

# Prevalence of MRI Shoulder Abnormalities in Asymptomatic Professional and Collegiate Ice Hockey Athletes

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**Background:** The literature demonstrates a high prevalence of asymptomatic knee and hip findings on magnetic resonance imaging (MRI) in athletes. Baseball pitchers are shown to have a high prevalence of asymptomatic shoulder MRI findings, but the incidence of asymptomatic shoulder MRI findings has not been systematically evaluated in nonthrowing contact athletes.

**Purpose/Hypothesis:** The purpose of this study was to determine the prevalence of shoulder abnormalities in asymptomatic professional and collegiate hockey players. We hypothesized that, similar to overhead throwing athletes, ice hockey players will have a high prevalence of asymptomatic MRI findings, including labral, acromioclavicular (AC), and rotator cuff pathology on MRI.

**Study Design:** Cross-sectional study; Level of evidence, 4.

**Methods:** A total of 25 asymptomatic collegiate and professional hockey players (50 shoulders) with no history of missed games or practice because of shoulder injury, pain, or dysfunction underwent bilateral shoulder noncontrast 3.0-T MRI. MRIs were read blinded by 2 board-certified radiologists at 2 separate time points, 3 months apart, to determine the prevalence of abnormalities of the joint fluid, bone marrow, rotator cuff tendon, biceps tendon, labrum, AC joint, and glenohumeral joint. Interrater and intrareader reliability was determined, and regression analysis was performed to identify the prevalence and relationship to stick-hand dominance.

**Results:** Labral abnormalities were seen in 25% of the shoulders. AC joint abnormalities and rotator cuff findings were noted in 8% and 6% of shoulders, respectively. One shoulder was noted to have a biceps tendon abnormality, and 1 shoulder demonstrated glenohumeral joint chondral findings. Interrater reliability coefficients were 0.619 for labral abnormalities. Intrareader reliability kappa coefficients were 0.493 and 0.718 for both readers, respectively, for labral abnormalities. Regression analysis was performed and revealed that the overall shoulder pathology was more common in the nondominant stick hand (top stick hand) (coefficient  $-0.731$ ;  $P = .021$ ).

**Conclusion:** Professional and collegiate ice hockey players had an overall prevalence of labral abnormalities in 25% of their shoulders, with findings more often found in the nondominant stick hand. Rotator cuff abnormalities were uncommon in ice hockey players. These findings differ significantly from published reports examining professional baseball players and other overhead sports athletes.

**Keywords:** shoulder; ice hockey; imaging; MRI; labrum; rotator cuff

Injuries are common in ice hockey, with a rate of 14.2 per 1000 player-games according to data from the International Ice Hockey Federation.<sup>20</sup> Face and lower extremity injuries are the most common followed by upper extremity injuries, with a rate of 3.1 per 1000 player-games. The shoulder has been reported to be the most common site of injury for the upper extremity in ice hockey.<sup>20</sup>

Magnetic resonance imaging (MRI) is the most common imaging modality for evaluation of soft tissue abnormalities of the shoulder.<sup>19</sup> It has been shown to have high sensitivity and specificity for detection of labral injuries.<sup>9</sup>

Studies examining the incidence of shoulder MRI findings in asymptomatic athletes have previously focused on overhead throwing athletes. Miniaci and colleagues<sup>11</sup> found a rate of 79% of labral abnormalities in asymptomatic professional baseball players. Similarly, high rates of asymptomatic shoulder findings have been found in tennis players, water polo players, and volleyball players.<sup>4-6</sup> MRI evaluation of asymptomatic hip and knee pathology in

The Orthopaedic Journal of Sports Medicine, 7(10), 2325967119876865  
DOI: 10.1177/2325967119876865  
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TABLE 1  
MRI Protocol Used for Imaging Shoulder

	Repetition Time, ms	Echo Time, ms	Slice Thickness, mm	Field of View, cm	Echo Train Length
Axial proton-density fat-saturated sequence	4000	9.8	3.0	13	5
Coronal T1-weighted sequence	720	12.0	3.0	13	4
Coronal T2 fat-saturated sequence	3500	55.0	3.0	13	11
Sagittal T2 fat-saturated sequence	5510	65.0	2.5	13	14

collegiate and professional ice hockey athletes has demonstrated a significant incidence of abnormal findings.<sup>13,18</sup> Silvis and colleagues<sup>18</sup> found a 56% rate of labral tears in the hip in asymptomatic collegiate and professional ice hockey athletes. Because MRI is frequently utilized to evaluate new shoulder injuries in collegiate and professional hockey players, understanding the prevalence of asymptomatic findings will help in decision making when evaluating new and chronic injuries.

The purpose of our study was to determine the prevalence of shoulder abnormalities on MRI imaging in asymptomatic professional and collegiate ice hockey players. We hypothesized that, similar to overhead throwing athletes, ice hockey players would have a high prevalence of asymptomatic findings on MRI, including labral, acromioclavicular (AC), and rotator cuff pathology.

## METHODS

### Subjects

After institutional review board approval, collegiate hockey players from a National Collegiate Athletic Association Division III team and professional hockey players from an American Hockey League/National Hockey League team were recruited for the study. Fifty shoulders in 25 male collegiate (n = 13) and professional (n = 12) ice hockey players were examined. To be eligible for the study, players needed to be >18 years of age and an active member of one of the abovementioned teams, as well as willing to undergo an MRI of the bilateral shoulders with no contraindications to MRI. Athletes were excluded from the study if there was any current or previous known shoulder injury, as determined by player records and patient self-reporting, that resulted in missed practice or playing time from athletic participation. Written informed consent was obtained from all participants.

### Clinical Evaluation/Intake Form

Upon study enrollment at the beginning of the 2016-2017 ice hockey season, players completed an intake questionnaire and had a physical examination of bilateral shoulders performed by a sports medicine board-certified orthopaedic surgeon (A.D.) or primary care sports medicine physician (C.O., M.S.). The physical examination included palpation, range of motion, neurovascular examination, and strength testing. Provocative examinations of bilateral shoulders were also completed for all players and the results recorded. This assessment included anterior apprehension and relocation test and Yergason, O'Brien, Speed, Neer, Hawkins, and Jobe tests, as well as palpation for pain over the AC joint and completion of a crossarm adduction.

### MRI Evaluation

In addition to the clinical evaluation, the athletes underwent noncontrast MRI scans of both shoulders at our research MRI facility with the use of 3.0-T scanners (PRISMA-Fit scanner; Siemens) and a dedicated shoulder phased-array coil. Table 1 describes the imaging sequences used in the study. After the completion of the MRIs, the images were blindly reviewed by 2 board-certified radiologists specialized in musculoskeletal radiology with extensive experience in reading shoulder MRIs (D.F., T.M.). Data from the reviews were recorded on a standardized form evaluating the following 7 areas for each side: joint fluid, bone marrow signal, rotator cuff tendon, biceps tendon, superior/anterior/posterior/inferior labrum, AC joint, and determination of whether chondral injuries of the glenohumeral joint were present. Three months later, both radiologists, blinded to their previous readings, reviewed the MRIs for a second time and recorded their findings on a new standardized form. Thus, there were 4 interpretations for each MRI.

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One or more of the authors has declared the following potential conflict of interest or source of funding: A.D. has received grant support from the US Department of Defense, Smith & Nephew, DJO, and Revotek and consulting fees from Avenue Therapeutics and Smith & Nephew. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval for this study was obtained from Penn State Milton S. Hershey Medical Center Institutional Review Board (study ID STUDY00005250).

Regarding overall prevalence, a finding at a given shoulder site and side was considered positive for abnormality if at least 3 of the 4 interpretations (ie, >50%) were classified as positive; otherwise, a negative finding was recorded.

### Statistical Analysis

For each of the 7 areas noted above as well as for each extremity side, observations from both readers were combined to form a single binary (positive/negative for abnormality) summary value for each participant. Counts and percentages of positive findings at each site and side were computed. We used R 3.4.1<sup>14</sup> and the psych R package<sup>16</sup> to compute kappa statistics and the associated 95% confidence intervals for measuring interrater and intrareader reliability at each site. Separate repeated-measures logistic regression models were developed for each site to assess the statistical significance of the association between the players' stick hand and positive finding. However, not all models could be fit because of the small number or absence of positive findings at certain sites. For this reason, we also fit an alternating logistic regression model using data from all sites. SAS 9.4 software (SAS Institute) was used to fit all regression models.

## RESULTS

A total of 30 ice hockey players were initially enrolled in the study, of which 5 were excluded because of either incomplete physical examination data or incomplete MRI imaging. Of the 25 athletes that completed the study, 13 were collegiate ice hockey players and 12 were professional ice hockey players. Their average age was 22.1 years and ranged from 18 to 28 years. On average, they had played ice hockey for 16.8 years with a range from 10 to 24 years.

### Clinical Evaluation

All athletes had normal physical examination findings for palpation, range of motion, neurovascular, and strength testing. One athlete had a positive O'Brien test on his nondominant stick hand, but otherwise all athletes had a normal provocative testing of the bilateral shoulders.

### MRI Findings

A total of 49 MRIs were available to be read by the radiologists (25 right shoulders, 24 left shoulders). Images for 1 athlete's left shoulder MRI was completed, but the images were not saved on the research facility computer system following completion of the MRI. This examination could not be interpreted, hence the reason for the total of 49 MRIs on 25 athletes.

Labral abnormalities were seen in 12 (25%) of the shoulders. Of these labral abnormalities, all were read as tears, and 75% were found in the nondominant (top) stick hand of the players. Two were found to be consistent with superior labral anterior and posterior (SLAP) tear and 2 were noted to be isolated to the anterior inferior labrum.

The remaining 8 were noted to involve the posterior labrum. Interrater reliability coefficients were 0.619 for labral abnormalities. Intrareader reliability kappa coefficients were 0.493 and 0.718 for reader 1 and reader 2, respectively, for labral abnormalities.

AC joint abnormalities were noted in 4 (8%) shoulders. No AC joint separations were noted. All 4 shoulders with AC joint abnormalities were found to have varying degrees of arthrosis, with 1 of the 4 shoulders additionally showing osteolysis/resorption of the distal clavicle. Of these AC joint abnormalities, 75% were noted in the dominant shoulders of athletes.

Rotator cuff findings were seen in only 3 (6%) of the shoulders. One abnormality involved a partial tear of the supraspinatus tendon in the nondominant stick hand of a hockey player. An additional shoulder had intrasubstance signal near the supraspinatus/infraspinatus junction, again in the nondominant stick hand. The last abnormality noted was a partial articular tear with intratendinous extension lesion of the infraspinatus tendon in the dominant stick hand of a player.

One shoulder was noted to have a biceps tendon abnormality. This player had MRI findings consistent with tendinopathy and subluxation of the biceps tendon out of the bicipital groove. Of note, this was also the same player found to have a partial articular-sided tear of the supraspinatus tendon.

Finally, 1 shoulder was found to have Modified Outerbridge Classification grade 2-3 cartilage changes of the glenohumeral joint. No shoulders were noted to have joint fluid abnormalities or abnormalities of the bone marrow.

We performed regression analysis, which revealed that the overall shoulder pathology was more common in the nondominant (top) stick hand (coefficient -0.731;  $P = .021$ ).

## DISCUSSION

Studies have demonstrated a high frequency of incidental shoulder pathology in baseball pitchers, volleyball players, swimmers, and water polo athletes.<sup>2,5,6,11</sup> Because incidental findings are common, MRIs should be reviewed within the framework of the patient's symptoms and clinical picture. Our hypothesis in this study, that asymptomatic MRI abnormalities in collegiate and professional hockey players would be similar to that historically seen in overhead athletes, was refuted. To our surprise, we found overall fewer asymptomatic shoulder MRI abnormalities in the contact sport of ice hockey as compared with overhead sports.

Labral tears were the most common finding on MRI in asymptomatic ice hockey players. Previously reported rates have ranged anywhere from 7.5% to 84% of asymptomatic shoulders showing labral abnormalities.<sup>1,2,17</sup> Our study found the prevalence of incidental labral tears to be 25%. Interestingly, 8 of 12 labral tears in our study involved the posterior labrum, and the nondominant stick hand was more commonly involved. This is in contrast to MRI studies performed on professional ice hockey athletes who had

sustained a traumatic injury to the shoulder with a history of acute subluxation or dislocation, in which 75% of the shoulders had an anterior labral lesion/Bankart lesion on MRI and only 8.4% of patients had isolated posterior labral tears.<sup>3</sup> The higher prevalence of posterior as compared to anterior labral tears in our study may be explained by repetitive trauma from actions such as checking and contact with the boards. Another potential cause is repetitive microtrauma from the flexed, internally rotated position of the nondominant shoulder experienced during the act of shooting, in contrast to the abduction–external rotation position associated with throwing.

Determining if a labral tear is the source of shoulder pain in a symptomatic athlete has significant consequences when surgery is being considered. Rangavajjula et al<sup>15</sup> found that in professional ice hockey players, the average return to play time after arthroscopic treatment for a labral tear was 4.3 months. That is more than half of the normal professional ice hockey season, with significant short-term economic implications as well as long-term career implications.

Previous studies on asymptomatic athletes have generally reported a much higher prevalence of incidental findings in the labrum and rotator cuff than that found in our study on ice hockey athletes. Miniaci et al reported that in asymptomatic professional baseball pitchers (average age, 20.1 years), labral abnormalities on MRI were found in 79% of the 28 shoulders studied.<sup>11</sup> In addition, they reported grade 1 changes, defined as a low signal intensity tendon with an area of intermediate signal either in the substance of the tendon or extending to the articular or bursal surface, in 79% of throwing shoulders and 86% of nonthrowing shoulders. These authors noted that such rotator cuff findings are similar to the data found in an asymptomatic nonathletic population and may represent normal variants or stem from imaging artifact. Of important difference, their study was performed with a 1.5-T MRI scanner as compared with the 3.0-T scanner used in our study.<sup>11</sup>

In another study, Miniaci and colleagues<sup>10</sup> noted in 30 shoulders in patients with an average age of 29 years (range, 17–49 years) that no shoulder they examined was normal with homogeneous low signal intensity throughout the entire tendon. All shoulders had at least grade 1 changes with intermediate signal intensity in the tendon, and an additional 23% of shoulders had grade 2 changes indicating a partial-thickness tear. Liou and coauthors<sup>7</sup> found similar results, with nearly all shoulders having intermediate signal intensity of the supraspinatus junction.

Our findings of a much lower incidence of rotator cuff pathology may have multiple explanations. This may represent the lower prevalence in the ice hockey population as compared with the throwing population. Another explanation is that with 3-T MRI a more accurate image is obtained.<sup>12</sup> This may explain why we had fewer findings as compared with the Miniaci et al<sup>11</sup> study performed with a 1.5-T MRI. Finally, our radiologist may not consider intermediate signal in a tendon to be a partial rotator cuff tear and may instead contribute this to a normal variant or

magic angle if tendon morphology was normal leading to fewer partial rotator cuff tears being reported.

This study has several limitations. It is important to note that this study was performed at the start of the ice hockey season, and therefore the prevalence of findings on MRI may differ if the study had been performed in the middle or end of the hockey season. An area for further research would be to follow these athletes over time to see if they develop symptoms consistent with their MRI findings.

The study was limited to 25 athletes with a total of 49 shoulders. In addition, the study was limited to players from 2 teams, 1 at the American Hockey League professional level and the other at the Division III collegiate level. There is also a possibility that athletes may have underreported their pain and symptoms. Weightlifting regimens or history of bodybuilding were not recorded, and athletes also participated in other recreational activities that could have influenced their shoulder findings. MRI has less sensitivity in detecting labral pathology as compared with MRI arthrogram.<sup>8</sup> The use of a 3-T magnet may differ from that used by some in practice, and thus our imaging, and incidence of detected abnormalities, may be different. In addition, there was no arthroscopic confirmation of the MRI findings, but the lack of surgical data simulates the decision-making assessment scenario, with just clinical and MRI findings. Finally, only moderate interrater and intra-reader reliability was achieved in the study, possibly due in part to known normal variability in the anatomy of the labrum, leading to variation in interpretation of the images.

## CONCLUSION

Overall, 25% of professional and collegiate ice hockey players had labral abnormalities in their shoulders, with findings more often seen in their nondominant stick hand. AC osteoarthritis was the next most common finding in 8% of shoulders. Finally, there was only a small prevalence of rotator cuff abnormalities found in hockey players (6%). These findings are in contrast to those of previously published studies examining professional baseball players and overhead sports athletes. They suggest that pathologic findings on MRI imaging of a hockey athlete are more likely to be new as compared with imaging of overhead and throwing athletes. While the prevalence of asymptomatic abnormal findings in elite hockey athletes is low and the data helpful in the evaluation of new injuries in hockey athletes, we certainly recommend continued utilization of MRI in the framework of an athlete's clinical examination and symptoms.

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