength testing but had persistent impingement pain and exacerbation with overhead activity. They had positive IRRST results and on arthroscopy were shown to have internal lesions. One patient had a meniscoid type II SLAP lesion; symptoms resolved with excision. The other patient had a type IV SLAP lesion and underwent arthroscopic superior labrum/biceps repair, again with a successful result. The supraspinatus repairs were intact in both subjects, and effective acromioplasties were noted on radiography and on arthroscopy.

Positive predictive value, defined as the percentage of patients with a positive IRRST result who actually had internal impingement as the cause of pain, was 88% (23/26). Negative predictive value, defined as the percentage of patients with a negative test who had outlet impingement only, was 96% (81/84). Overall accuracy, defined as the percentage of all patients accurately sorted into group 1 or 2 by the test prediction alone, was 94.5% (104/110). Of the patients younger than 50 years (the group at risk for internal impingement; N = 76), 52 had a diagnosis of outlet impingement, and 24 exhibited non-outlet impingement. In this group alone, the accuracy still remains high at 92%. In the cohort of patients 50 years and older (N = 34), only 2 patients showed evidence of internal impingement, which was as rare as might be expected; both of these were SLAP lesions (Table II).

To test for reliability of assumptions related to cohort size, a kappa correlation coefficient was calculated. This statistical measure is defined as a measure of agreement corrected for chance. The kappa correlation coefficient for this study population was 0.85, indicating excellent agreement with little chance effect.

**DISCUSSION**

Many reports have discussed the difficulty in differentiating between primary and secondary impingement through physical examination of the shoulder.**1,2,4,5** Magnetic resonance imaging or ultrasonography helps with rotator cuff pathology, but these methods have been inconsistent and often inaccurate in the diagnosis of SLAP lesions and conditions related to capsular laxity or subtle internal impingement.**10,12**

The shoulder is a complex joint because of inherent architectural instability plus the complex antagonist/agonist muscle contraction needed to maintain dynamic stability through the arc of motion. This makes subtle shoulder pathology often difficult to assess accurately through physical examination alone.

The impingement and sulcus signs described by Neer are still two of the most reproducible and accurate signs in physical shoulder diagnosis.**8,13** However, in the younger patient (younger than 50 years), we are often confronted by a situation where a painful arc is noted on active use, and the impingement sign is positive, but true outlet impingement may not be the diagnosis. Other patients may have both a positive impingement sign as well as pain in the apprehension position.

Jobe’s relocation sign for patients with pain in the apprehension position has been a helpful adjunct to

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<td>IRRST result</td>
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IRRST, Internal rotation resistance strength test.

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<th>Table II Statistical results</th>
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<td>Positive predictive value</td>
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Acc ≥50, Accuracy in patients 50 years and older.
our armamentarium in discerning the presence of secondary impingement or subluxation. However, Speer et al. indicate that the presence of pain alone in this testing position is not as accurate or specific in discerning the presence of underlying instability as originally reported. Henry et al. indicated lower accuracy for this test as well. Other authors have also designed and presented results from tests to determine the presence of SLAP lesions, but these reports do not address other forms of intra-articular or internal impingement.

At our center, we find that the use of the complete group of physical signs, when evaluated together, most often lead to the correct etiologic diagnosis. No single sign gives an accurate and reproducible diagnosis by itself, except the presence of a sulcus sign in determining unidirectional versus multidirectional instability. In the older patient with clear impingement and rotator cuff signs, diagnosis may be simple. In the traumatic dislocation patient with apprehension, positive relocation sign, and no impingement, the diagnosis is clear as well. This sign will be most helpful in the more subtle forms of internal impingement or secondary impingement related to instability in the younger patient.

The following criteria may be helpful in deciding whether a physical sign is worth performing or reporting:

1. It is easy to perform in a reproducible manner.
2. No special equipment is needed.
3. Prospective or retrospective study indicates high PPV, NPV, and accuracy.
4. The sign reliably divides the appropriate population of patients into useful categories that have some clinical significance (i.e., the use of the test has a demonstrable effect on clinical decision making).

The IRRST meets these criteria. In addition, its sensitivity, specificity, accuracy, and predictive values are equal or better than those of other reported tests.

Earlier reports have indicated that patients with rotator cuff impingement have the most weakness in external rotation when tested in an abducted arm position. Nissen et al. presented a group of patients with impingement who underwent isokinetic testing in the abducted position. In this cohort of patients, they found more resistance weakness in the internal rotators of the shoulder when tested in abduction. If the population in Nissen’s study is compared with those in previous studies, one reason for this contradiction becomes clear: in previous cohorts, the patients, on average, were 50 years or older and had experienced symptoms for more than 8 months. This would be a standard population presenting with Neer outlet impingement. The population in Nissen’s study had an average age of 30 years and symptoms of pain in impingement positions for only 3 to 6 months. This group may have exhibited more weakness in internal rotation because there were more patients with secondary or internal impingement in this younger group, which would empirically be expected in an unselected group of younger patients presenting with overuse symptoms. Our study therefore supports the findings of all these studies: our population 50 years and older commonly had more weakness in external rotation (94%), whereas the population younger than 50 years exhibited more weakness in internal rotation (positive IRRST result) 66% of the time.

In this study, we included patients of all age groups to validate the sign. Ultimately, it will be most helpful when combined with the Neer impingement sign and sulcus and/or relocation signs for the correct diagnosis of the cause of shoulder pain in the younger athlete or worker performing overhead activities. In cases of anterior instability alone, the test result is not always positive: several patients in this cohort had a positive IRRST test result despite negative apprehension caused by subtle intra-articular lesions, whereas others had negative tests with positive apprehension when an impingement sign was not also present.

Biomechanically, a positive test result may be an “apparent”—not “true”—weakness in internal rotation. As the abducted externally rotated arm is resisted in its attempt to internally rotate against force, a vector is created, pushing the humeral head anteriorly toward the glenoid rim and labrum. This force vector places tension along the biceps labral complex and along the capsuleolabral border so that the pain from both subtle subluxation and biceps and SLAP lesions will be magnified in this position, causing the appearance of weakness. Pain will also be exacerbated in patients with true internal impingement because this forward motion reduces the obligate posterior translation that normally occurs with external rotation. This would cause rotator cuff contact between the superior glenoid and humeral head, resulting in pain on resisted internal rotation. An adequate dynamic biomechanical model to support this theory has yet to be developed.

The high NPV of this test (96%) may be its most important feature. For a patient with a positive impingement sign and a negative, IRRST, subacromial decompression alone should be effective in eliminating the impingement. In the same patient, a positive test would suggest that an arthroscopic examination of the glenohumeral joint is necessary to avoid missing clinically significant pathology. Clearly, a thorough evaluation in the younger patient with a positive IRRST result should be considered at all times.

In conclusion, the IRRST adds to our armamentarium of physical examination signs in the younger worker or athlete with a painful shoulder. This test helps the treating physician accurately separate the population of patients with a positive impingement sign into two groups: those in whom the pathology is related to outlet impingement and those in whom the pain is related to either intra-articular pathology or secondary impingement caused by underlying instability.
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REFERENCES