Abnormal Findings on Knee Magnetic Resonance Imaging in Asymptomatic NBA Players

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ABSTRACT: The purpose of this study was to evaluate the knees of asymptomatic National Basketball Association (NBA) players via magnetic resonance imaging (MRI) and confirm or dispute findings reported in the previous literature. It is thought that a variety of significant abnormalities affecting the knee exist in asymptomatic patients and that these findings can be accurately identified on MRI. Two months prior to the 2005 season, bilateral knee MRI examinations of 14 asymptomatic NBA players (28 knees) were evaluated for abnormalities of the articular cartilage, menisci, and patellar and quadriceps tendons. The presence of joint effusion, subchondral edema, and cystic lesions and the integrity of the collateral and cruciate ligaments were also assessed.

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INTRODUCTION

Magnetic resonance imaging (MRI) is a valuable tool in the evaluation of the knee. It is often the test of choice for diagnosing or confirming derangements of the articular cartilage,[6,10,25] ligament[20,23] and tendon injuries,[23] meniscal tears,[8,9,23,26,34] joint effusions,[2] bone marrow edema,[14] and cysts.[31] The abnormalities seen on MRI are not always clinically significant, which has encouraged clinicians to use MRI to support clinical examination findings rather than as the sole tool to diagnose injury.[3-5,29] The prevalence of abnormal findings has been well documented in asymptomatic individuals on shoulder[29] and spine[3,5] MRI. However, the reported prevalence rates for MRI abnormalities in athletes' knees vary widely.* Although the prevalence of meniscal lesions is well documented in the asymptomatic noncompetitive athletic population,[12,16,19,24] significantly higher rates have been reported for elite basketball players. The reported prevalence of meniscal abnormalities in elite competitive basketball players has been as high as 20%.[7,15,16,22] The prevalence of articular cartilage abnormalities in asymptomatic collegiate and professional basketball players has been reported to approach 50%.[7,15,18,22] However, the relatively small study populations and differences in the kinds of abnormalities assessed may account for this variability. Additional studies, such as this study, will verify the findings from other studies as truly representative of the National Basketball Association (NBA) as a whole. That considered, unlike the prior study of NBA players that evaluated only the articular cartilage and meniscus,[15] this study evaluated the articular cartilage, meniscus, collateral and cruciate ligaments, bone marrow, joint effusion, and patellar and quadriceps tendons in professional basketball players.

The purpose of this study was to evaluate the MRI of asymptomatic NBA players to confirm or dispute findings reported in the previous literature. It is thought that a variety of significant abnormalities affecting the knee exist

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**7, 13, 15, 17, 18, 21, 22, 27, 28*

in asymptomatic patients and that these findings can be accurately identified on MRI.[2-5,7-10,14,16] Reports of knee abnormalities vary significantly in the literature.[7,15,22] Further evidence supporting the inconsistent prevalence of asymptomatic findings may support the establishment of a registry or a standardized preparticipation MRI to provide a baseline image that is individualized and used for future comparison in the event of an injury. This would be an important aid in making an accurate clinical diagnosis and determining future treatment. Therefore, MRI studies were performed in the month preceding training camp as part of a comprehensive preparticipation physical examination.

METHODS

Magnetic Resonance Imaging and Interpretation

A total of 14 male players had MRI of both the left and right knees prior to the start of the 2005 NBA season, for a total of 28 MRI studies. The mean age of the players was 26.3 years (range, 20-36 years). A standardized knee protocol was used to best visualize the articular cartilage, menisci, and ligaments. Axial, coronal, and sagittal scout sequences were obtained for all players. They all included T2-weighted or proton density fast spin-echo sequences, which are useful for articular cartilage abnormalities.[24] The studies were performed on one of three separate machines. Images were obtained with the Altaire 0.7-T magnet open high field extremity MRI (Hitachi, Twinsburg, Ohio) for 7 players, with the Airis II 0.3-T magnet open extremity MRI (Hitachi) for 6 players, and with the Signa EXCITE 11.0 1.5-Tesla magnet (GE Healthcare Milwaukee, Wis) and a conventional transmit-receive extremity coil for 1 player. Standardized protocols for each machine were used for imaging. The Hitachi Altaire 0.7-T open high field MRI used six sequences. A T2-weighted axial fast spin-echo sequence, two coronal sequences (inversion recovery and a proton density fast spin-echo), two sagittal sequences (a proton density fast spin-echo and a dual equivalent T2-weighted fast spin-echo), and a T2-weighted oblique coronal sequence optimized the evaluation of the anterior cruciate ligament (ACL).

To better visualize the ACL, the Hitachi Airis II 0.3-T open protocol consisted of eight separate sequences: a sagittal sequence, axial and coronal inversion recovery sequences, a fat-saturated axial sequence, a proton density/T2-weighted sagittal sequence, a sagittal inversion recovery sequence, a coronal T1-weighted sequence, and a T2-weighted fast spin-echo axial sequence.

The GE Signa EXCITE 11.0 1.5-T machine imaged a single player with six sequences of the knee: a fat-saturated axial T2-weighted sequence, a dual echo oblique sagittal proton density/T2-weighted sequence, an oblique coronal T1-weighted sequence, an oblique coronal T2-weighted fat-saturated sequence, an oblique fast spin-echo sequence, and an oblique coronal 3D sequence to view the ACL. A total of 6 staff radiologists (B.E.W., P.C.M., R.W.K., A.Z., F.T., B.J.C.) provided an initial interpretation, with the read of a senior fellowship-trained musculoskeletal radiologist (A.Z.) used for final consensus.

Criteria for Evaluation

Articular cartilage was evaluated for focal defects and inhomogenous or high signal. The presence of any of these findings was considered abnormal. Menisci were considered abnormal if there was intrameniscal high signal (MRI Grade II), according to an established grading system.[34] A meniscus was considered torn if there was evidence of linear high signal extending to the articular surface (MRI Grade III).

The patellar tendon and quadriceps tendon were considered abnormal if there was inhomogeneity or evidence of high signal abnormality consistent with tendonosis. The knee was also evaluated for evidence of subchondral bone marrow edema, joint effusion, and evidence of cystic lesions. Both the cruciate and collateral ligaments were visualized and evaluated for structural integrity and evidence of tears. The MRI was also reviewed for any other abnormal findings, which were recorded.

Inclusion Criteria

Each subject was a signed NBA player from the same team being evaluated for a routine preparticipation physical. The team physician (B.J.C.) performed the history and physical examination on all players. Each player's past medical history was reviewed for playing time missed due to knee complaints, prior knee injury, or knee surgery. One player had a previous arthroscopy on his left knee; one player had a small lateral arthrotomy on his right knee for open irrigation and debridement of a suspected, but not confirmed septic knee; and one player reported a history of a medial collateral ligament sprain on his right knee. All players were asymptomatic at the time of this evaluation. All players were questioned about history of swelling, mechanical symptoms, and instability. Each player included in the study demonstrated painless full range of motion, no joint effusion, no ligamentous instability, no joint-line tenderness, negative patellofemoral compression test, and no neurovascular compromise.

RESULTS

Twenty-five (89.3%) of the 28 knees imaged had one or more abnormalities, and only 3 knees (10.7%) had no

TABLE 1

PREVALENCE OF KNEE ABNORMALITIES

Abnormality	Right Knees	Left Knees	Total
Normal*	1	2	3 (10.7%)
Abnormal signal/chondromalacia of articular cartilage	6	8	14 (50%)
Focal chondral defect	1	1	2 (7.1%)
Subchondral bone marrow edema	2	5	7 (25%)
Meniscal tears	0	1	1 (3.6%)
Possible meniscal tear	2	0	2 (7.1%)
Reactive signal without meniscal tear	8	7	15 (53.6%)
Joint effusion	3	5	8 (28.6%)
Patellar tendonosis	5	6	11 (39.3%)
Cystic lesion	2	2	4 (14.3%)
Quadriceps tendonosis	1	1	2 (7.1%)
Pre-patellar bursitis	0	2	2 (7.1%)
Loose body	1	1	2 (7.1%)
Synovial hypertrophy	1	1	2 (7.1%)
Non-ossifying fibroma	1	1	2 (7.1%)
Bone island	1	0	1 (3.6%)
Osteochondral Fx	1	0	1 (3.6%)

* Each normal knee involved separate study participants. All 3 study participants had an abnormality involving the contralateral side.

TABLE 2

FREQUENCY OF ARTICULAR CARTILAGE LESIONS BY LOCATION

Location	No. in Right Knee	No. in Left Knee	Total
Patella	6	6	12 (44.4%)
Trochlear groove	2	5	7 (25.9%)
Medial femoral condyle	2	2	4 (14.8%)
Lateral femoral condyle	1	2	3 (11.1%)
Lateral tibial plateau	0	1	1 (3.7%)
Total articular cartilage lesions	11	16	27 (100%)

evidence of abnormalities on MRI (Table 1). There was no significant difference between the right and left knees for any of the categories assessed. All 14 players had at least one knee showing MRI evidence of abnormality. Fifty percent of the knees had evidence of an articular cartilage abnormality. The frequency and specific locations of the articular cartilage lesions within each knee (27 lesions in 14 knees) are summarized in Table 2. Of the 14 knees with articular changes, 100% had involvement of the patellofemoral joint. A total of two knees had sizeable focal chondral defects: a 6.2×4.8×2.6-mm central medial femoral condyle defect, and a 1.0×0.6×0.3-cm lateral patellar defect in another player (Figure 1).

A total of 15 knees (53.6%) had presumed degenerative changes of the meniscus without evidence of focal tearing (Figure 2). Meniscal tears could not be excluded in two of the knees. However, one knee had evidence of a linear Grade II signal in both the medial and lateral menisci, which were consistently read as partial tears. Joint effusion was present in 28.6% of the knees and subchondral edema was present in 25% of the knees. The subchondral edema occurred in the areas with overlying articular cartilage abnormalities. There was evidence of tendonosis in 11 (39.3%) of the 28 patellar tendons and 2 (7.1%) of the distal quadriceps tendons (Figure 3). Two knees (7.1%) had evidence of possible early prepatellar bursitis. Synovial hypertrophy was apparent in 2 knees (7.1%). Four knees (14.3%) had cystic lesions: 3 small Baker's cysts and 1 small subcortical cyst of the posterior distal lateral femoral metaphysis. Of the 28 knees, 2 knees (7.1%) had loose bodies on MRI. There was a 1.5×2.0-mm loose body located in the medial compartment in one player, and a 1.4×0.4×0.4-cm loose body located at the medial aspect of the patellofemoral joint space in another player. Other abnormalities that were detected included one osteochondral fracture of the patella (age could not be determined), two non-ossyifying fibromas (1.3×0.8×0.8 cm and 1.4×2.4×0.5 cm) (Figure 4), and one bone island identified at the lateral aspect of the medial femoral condyle. None of the 28 knees had abnormalities of the cruciate or collateral ligaments.

DISCUSSION

The most compelling observation is that in this small, select group of asymptomatic professional basketball players, 25 (89.3%) of 28 knees had abnormalities on routine preseason knee MRI evaluation. The high prevalence of articular cartilage abnormalities is of particular interest due to the extensive and consistent load placed on the knee in elite basketball players. Major and Helms[22] described a 41% prevalence of abnormal articular cartilage on knee MRI in collegiate basketball players. Kaplan et al[15] reported 47.5% of NBA players had articular cartilage lesions. Our study was consistent with these prior studies regarding the prevalence of articular cartilage signal abnormality (50%) primarily affecting the patellofemoral

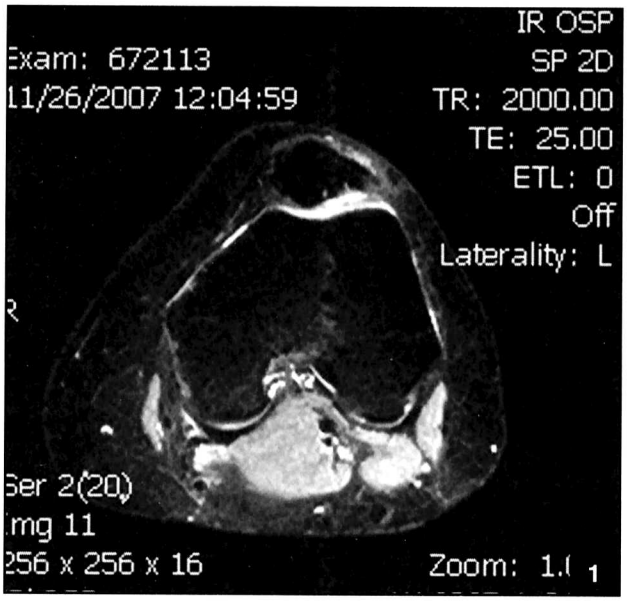

Figure 1. Fast spin-echo transverse MRI with evidence of T2 hyperintensity within the lateral aspect of patellar cartilage.

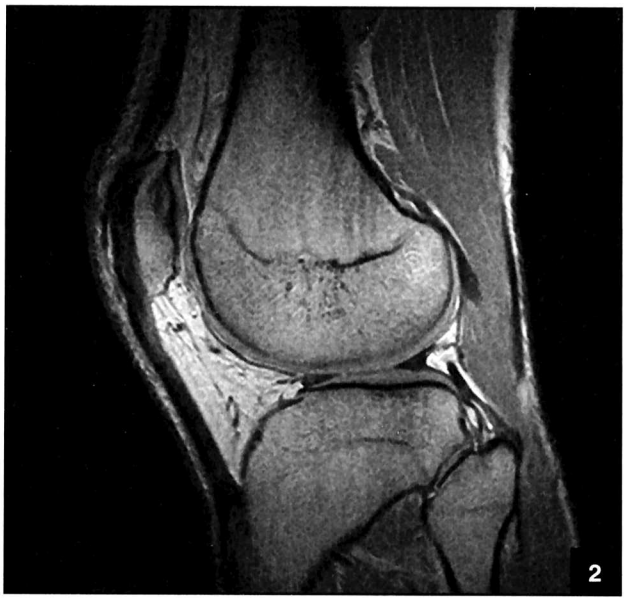

Figure 2. Proton density fast spin-echo sagittal MRI of increased signal without evidence of meniscal tears.

joint.[15,22] Specifically, the femoral trochlea was involved in 25% of the knees in our study which is identical to the 25% prevalence reported by Kaplan et al in their study of NBA players.[15] These numbers are not only consistent, but also remarkably higher than the prevalence of patellofemoral joint abnormalities in the general population (3.7%).[19] The patellofemoral joint is an important weight loaded joint. It is apparent that degenerative changes occur more frequently in elite basketball players, compared with other individuals. Potential activities involved in basketball that influence the prevalence of degenerative changes include jumping and direct contact to the knee. This appears to support previous studies documenting greater cartilage deformation in weight lifters performing knee-bending exercise[11] and may have implications for the kind of exercises and training regimens recommended for basketball players. Although all of the players were functioning at the highest level of competitive athletics without complaints of knee symptoms, research continues to support evidence that degenerative changes occur throughout the careers of these athletes.

The prevalence of joint effusions in collegiate basketball players was reported to be 35% by Major and Helms.[22] We found a similar, but slightly lower, prevalence in professional players (28.6%). One player noted to have minimal joint effusion missed 1 day of practice prior to this study due to knee effusion. No playing time was missed due to joint effusion in the rest of the sample prior the study. This further supports the notion that athletes are able to function at a high level of activity despite the presence of a minor joint effusion.

The prevalence of patellar tendon signal abnormalities was slightly higher in this study of professional athletes, compared with collegiate athletes. Major and Helms[22] reported a 24% incidence of patellar tendon abnormalities in the collegiate population, which is significantly less than the 39.3% we found in this population of professional basketball players. This difference may represent chronic changes in a population of players exposed to a longer duration of repetitive patellar tendon loading.[1,32]

The significance of bone marrow edema in apparently asymptomatic athletes in not known. Previous investigation of the prevalence of bone marrow edema was reported to be 41% in collegiate players.[22] However, our study of professional basketball players, who are often larger and older than collegiate players, yielded a lower prevalence (25%).

Physical demands of basketball involve running, jumping, cutting, and twisting. These movements place an enormous demand on the meniscus. Therefore, the prevalence of meniscal pathology, particularly meniscal tears, is of interest. Wide variability has been reported in the literature on asymptomatic meniscal tears. Major and Helms[22] found no meniscal tears in 34 knees of collegiate basketball players. This is contrasted by Kaplan et al,[15] who reported that 20% of their professional basketball players had evidence of meniscal tears on MRI. Our examination of 28 knees of professional basketball players found only 1 knee (3.6%) with a partial thickness meniscal tear. Although the reason for this variation is unknown, several factors are evident. It is possible that variations in

Figure 3. Evidence of mild patellar tendonosis in the left knee of an asymptomatic 29-year-old professional basketball player.

Figure 4. Non-ossifying fibroma in a right knee of an asymptomatic 22-year-old professional basketball player. Note the lack of signal at the distal femoral metaphysis.

the sensitivity of MRI machines influence the prevalence of pathology. This variability could also be due in part to the examiners' definition of a tear or meniscal pathology varying, depending on the sample population.

Cystic lesions have also been reported in previous literature. Major and Helms[22] found one cyst involving the ACL. Three small Baker's cysts and one small subcortical cyst were found in our athletes.

Other interesting findings in our population were the presence of a small bone island, two non-ossifying fibromas, and two loose bodies. One player's knee had an osteochondral fracture of the patella. Two players had prepatellar bursitis. These findings did not affect the players, as all were asymptomatic and were cleared to play at the highest athletic level.

It is interesting to study professional basketball players because these athletes place the highest level of demand on their knees. The high prevalence of degenerative and inflammatory changes affecting the articular cartilage, menisci, and patellar and quadriceps tendons is evidence that the athletic demands placed on the lower extremity in professional basketball players are not without cost to the knee. Although the number of articular cartilage abnormalities has been consistently near 50% and greatest in the patellofemoral joint, the prevalence of meniscal pathology varies. Kaplan et al[15] reported a 20% prevalence in professional basketball players, but our study is consistent with the lower numbers of meniscal tears reported by Major and Helms.[22] However, it would be interesting to follow these athletes in a cohort study to find the percentage of players who develop clinical symptoms suggestive of a meniscal tear. It is possible that the potential ramifications of the players' salary or playing time may have led players to underreport their symptoms. However, it is documented that the use of MRI alone may lead to false-positive findings.[30,33] Therefore, it is recommended to use MRI as an adjunct to clinical examination and to have the images evaluated by a musculoskeletal radiologist.

There are several limitations to this study. The cross-section data reflect only one NBA team at a given point in time. Work is underway to compile the data from several NBA teams to further define the prevalence rates across the league, which may be highly variable. The use of standardized knee MRI protocols is helpful because the use of different scanners and techniques may affect the ability of the radiologist to detect subtle abnormalities. In addition, although this study reports the prevalence of abnormalities in this select group, it does not address the significance of such abnormalities. Although all players were asymptomatic at the time of imaging, it would be interesting to correlate when and whether any of these findings become symptomatic over time. To this end, we are in the process of obtaining serial images in both the preseason and postseason, as well as over several consecutive seasons.

We think that because knee abnormalities vary widely in asymptomatic athletes, preseason MRI should be obtained for all players for future comparison, and a registry of abnormalities should be begun for future data analysis. This may prove to be clinically advantageous for injury

prevention, better diagnostic accuracy that may reduce game or practice time missed, and faster rehabilitation following injury. In the season following the procurement of these preseason MRIs, two knee injuries occurred, which demonstrated no interval change on MRI, whereas two separate knee injuries demonstrated new MRI findings. The preseason MRI was particularly helpful in determining the treatment plan and recommendations for return-to-play, and for counseling athletes on future risks for knee symptoms or options for future treatment.

CONCLUSION

The majority of professional basketball players have one or more abnormalities within the knee. This is further support for the use of clinical correlation when evaluating a player's injury. The fact that knee abnormalities vary widely in asymptomatic athletes is evidence to offer players preseason MRI for future comparison and to begin a registry of abnormalities for future data analysis. This may prove to be clinically advantageous for injury prevention and improving diagnostic accuracy for knee complaints. Ultimately, a baseline MRI can be used as a powerful tool to better treat asymptomatic or symptomatic knees.

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