

# Magnetic Resonance Imaging of the Shoulder in Asymptomatic Professional Baseball Pitchers

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## ABSTRACT

The purpose of this study was to evaluate the magnetic resonance imaging findings in both shoulders of asymptomatic professional baseball pitchers. Fourteen pitchers who were without significant prior injury underwent a blinded clinical assessment and magnetic resonance imaging of both shoulders. All images were interpreted by two experienced musculoskeletal radiologists. The appearance of the rotator cuff tendons was graded, with additional evaluation of the biceps, labrum, and osseous structures. Ten athletes were found to have stable shoulders and painless full range of motion. Clinically, four athletes had at least a 40° loss in internal rotation as compared with the nonthrowing arm. There were no significant differences in magnetic resonance imaging findings of the supraspinatus and infraspinatus tendons between the throwing and nonthrowing shoulders. The labrum was abnormal in 79% of the 28 shoulders. Enthesopathic changes of the posterior glenoid labrum were identified in the four pitchers who had loss of internal rotation. We conclude that unenhanced magnetic resonance imaging of the shoulder in asymptomatic high performance throwing athletes reveals abnormalities that may encompass a spectrum of "nonclinical" findings. These data can be useful in separating symptomatic pathologic findings from these variants. Enthesopathic changes of the posterior glenoid labrum in the throwing arm may represent an early Bennett-type lesion. The cause may be

excessive traction on the posterior capsule during the pitching motion, with subclinical injury to this area.

Magnetic resonance imaging has become a very important modality in the evaluation of the shoulder, especially in the assessment of the professional or elite athlete's shoulder. The shoulder of the throwing athlete presents a particularly difficult diagnostic challenge because the shoulder is repetitively stressed and even injured in the course of regular sporting activity. Interpretation of MR scans in this population is difficult because there are myriad diagnostic possibilities related specifically to their throwing and training activities. The stresses that accompany such activities are beyond what is normally encountered in the general population, and determining the significance of MRI findings in the injured shoulder of a throwing athlete is difficult because comparative premorbid MRI scans are not usually available.

Previous studies of asymptomatic "average" volunteers have demonstrated that many signal changes can be present even when symptoms are absent.<sup>16,17,19</sup> Miniaci et al.<sup>17</sup> studied athletically active patients by means of unenhanced MRI scans and determined that a wide array of abnormal MRI signals could be found on scans of the rotator cuff tendons of this population group. To our knowledge, there are no MRI studies of the shoulder of the professional throwing athlete. It was our hypothesis that throwing athletes subject their shoulders to significantly more activity and stress than the average active person does and therefore their MRI scans might have more abnormal signal changes than the average person's. The purpose of this study was to evaluate the spectrum of findings in shoulders of asymptomatic professional baseball pitchers, compare these findings with the clinical findings in their shoulders, and provide a baseline of what might be considered "normal" signal changes and findings in this population.

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## MATERIALS AND METHODS

### Subjects

Twenty-eight shoulders in 14 male professional baseball pitchers (average age, 20.1 years; range, 18 to 22) were evaluated in this study. Eleven of the 14 pitchers were right-handed and 3 were left-handed. Each pitcher had at least 1 year of professional experience. All athletes were completely asymptomatic with regard to their shoulders and had no history of previous shoulder injury, symptoms, or surgery. Before the MRI examination, each athlete had at least 1 day of rest from pitching. In all 14 pitchers, both shoulders were evaluated clinically and with nonenhanced MR imaging, resulting in 28 shoulders available for study: 14 dominant, throwing shoulders and 14 nondominant, nonthrowing shoulders. A complete orthopaedic assessment was performed by one surgeon (AM) before the MRI scans. Players were evaluated and underwent MR imaging at the Toronto Western Hospital in Toronto, Ontario, Canada.

### Clinical Evaluation

Each of the 14 athletes had an independent physical examination of both shoulders performed by one orthopaedic shoulder surgeon (AM). All shoulders were inspected for scars, atrophy, deformities, and rhythm of motion. Palpation was systematic about the shoulder girdle with attention for areas of localized tenderness, warmth, swelling, or deformity. Range of motion examination included documentation of forward elevation and internal and external rotation. Rotation was evaluated with the pitcher's arm at the side as well as in 90° of abduction. Strength testing was specific for rotator cuff strength, but we also evaluated strength of the entire upper extremity. Provocative tests for instability, impingement, biceps and labral lesions, acromioclavicular arthrosis, and neurovascular disorders were performed, documented, and compared with results from the opposite shoulder.

### MRI Protocol

Magnetic resonance images of both shoulders were obtained for each of the 14 professional throwing athletes during a 2-month period of regular season play. All scans were performed on Signa 1.5-T scanners (General Electric Medical Systems, Milwaukee, Wisconsin), using system software 5.5 and dual 5-inch (13-cm) surface receive-only coils (Extremity Coil, General Electric Medical Systems). The patients were placed supine with the arm at the side as described by Davis et al.<sup>2</sup> The MRI scanning protocol included the following four sequences: 1) an axial T1-weighted spin-echo sequence with repetition time (TR) of 500 msec, echo time (TE) of 10 msec, 1 excitation, 256 × 192 matrix, 16-cm field of view, 4-mm slice thickness, and 1-mm interslice gap; 2) an oblique coronal proton-density weighted image; 3) a T2-weighted fast-spin echo fat-saturated image sequence, parallel to the supraspinatus muscle with TR of 1800 msec (range, 1723 to 2800), TE of 90

msec, 3 excitations, a 256 × 256 matrix, 14- to 16-cm field of view, 3-mm slice thickness, and 1-mm interslice gap; and 4) an oblique sagittal T2-weighted fast-spin echo fat-saturated sequence, perpendicular to the oblique coronal sequence, with TR of 2800 msec, TE of 90 msec, 3 excitations, a 256 × 224 matrix, 16-cm field of view, 3-mm slice thickness, and 1-mm interslice gap.<sup>5,17,19</sup>

### Review of MRI Studies

The images were reviewed by two musculoskeletal radiologists who are experienced in interpreting shoulder MRI studies. The cases were read in conference, in a blinded and random fashion. Conclusions were reached by consensus. The rotator cuff tendons were evaluated according to a modified grading system adopted from Farley et al.,<sup>5</sup> Neumann et al.,<sup>19</sup> and Zlatkin et al.<sup>32</sup> In this classification system, not only was the signal pattern of the tendon evaluated, but also the extent of the signal toward a tendon margin: grade 0 (normal), tendon with a completely homogeneous low signal intensity on all imaging sequences; grade 1A, low signal intensity tendon with a diffuse area of intermediate signal intensity within the substance of the tendon; grade 1B, low signal intensity tendon with an area of intermediate signal intensity that extended to either the articular or bursal surface; grade 1C, low signal intensity tendon with a focal area of intermediate signal intensity; grade 2 (partial tear), tendon with an area of diffuse, linear, or focal high signal intensity, but less than full thickness; grade 3 (full tear), tendon with a focal or diffuse area of high signal intensity through the full thickness of the tendon. Grade 1 (A through C) lesions may be interpreted as normal, degeneration/tendinopathy, or "magic angle" artifact.<sup>4</sup>

The location of the myotendinous junction of the supraspinatus tendon was noted. It was defined as the most distal part of the muscle in which tendon fibers could be visualized. The most superior aspect of the humeral head was the reference point (the 12-o'clock position). The position of the myotendinous junction was recorded in intervals of 15° lateral or medial to this reference point (0° equivalent to 12 o'clock). Neumann et al.<sup>20</sup> have previously recorded this position in "normal" shoulders. It was our hypothesis that if there were muscular hypertrophy of the supraspinatus in the throwing shoulder, then there would be an asymmetry of the musculotendinous junction between the throwing and the nonthrowing shoulder.

Muscle bulk was evaluated for three muscles: the supraspinatus, subscapularis, and anterior deltoid. The supraspinatus muscle belly was measured on the oblique coronal image at the level of the suprascapular notch, in a superior-inferior dimension. The subscapularis muscle belly was measured on the axial image, 3.0 cm medial to the distal myotendinous junction, in an oblique anterior-posterior dimension. The anterior deltoid muscle belly was also measured on the axial image, at the level of the coracoid process, in an anterior-posterior dimension.

The biceps tendon was evaluated with tendon signal recorded as either normal on all sequences or abnormal. If abnormal signal was identified on the T1- or T2-weighted

images, it was further categorized into one of the following three descriptions: 1) intrasubstance signal, 2) thickened tendon, or 3) torn or attenuated tendon. The amount of fluid in the biceps sheath was also graded as normal or abnormal. If it was graded as abnormal, then a further description (mild, moderate, or severe) was recorded.

The labral signal was recorded as normal or abnormal. If it was graded as abnormal, then it was further classified as an intrasubstance signal or tear. The presence of a superior labral anterior-posterior (SLAP) lesion was also documented. Enthesopathic change of the posterior glenoid labrum was evaluated. If change was present, then further description (small, moderate, or severe) was recorded.

The acromial shape was assessed in all 28 shoulders imaged on both the sagittal and coronal oblique views.<sup>3,8,22</sup> The sagittal oblique view is best for determining acromial shape, although large spurs are readily identified on the coronal oblique view. The acromions were classified with respect to their appearance on the image just lateral to the acromioclavicular joint. In addition, the presence of subacromial enthesophytes and acromioclavicular joint osteoarthritis was noted.

#### Data Analysis

The observed differences between shoulders of the 14 pitchers were measured with a nonpaired *t*-test, as were the differences in means between shoulders. The significance level was  $P < 0.05$ .

## RESULTS

### Clinical Evaluation

Overall, there were no dramatic physical abnormalities or weakness to strength testing exhibited by this group, which was not surprising as none had any shoulder problems of note. Subjectively, 12 of the 14 pitchers had what was thought by the examiner to be increased shoulder translation as compared with the nonthrowing shoulder. In these 12 shoulders the humeral head could be translated to the glenoid rim or beyond. Three of the pitchers had generalized ligamentous hyperlaxity, as noted by hyperextension of the elbow and first metacarpophalangeal joint. These three pitchers had multidirectional shoulder laxity as demonstrated by a positive sulcus sign in both shoulders. Statistically, the only positive difference that could be documented was reduced internal rotation in the throwing shoulder as compared with the nonthrowing shoulder (Table 1). At 90° of abduction, the throwing shoulders had an average internal rotation of 75° (SD, 17), versus 90° in the nonthrowing shoulder (SD, 7) ( $P < 0.0015$ ). Although there was a trend toward increased external rotation in the throwing shoulder versus the nonthrowing shoulder (130° versus 120°), the magnitude of the standard deviations and the relatively small number of shoulders did not allow us to state conclusively that external rotation was increased. Our clinical experience

TABLE 1  
Internal and External Rotation (in degrees) in the Throwing and Nonthrowing Shoulders

Player	Throwing shoulder		Nonthrowing shoulder	
	Internal	External	Internal	External
1	70	110	90	110
2	80	180	90	170
3	90	100	100	100
4	70	130	90	100
5 <sup>a</sup>	-60	-120	90	110
6 <sup>a</sup>	-40	-160	80	160
7 <sup>a</sup>	-50	-120	90	110
8 <sup>a</sup>	-45	-120	95	120
9	80	100	90	100
10	80	120	90	90
11	90	120	110	100
12	90	170	100	170
13	80	120	90	110
14	70	170	90	140

<sup>a</sup> These patients had evidence of glenoid enthesopathy on MRI.

suggests that professional pitchers routinely have greater external rotation in their pitching shoulder.

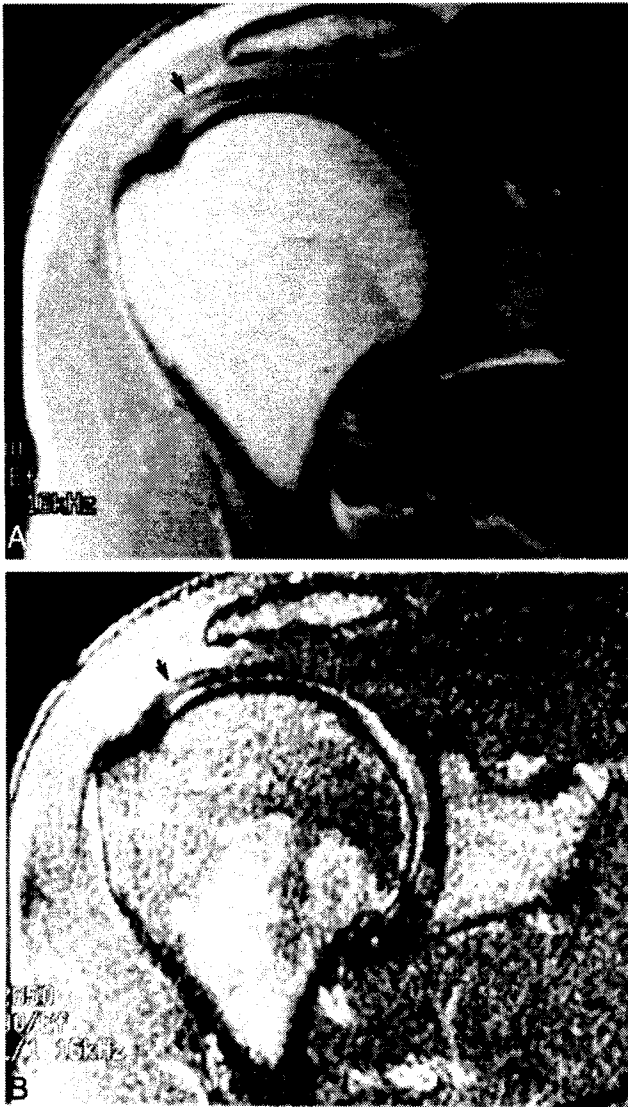
Some physical examination findings correlated with positive MRI findings. There was correlation of loss of internal rotation and the presence of posterior glenoid and capsular abnormalities. Four players had posterior glenoid enthesopathy that was correlated with more loss of internal rotation (40°; SD, 8.2) in these players than in the throwing shoulders of the 10 pitchers who did not have posterior enthesopathy (14°; SD, 5.2) ( $P < 0.0001$ ).

### MRI Findings

**Rotator Cuff.** Of the 14 throwing shoulders 11 (79%) were found to have 1A or 1B changes in the supraspinatus tendon, and 3 of the 14 shoulders (21%) had grade 0 changes (Fig. 1). Of the 14 nonthrowing shoulders, 12 (86%) were found to have 1A or 1B changes in the supraspinatus tendon, 1 (7%) had grade 0 changes, and 1 (7%) had grade 2 changes. Twelve of the 14 throwing shoulders (86%) were found to have 1A or 1B changes in the infraspinatus tendon and 2 (14%) had grade 2 changes. Eleven of the 14 nonthrowing shoulders (79%) were found to have 1A or 1B changes and 3 (21%) had grade 0 changes. Thus, there was no significant difference in the supraspinatus and infraspinatus tendons between the throwing and nonthrowing shoulders ( $P > 0.05$ ). All 28 teres minor and subscapularis tendons were found to be grade 0 (normal).

The myotendinous junction of the supraspinatus muscle was observed to be at 0° in 9 of the 14 throwing shoulders. In the remaining five shoulders, the junction was recorded as 15° lateral in four shoulders and as 15° medial in one shoulder. In the 14 nonthrowing shoulders, the junction was recorded as 0° in 12 shoulders and as 15° medial in 2 shoulders. There did not appear to be any hypertrophy of the supraspinatus muscle belly causing lateral shift of the musculotendinous junction, as both the throwing and nonthrowing shoulders were symmetrical.

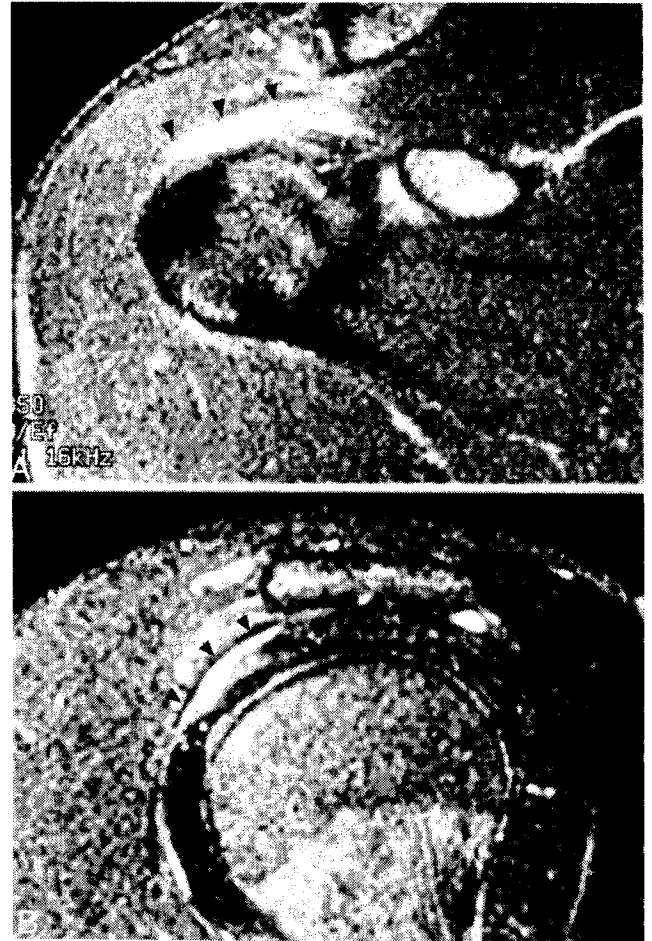
The mean thicknesses for the muscle bellies of the supraspinatus, subscapularis, and anterior deltoid muscles,



**Figure 1.** Magnetic resonance images of the supraspinatus tendon showing grade 1B changes. A, a coronal oblique proton-density-weighted (TR, 2000 msec; TE, 15 msec) image demonstrates a low signal intensity tendon within an area of intermediate signal intensity that extends to the bursal surface (solid black arrow). B, a coronal oblique T2-weighted (TR, 3200 msec; TE, 90 msec) fat-suppressed image also shows an area of increased signal intensity within the substance of the tendon that extends to the bursal surface (solid black arrow).

were as follows: supraspinatus, 25.4 mm in the throwing shoulders and 26.6 mm in the nonthrowing shoulders; subscapularis, 21.2 mm in the throwing shoulders and 19.6 mm in the nonthrowing shoulders; and anterior deltoid, 34.6 mm in the throwing shoulders and 31.6 in the nonthrowing shoulders.

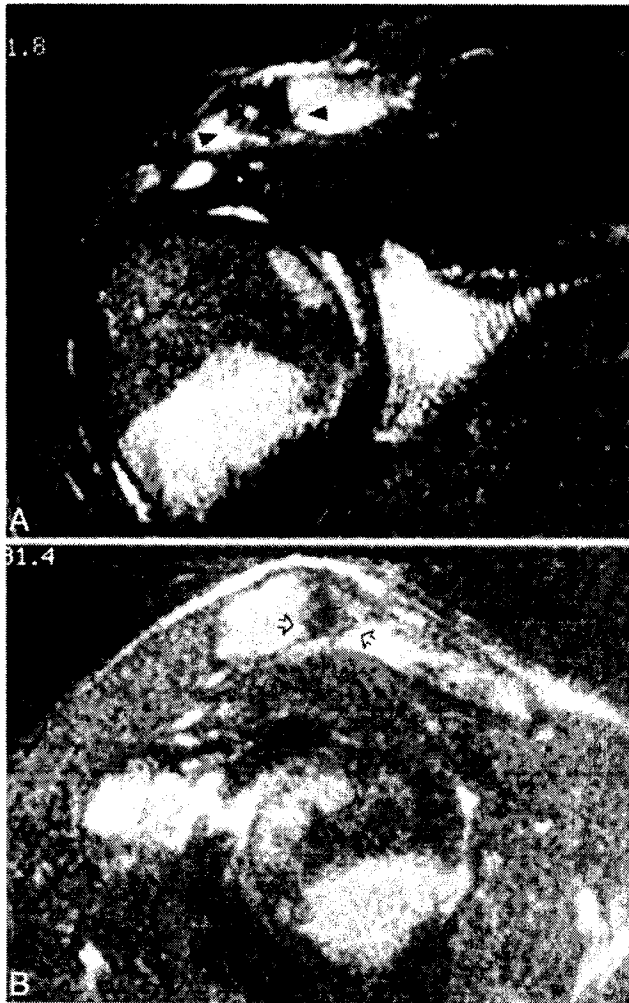
**Biceps.** The biceps tendons were normal in all 28 shoulders imaged, with no abnormal peritendinous fluid.



**Figure 2.** Magnetic resonance images of the subacromial region showing subacromial fluid. A, a coronal oblique T2-weighted (TR, 3200 msec; TE, 90 msec) fat-suppressed image demonstrates increased fluid within the subacromial bursa (solid black arrowheads). B, a sagittal oblique T2-weighted (TR, 3800 msec; TE, 105 msec) fat-suppressed image further shows the increase in subacromial fluid (solid black arrowheads).

**Labrum.** Signal abnormalities of the labrum were detected in 22 of the 28 shoulders imaged. The abnormalities were located either in the anterosuperior, anteroinferior, or posteroinferior quadrant of the labrum and were identified in 11 throwing shoulders and 11 nonthrowing shoulders. Of the 11 throwing shoulders with signal abnormalities of the labrum, 6 (55%) had an abnormal increase in intrasubstance signal and 5 (45%) had signals that extended to the surface and were classified as tears by the radiologists. Of the 11 nonthrowing shoulders, 7 (64%) had an abnormal increase in intrasubstance signal and 5 (36%) demonstrated "tears." There was no significant difference in the labral changes between the throwing and nonthrowing shoulders ( $P > 0.05$ ). Two SLAP lesions were identified, in both shoulders of one pitcher.

**Acromion and Related Anatomy.** In the throwing shoul-



**Figure 3.** Magnetic resonance images of the acromioclavicular joint showing osteoarthritis. A, a coronal oblique T2-weighted (TR, 3200 msec; TE, 90 msec) fat-suppressed image demonstrates irregularity along the articular surfaces of the acromioclavicular joint associated with increased signal, representing edema, in the subchondral bone (solid black arrowheads). B, a sagittal oblique T2-weighted (TR, 3800 msec; TE, 105 msec) fat-suppressed image further shows irregularity of the acromioclavicular joint, with associated edema in the surrounding bone (open arrows).

ders, the acromial shape was type I in eight shoulders, type II in five, and type III in one. In the nonthrowing shoulders, the acromial shape was type I in six shoulders, type II in seven, and type III in one. Subacromial enthesophytes were identified in 7 of the 14 throwing shoulders (50%), and in 6 of 14 nonthrowing shoulders (43%). There was no significant difference between the throwing and nonthrowing shoulders for the presence of a subacromial spur ( $P > 0.05$ ). Minimal-to-moderate increase in subacromial-subdeltoid fluid was observed in 12 of the 14 throwing shoulders (86%), and in 10 of the 14 nonthrowing



**Figure 4.** Magnetic resonance image of the glenoid showing enthesopathic changes of the posteroinferior glenoid. Axial T1-weighted (TR, 500 msec; TE, 10 msec) image of the glenohumeral joint demonstrates an area of low signal intensity emanating off the posteroinferior glenoid, in the region of the posterior capsular origin (open arrow). This represents enthesopathic changes of the posteroinferior glenoid.

shoulders (71%) (Fig. 2). In addition, subacromial-subdeltoid fat was identified in 8 of 14 throwing shoulders (57%) and in 9 of 14 nonthrowing shoulders (64%). Thus, there was no significant difference between shoulders for the presence of subacromial-subdeltoid fluid or fat ( $P > 0.05$ ).

Acromioclavicular joint osteoarthritis (graded as mild to moderate) was observed in 4 of the 14 throwing shoulders (29%) and in 6 of the 14 nonthrowing shoulders (43%) (Fig. 3). There was no significant difference in this finding between shoulders ( $P > 0.05$ ).

**Glenohumeral Joint.** There were many statistically significant observations concerning the glenohumeral joint, including four Hill-Sachs lesions in four of the throwing shoulders (29%) but none in the opposite nonthrowing shoulders ( $P < 0.05$ ). One pitcher with a Hill-Sachs lesion had associated cartilaginous and osseous Bankart lesions, and another had a reverse osseous Bankart lesion. The other two pitchers with Hill-Sachs lesions had associated cartilaginous Bankart lesions.

Four of 14 throwing shoulders (29%) had enthesopathic changes (extraarticular ossification) in the posteroinferior quadrant of the glenoid labrum (Fig. 4). These findings were not present in the nonthrowing shoulders. This was also a statistically significant finding ( $P < 0.05$ ). These same four pitchers, on physical examination, were found to have loss of internal rotation ( $40^\circ$ ) in their throwing shoulders that was greater than the reduced internal rotation ( $14^\circ$ ) in the 10 throwing shoulders without these posteroinferior glenoid changes (Table 1). Two of these four pitchers also demonstrated cartilaginous Bankart lesions in their throwing shoulder.

Five degenerative cysts (36%) were identified in the humeral head of the throwing shoulder at the insertion of the infraspinatus tendon onto the greater tuberosity, versus only one such cyst (7%) in a nonthrowing shoulder ( $P < 0.05$ ). One subject was found to have a posterior labral cyst (ganglion) in the nonthrowing shoulder.

## DISCUSSION

Clearly, many significantly variable MRI findings were documented in this study. For the purposes of discussion we have classified these findings into three distinct groups. Group 1 were those findings that were symmetrical between the throwing and nonthrowing shoulders and also similar to those previously documented in an athletically active population.<sup>17</sup> Group 2 were those findings that were also symmetrical but were different from those that have been reported for the general population. Finally, group 3 were those findings that were asymmetrical between the throwing and the nonthrowing shoulders.

### Group 1—Symmetric Findings Similar to Those of the General Population

**Rotator Cuff.** Magnetic resonance imaging findings of the rotator cuff in the asymptomatic shoulder have been well described.<sup>9,12,16–20</sup> We used methods similar to those used in previous studies in an attempt to maintain consistency in the evaluation of the shoulder. However, in this group of subjects, we evaluated the nonthrowing shoulder with the thought of using it as the internal control. Our results have demonstrated that there were no significant differences in the findings observed in the rotator cuff between shoulders in the 14 athletes studied. Specifically, in the supraspinatus and infraspinatus tendons, about 80% of the shoulders demonstrated grade 1A or 1B changes. These data are similar to the findings observed in other studies of the asymptomatic shoulder in average volunteers.<sup>17–19,32</sup> Many authors have described these grade 1A and 1B changes as normal variants.<sup>9,12,18</sup> In addition, these findings have also been attributed to artifact, such as the magic angle phenomenon,<sup>4,29</sup> arm position,<sup>2</sup> or the “pseudogap.”<sup>31</sup> The pseudogap refers to a zone of increased signal intensity near the insertion of the supraspinatus tendon onto the greater tuberosity, which represents the difference in orientation between the anterior (dominant) and posterior bundles of the tendon.<sup>31</sup> Thus, when the injured throwing athlete does undergo MR imaging, true rotator cuff lesions may be more easily discerned from this array of findings.<sup>1,5,10,21,23–26</sup> Partial-thickness tears, however, are more difficult to interpret. Partial-thickness tears, or grade 2 changes, can be present in up to 23% of patients (7 of 30),<sup>17</sup> and determining whether they are the source of symptoms is difficult. In this study there were two grade 2 changes interpreted as partial-thickness tears of the infraspinatus tendons on the throwing side. Although not statistically significant, this was an interesting finding since many throwing athletes are found to have this type of lesion at surgery. We may infer that grade 2 changes in these athletes may represent

either a normal variant that is present as a result of the type of activity in which the athlete is involved or a subclinical finding that might lead to problems in the future.

**Biceps.** No signal abnormalities were demonstrated in any of the biceps tendons. All biceps tendons were observed to have normal peritendinous fluid. Thus, an abnormality detected in the biceps tendon of a symptomatic pitcher should be regarded with a high degree of suspicion.<sup>9,18</sup>

### Group 2—Symmetric Findings Different from Those of the General Population

**Labrum.** Numerous authors have described normal variations in the signal intensity, size, and shape of the labrum in asymptomatic average subjects.<sup>13,20,29,30</sup> The anterosuperior labrum demonstrates two distinct variants, the sublateral foramen and the Buford complex.<sup>14,27,30</sup> Furthermore, increased intralabral signal intensity can be seen in up to 46% of normal shoulders (finding based on 30 shoulders).<sup>15</sup> This is similar to our findings (throwing shoulder, 55%; nonthrowing shoulder, 64%). A correlation of altered intralabral signal and histologic findings indicates the presence of fibrovascular tissue, mucoid or eosinophilic degeneration, calcification, ossification, or synovial tissue.<sup>13</sup>

Whenever an abnormally increased labral signal extended to the surface in a linear fashion on T1- or T2-weighted images, we classified the finding as a labral tear. This corresponds with a type 3 labral tear according to the classification system proposed by Zlatkin et al.,<sup>32</sup> and histologically correlates with the MRI classification by Loredo et al.<sup>13</sup> In our study, 45% of the throwing shoulders and 36% of the nonthrowing shoulders were found to have type 3 labral tears. Although there was no significant difference between the shoulders of the individual athletes in our study, this was a relatively high incidence in comparison with asymptomatic average subjects.<sup>11,13,15,20</sup> Even though the throwing athletes in our study primarily use their dominant arm, their training and conditioning frequently involves both upper extremities. This increased activity and subsequent stress resulting from such training may lead to this increased incidence in findings in the nonthrowing shoulder in pitchers. No definitive conclusions, however, can be drawn from these results.

**Acromion and Related Anatomy.** It has been demonstrated that the severity of rotator cuff abnormalities increases with progressive curvature of the undersurface of the acromion.<sup>3,8,22</sup> We did not identify a relationship between acromial type and the severity of grading of abnormalities of the supraspinatus tendon. We can postulate that the athletes in our study, who were early in their careers, had MRI performed before the development of more extensive rotator cuff abnormalities. Alternatively, this result may be caused by a sampling error.

Although there was no difference between the throwing and nonthrowing shoulders of the 14 athletes in our study, 29% of the throwing shoulders were found to have acromioclavicular joint osteoarthritis. Early changes that we

found included the presence of osteophytes and an increase in acromioclavicular joint fluid. In cases of advanced arthrosis there will be edema in the osseous structures of the joint.<sup>3</sup> The biomechanics of the throwing motion significantly stress the acromioclavicular joint, so it was not surprising to observe premature degenerative changes in this joint. However, what was surprising was the similar finding of acromioclavicular joint arthrosis in the nonthrowing shoulder. We could not explain this finding except that perhaps this is a reflection of training methods that usually involve both shoulders, such as in weightlifting. This may be the reason these findings were identified bilaterally. Whatever the reason, acromioclavicular changes are common in these athletes and one needs to be cautious in instituting treatment for problems in this area unless one is certain that this joint is truly symptomatic for the athlete.

### Group 3—Asymmetric Asymptomatic Findings

*Glenohumeral Joint.* None of the subjects in this study had any history of instability or remote trauma; however, five had degenerative cysts in the posterosuperior aspect of the humeral head and four had edema and Hill-Sachs lesions. Clinical examination of pitchers usually reveals a loose capsule with a capacious glenohumeral joint, because the throwing motion stretches the capsule over repetitive events. Therefore, although these athletes never had frank shoulder instability, they may have been experiencing microinstability with the throwing motion, which might explain the observed findings. Alternatively, the findings may be related to "internal impingement" with abutment of the posterosuperior humeral head on the posterosuperior glenoid and labral complex. Whatever the cause, these findings are unique to the throwing shoulder and are not commonly found in asymptomatic volunteers.<sup>15</sup>

An interesting finding in this study was the enthesopathic changes observed at the posteroinferior glenoid in 29% of the throwing shoulders. These enthesopathic changes may represent the early stages of the Bennett lesion, which has been previously reported in throwing athletes.<sup>6,28</sup> The Bennett lesion is an extraarticular ossification of the posteroinferior glenoid. It has been associated with posterior labral injury and posterior undersurface rotator cuff injury. Originally thought to represent traction stresses from the triceps muscle insertion, the Bennett lesion is now considered a result of traction stresses from the posterior capsule.<sup>6,28</sup> Although our subjects were asymptomatic, they did have decreased motion in internal rotation as compared with the other pitchers in our study in whom these findings did not exist. It is possible, therefore, that these findings may represent subclinical changes that could develop into a Bennett lesion in the future. Computerized tomography has been shown to be more sensitive than MRI for identification of these lesions.<sup>28</sup> Our study focused on MR imaging of these athletes. Our methods did not incorporate other imaging modalities and we may have underestimated the prevalence of this finding. There is an association between the Bennett lesion and posterior labral tears.<sup>6</sup> This association

may be the differentiating factor as to whether these lesions become symptomatic.

### Study Limitations

Several limitations of this study should be addressed. One limitation is that we could not verify MRI findings. Ideally the MRI findings would be confirmed by surgery. However, in an asymptomatic volunteer group such as ours, arthroscopic evaluation is not possible. In this study, the labrum was assessed mainly with the axial T1-weighted sequence. We tried to be consistent with other studies in which asymptomatic shoulders were also analyzed.<sup>15,17</sup> However, other studies describe the use of gradient-echo and T2-weighted images in the axial plane to more accurately assess the labrum.<sup>7,11,15</sup> Thus, the findings identified in the labrum in this study may not be as accurate as possible. Ideally, the addition of further axial sequences would improve the imaging of the labrum and better delineate the presence or absence of findings.

The athletes who underwent MRI in our study were relatively young and were at the start of their professional careers as baseball pitchers. Thus, our findings may not fully represent the spectrum of abnormalities that could be present among all professional pitchers. In particular, pitchers may compete well into their mid-30s, or even early 40s. However, there is a reduced probability that more senior pitchers rather than young pitchers remain asymptomatic and injury-free. Therefore, it is also likely that some of the observed findings, although not causing symptoms at present, may develop into a source of symptoms for some of these pitchers in the future. Perhaps a longitudinal study would help identify which findings are precursors of future injuries and which findings are normal signal changes as a result of the athletes' specific activity.

### CONCLUSIONS

Interpretation of MR images in a professional baseball pitcher is a difficult exercise. The mere presence of signal changes or abnormalities does not necessarily indicate pathologic symptomatic findings. Baseline MRI in all pitchers at the onset of their careers or at the beginning of each season may help identify new changes but does not necessarily guarantee correct identification of symptom origin. In addition, plain MRI does not image structures such as the labrum as well as MR arthrography does. Given the difficulties in interpretation, a single plain MR image may have little role in the evaluation of the symptomatic shoulder of a professional pitcher. Knowledge of the signal changes that may normally be present in these athletes will aid in the interpretation of these studies and help differentiate pathologic from nonpathologic findings.

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