Internal Impingement of the Shoulder: Comparison of Findings Between the Throwing and Nonthrowing Shoulders of College Baseball Players

Jeffrey L. Halbrecht, M.D., Phillip Tirman, M.D., and David Atkin, M.D.

Summary: The authors evaluated and compared the findings of gadolinium-enhanced magnetic resonance imaging (MRI) studies of throwing and nonthrowing shoulders in college baseball athletes and contrasted these findings with the clinical examination results. Ten throwing college baseball athletes were prospectively clinically examined for instability, range of motion, impingement signs, and relocation testing, then evaluated with bilateral gadolinium enhanced MRI using the nonthrowing shoulder as a control. All MRIs were performed on a 1.5-Tesla magnet and included routine adduction images and images obtained in abduction and external rotation (ABER). Studies were interpreted by a musculoskeletal radiologist and an orthopaedic surgeon specializing in shoulder surgery. In all shoulders, ABER imaging showed physical contact between the undersurface of the rotator cuff and the posterior superior glenoid. No imaging or physical examination abnormalities were identified in the nonthrowing shoulders. Three of 10 throwing shoulders had superior labral tears and adjacent paralabral cysts extending toward or into the spinoglenoid notch. Four of 10 throwing shoulders had abnormal signal change in the rotator cuff tendons. No correlation was identified between positive MRI findings and instability on physical examination. Physical contact between the rotator cuff undersurface and the subjacent labrum can be seen normally in the ABER position. Abnormalities of the rotator cuff and superior labrum are seen in asymptomatic throwing shoulders but not nonthrowing shoulders. MRI abnormalities consistent with internal impingement can be seen in asymptomatic patients. Treatment of these abnormalities in young throwing athletes should be approached with caution. Key Words: Internal impingement—Throwing shoulder—Rotator cuff tear—Superior labral tear—MRI—Baseball.

The source of shoulder pain in the throwing athlete remains controversial.1-7 Recently, the concept of internal impingement has been suggested as a likely cause of pain occurring with the arm in the maximally abducted externally rotated position of the late cocking phase of throwing. In this position, injury to the undersurface of the rotator cuff and posterior superior labrum are thought to occur as these areas make contact1,3,4,5,8 (Fig 1).

The purpose of this study was to determine the frequency with which internal impingement contact occurs in throwing shoulders compared with nonthrowing controls, and to determine the incidence of pathological changes associated with this contact as determined by magnetic resonance imaging (MRI). In addition, an attempt was made to correlate these findings to the presence of instability on physical examination and the presence or absence of rotator cuff or instability symptoms.

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MATERIALS AND METHODS

Ten male college baseball athletes volunteered to participate in the study. Selection criteria included asymptomatic college throwers. Players who were under the care of a physician for shoulder pain, or who had previously had shoulder surgery or cortisone injections were excluded. All athletes filled out a data form defining their frequency of throwing, player position, age, and history of any shoulder symptoms.

A thorough physical examination was performed by an experienced, fellowship-trained orthopaedic surgeon specializing in shoulder injuries, specifically looking for any evidence of instability, subacromial impingement, or altered range of motion or strength. Examination consisted of range of motion testing to forward elevation, external rotation in the abducted position, and internal rotation. Instability was evaluated using the apprehension sign, the relocation test, sulcus sign, and translation of the humeral head on the glenoid as tested in the lateral decubitus position. Instability grading was: 0, normal; 1, 0 to 25% subluxation; 2, 25 to 50% subluxation; 3, + >50% subluxation. Rotator cuff examination included impingement sign and rotator cuff resistance testing for the supraspinatus and external rotators. Biceps examination included Speed’s test, Yergeson’s test and direct palpation.

The patients were then examined by MRI using the following protocol: after the intravenous administration of 15 mL of gadopentate dimeglumine (Magnavist; Berlex Laboratories, Wayne, NJ) the patient was exercised on an upper extremity bicycle apparatus for 10 minutes. Exercise after intravenous administration of gadolinium chelate encourages the development of a joint effusion and allows diffusion of gadolinium chelate into the joint. This in turn allows the joint fluid to be imaged as increased signal intensity on T1-weighted MRIs in contrast to the decreased signal intensity of the labrum, capsule, and rotator cuff.

MRI of the shoulder was performed with a 1.5-Tesla imager (Signa; GE Medical Systems, Milwaukee, WI) with a phased-array shoulder coil. T1-weighted images utilizing accepted commonly performed imaging parameters were obtained. A fast spin echo T2-weighted coronal oblique sequence was also used to evaluate for the presence of bone edema and superior surface rotator cuff pathology. Fat saturation (nullifying the signal from fat to rid it of its potential confusing signal) was used on all sequences.

The patient was instructed to place the hand of the imaged extremity into the throwing, or abducted externally rotated position (ABER). Then a T1-weighted coronal localizer sequence (300/12, 5-mm section thickness, 5-mm intersection gap, 48-cm FOV, 256 × 128 matrix, and 0.5 NSA) was performed. T1 to proton density weighted oblique axial images were obtained from a localizer image along the axis of the humerus with the following parameters: 400-700/12, 3-mm section thickness, 1-mm intersection gap, 256 × 128 matrix, 12-cm FOV, chemical selection fat saturation, and two NSA. After one shoulder was imaged, the patient was then exercised again for 5 minutes and the contralateral shoulder was imaged.

MRIs were interpreted by a musculoskeletal radiologist, who was blinded to the results of the physical examination and history. The status of the rotator cuff, labrum and humeral head was recorded using accepted criteria for abnormalities. MRI findings, historical data, and clinical findings were then tabulated.

RESULTS

History

All of the athletes were actively throwing at the time of the study or were temporarily out for nonshoulder
related injuries (one athlete). Two of the athletes reported having occasional mild discomfort after throwing. One pitcher reported pain with throwing that did not interfere with his ability to pitch. There were four pitchers, two outfielders, three infielders, and one catcher included in the study. The average age was 20 years (Table 1).

MRI in Throwing Shoulders

**Rotator Cuff:** All patients showed contact between the undersurface of the rotator cuff and the posterior superior labrum when imaged in abduction and external rotation (Fig 2).

Four throwers (40%) showed abnormal signal change in the rotator cuff of the throwing shoulder. Two of these had findings most consistent with isolated internal impingement, including one with undersurface changes of the supraspinatus tendon (Fig 3), the other with infraspinatus changes most likely representing an interstitial region of delamination (Fig 4). The other two throwers had more nonspecific changes of cuff thickening and signal change consistent with tendinosis (Fig 5). None of the players had evidence of a through-and-through full-thickness rotator cuff tear. Three of the four rotator cuff abnormalities were in pitchers.

**Labrum:** Three throwers (30%) demonstrated posterior superior labral degeneration and tearing and associated paralabral cysts in their throwing shoulders (Figs 5 and 6).

**Bone:** Two subjects were found to have exaggerated posterior superior humeral head cystic changes as well as posterior glenoid subarticular cystic changes and evidence of bone remodeling (Fig 6).

MRI in Nonthrowing Shoulders

None of the nonthrowing shoulders showed any MRI changes typical of internal impingement. One athlete with generalized ligamentous laxity and bilateral asymptomatic multidirectional instability had a direct posterior labral tear and paralabral cyst in the nonthrowing shoulder (not in a location attributable to internal impingement). The rotator cuff was interpreted as normal in all nonthrowing shoulders.

**Physical Examination**

None of the patients experienced pain with relocation testing. One patient had generalized bilateral ligamentous laxity and asymptomatic multidirectional instability. This patient had no findings of internal impingement on MRI, but did show what was believed to be an unrelated direct posterior labral tear and paralabral cyst in the nonthrowing shoulder.

One patient with internal impingement findings on MRI had trace anterior laxity of the throwing shoulder.

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**Table 1. Internal Impingement of the Shoulder in Asymptomatic College Throwers: Physical Examination and MRI Results**

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Abbreviations: B, bilateral; C, catcher; ER, external rotation; HUM, humeral head cystic changes; I, infielder; IMP, impingement; IR, internal rotation; NT, nonthrowing; O, outfielder; P, pitcher; RTC, rotator cuff.

Instability rating: 0, normal; 1, <25% translation; 2, 25%-50% translation; 3, >50% translation.
Figure 2. Oblique axial image through the joint obtained in the ABER position shows contact between the undersurface of the posterior supraspinatus (arrow) and the adjacent posterosuperior labrum (arrowhead).

(1 + 1 0-1 on the contralateral side). In the remaining shoulders, there was no correlation between laxity on examination and MRI evidence of internal impingement. Two of the patients with abnormal rotator cuff signal on MRI had positive impingement signs.

The throwing shoulders measured an average of

Figure 4. Humeral head and infraspinatus changes consistent with internal impingement: oblique axial image through the joint obtained in the ABER position shows exaggerated cystic changes within the posterior superior humeral head (arrow). The patient did not have a history of anterior dislocation and, therefore, the lesion did not represent a Hill-Sachs deformity. Contrast material (small arrows) fill an area of delamination within the infraspinatus tendon.

5.0° increased external rotation in abduction, and 1.1 vertebral levels decreased internal rotation with the arm behind the back, compared with the opposite side. Seven of the athletes reported throwing several hours a day 5 to 6 days a week. The other three reported throwing between 3 and 10 hours a week.

**DISCUSSION**

Accepted sources of pain in the throwing athlete include primary subacromial impingement, impingement secondary to instability (secondary impingement), intrinsic failure of the rotator cuff, superior labral lesions due to traction overload, and primary instability.1-3,6,7,15-19

Recently, an additional mechanism has been found in an arthroscopic study by Walch et al.3 and supported in a cadaveric study by Jobe.4 These investigators suggested that impingement of the undersurface of the
rotator cuff on the posterior superior labrum and
glenoid occurred during the late cocking phase of
throwing in some athletes, and could cause shoulder
pain. At this point in the throwing motion, the arm is
abducted 90° and maximally externally rotated. Con-
tact between the undersurface of the rotator cuff and
the posterior superior glenoid and labrum occurs in
this position as shown in Fig 4. This condition has
been called posterior superior glenoid impingement or
internal impingement.

The role of instability in internal impingement
remains in question. Wahl et al.5 did not find evidence
of instability in any of the shoulders in their series
examined under anesthesia. Jobe4 has suggested that
stretching of the anterior shoulder capsule in throwers
allows increased angulation (external rotation) of the
arm and thus allows increased posterior superior
glenoid contact, but did not feel that anterior transla-
tion was a contributing factor. Liu and Boyn ton,20 on
the other hand, reported a case of internal impinge-
ment associated with 1+ anterior laxity on examina-
tion under anesthesia.

In the present study we have shown that contact
between the undersurface of the rotator cuff and
posterior superior labrum and glenoid occurred in all of
our subjects with the arm in the abducted externally
rotated position (late cocking phase of throwing). This
is true for both throwing and nonthrowing control
shoulders and suggests that internal impingement
contact is physiological in this arm position.

Figure 5. Superior labrum abnormality: oblique coronal image
shows reticulated predominately linear increased signal within the
superior labrum (thin arrow). The anterior aspect of a paralabral
cyst is shown (arrowhead). The patient has a thickened rotator cuff
with signal changes consistent with tendinosis (thick arrow).

Figure 6. Superior labrum tear and paralabral cyst in an asymptomatic thrower. (A) Axial image through the superior joint shows contrast
(thin arrow) within the posterior superior labrum (arrowhead) consistent with a tear. The tear communicated with a moderate-sized paralabral
cyst (thick arrow) residing within the spinoglenoid notch. Linear signal abnormality within the anterior superior labrum found in all imaging
planes in this patient was believed to represent the anterior extension of a SLAP lesion. (B) Oblique axial image obtained in the ABER position
shows the superior labrum tear (thin arrow) and the paralabral cyst (arrowhead). Note the contact between the posterior superior labrum and
rotator cuff undersurface (thick arrow).
MRI evidence of abnormality of the rotator cuff was shown in 40% and of the posterior superior labrum in 30% of the throwing shoulders examined in these young asymptomatic athletes. None of the nonthrowing shoulders had MRI findings of pathology resulting from internal impingement.

These findings suggest that, although contact between the rotator cuff and posterior superior labrum is normal in the ABER position, repetitive contact in throwing shoulders may lead to pathological findings on MRI. These findings do not necessarily correlate to symptoms. The ultimate clinical significance of these findings cannot be concluded from this study. Ongoing study of these athletes is planned to determine if these pathological findings have prognostic significance.

Because superior labral tears and rotator cuff abnormalities were relatively common in this study population of asymptomatic throwers, clinicians should be cautious in interpreting and treating these findings.

We found no correlation between anterior instability and MRI evidence of internal impingement in this group of young asymptomatic throwers. This would support the contention of Walsh et al. that instability is not a causative factor. Ongoing study is necessary, including evaluation of symptomatic patients, to further define the role of instability. Until further information is available, stabilization procedures in this setting should be approached with caution.

REFERENCES