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The Prevalence of Abnormal Magnetic Resonance Imaging Findings in Asymptomatic Knees

With Correlation of Magnetic Resonance Imaging to Arthroscopic Findings in Symptomatic Knees*

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ABSTRACT

The purpose of this study was to prospectively evaluate the prevalence of abnormal magnetic resonance imaging scans of the knees of asymptomatic subjects. A prospective analysis of magnetic resonance imaging to arthroscopic findings in symptomatic knees was also performed. The prevalence of meniscal tears found in asymptomatic knees was 5.6% (medial meniscus, 1.9%; lateral meniscus, 3.7%). Other abnormal findings included a prevalence of 1.9% for degenerative changes of the medial femoral condyle and 3.7% both for ganglion cysts and patellofemoral joint articular cartilage degenerative changes. There was also a prevalence of 24.1% of Grade II signal changes of the posterior horn of the medial meniscus. Statistical comparison of our results to previous studies revealed that the magnetic resonance imaging scan readings on the asymptomatic knees in this study were accurate and lesions were correctly identified. We recommend that clinicians match clinical signs and symptoms with magnetic resonance imaging findings before instituting surgical treatment because of a 5.6% prevalence of meniscal tears in the asymptomatic population. The significance of the high percentage of posterior horn medial meniscal Grade II signal changes is unknown.

Magnetic resonance imaging (MRI) has been used in the interpretation of intraarticular pathologic changes of the knee joint since the studies of Reicher et al.[25] in 1985 demonstrated its clinical usefulness. Because it is painless, noninvasive, does not use ionizing radiation, and has no known adverse biological effects on humans,[2,11,21,30] MRI has replaced arthrography as the diagnostic tool of choice for intraarticular knee lesions. Magnetic resonance imaging can provide high sensitivity, specificity, and accuracy in diagnosing cruciate ligament and meniscal tears.[8,13,16,17,34] Magnetic resonance imaging has also proven useful in the diagnosis of patellofemoral disorders, intraarticular loose bodies, and osteochondral lesions.[17,25,33]

In spite of the increasing sensitivity and specificity of MRI in identifying intraarticular pathologic changes, it still may not reveal the real cause of a patient's symptoms because the denominator of asymptomatic patients with positive MRI findings of intraarticular pathologic changes is unknown at this time.[26] Previous studies in the spine literature have revealed that there is a large percentage of asymptomatic individuals with documented positive findings on diagnostic imaging studies of the cervical spine (19% to 57%)[2,32] and lumbar spine (28% to 35%).[1,35] This type of information is not available for lesions about the knee.

The goal of this study was to determine the prevalence of abnormal findings on MRI scans of the knee in asymptomatic patients through a controlled, prospective study. This information may assist the clinician in correlating clinical signs and symptoms to MRI findings before instituting surgical treatment.

MATERIALS AND METHODS

The study sample consisted of 54 patients (25 men and 29 women) with asymptomatic knees. The average age of the

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patients was 28.5 ± 4.7 years (range, 19 to 39; 1 SD). The project was approved by the Institutional Review Board and all patients signed an informed consent form. The subjects consisted of health professional volunteers or patients in the Southwest Michigan Sports Medicine Clinic seen for injuries not related to their knees. A clinical history was obtained on each patient and none demonstrated a previous history of knee injuries, traumatic or atraumatic effusions, or symptoms consistent with a possible intraarticular derangement, such as catching, locking, or instability of the knee. A brief physical examination was also performed that documented a full, painless range of motion of the knee, a negative McMurray test, and a stable knee. The instability tests included valgus and varus stressing of the knee, Lachman examination, and anterior/posterior drawer testing to rule out laxity of the collateral or cruciate ligaments.

We established the age range as 18 to 39 years before the initiation of the study for two reasons. First, children and preadolescents may have increased signal intensity in the posterior horns of the menisci because of normal meniscal vasculature[22]; this may have been interpreted as an abnormal scan. Second, the upper age was chosen to avoid those patients who may have asymptomatic degenerative meniscal tears.[5,19] Degenerative meniscal tears have been noted to increase with aging but are rare in patients less than 40 years old.[15,20]

A concurrent, prospective study was performed to analyze MRI and arthroscopic findings in symptomatic knees. This group of 72 patients (48 men and 24 women) had MRIs before undergoing arthroscopy of their knees (Table 1). The average age of these patients was 34.0 ± 15.9 (range, 14 to 78; 1 SD). This portion of the study was performed to determine the reliability of the asymptomatic MRI scans. Since we could not perform arthroscopies on asymptomatic knees to determine the accuracy of the MRI findings, MRI scans and arthroscopic results for symptomatic knees were evaluated so they could be compared with the MRI scans of the asymptomatic population. The asymptomatic and symptomatic MRI scans were randomly mixed along with others obtained in the community to eliminate any potential bias in reading them. All arthroscopic procedures were performed by one of the two senior orthopaedic surgeons (QB, MV).

Magnetic resonance imaging findings of meniscal lesions were graded I to IV.[6,11,28] Grade I signal intensity was focal and did not extend to the meniscal surface. Grade II signals were linear signals within the meniscus and also did not extend to the meniscal surface. Grade III tears extended to the meniscal surface. Grade IV tears demonstrated architectural distortion of the meniscus.

Ninety-five percent simultaneous confidence intervals (CIs) for accuracy, sensitivity, and specificity were used to evaluate the reliability of the MRI scans. The Bonferroni fix was the method of simultaneous inference. This analysis was conducted on data concerning medial meniscal tears, lateral meniscal tears, and ACL tears. In addition, Fisher's exact test was used to evaluate the reliability of the scans. To address the prevalence of knee abnormalities in the asymptomatic population, standard 95% CIs for a single population proportion were used.

All patients were scanned on a Siemens 1.0 Tesla Magnetom (Siemens Medical Systems, Erlangan, Germany) using a dedicated send/receive extremity coil. A 16-cm field of view and a 128 × 256 matrix were used for all examinations. Oversampling in the frequency and coded direction was routinely used. In all cases 4-mm sagittal T1-weighted spin echo (echo time [TE] 20/repetition time [TR] 500 to 900) and 5-mm sagittal and coronal proton density/T2-weighted spin echo (TE 25/90/TR 2000 to 2700) sequences were performed. Two signal averages were used for the T1-weighted sequences and one signal average for the proton density/T2-weighted sequences.

At the beginning of each study, the knee was placed in approximately 20° of external rotation. An axial T1-weighted localizer sequence was used to set up the sagittal and coronal sequences. If the ACL was not well seen on the initial sagittal T1-weighted sequence, the sagittal images were rotated slightly to visualize the contents of the intercondylar notch clearly.

RESULTS

In the asymptomatic study, one tear of the medial meniscus was found in a 31-year-old man (Fig. 1), for a prevalence of 1.9% (95% CI: 0.0, 5.4). Thirteen subjects (six men and seven women) had Grade II signal changes of the posterior horn of the medial meniscus (Fig. 2). The prevalence of Grade II changes of the medial meniscus was 24.1% (95% CI: 12.7, 35.5). The average age of these patients was 29.5 years (range, 19 to 38).

Two patients, a 37-year-old woman and a 38-year-old man, had tears of the lateral meniscus. The prevalence for lateral meniscal tears was 3.7% (95% CI: 0.0, 8.7). No intrameniscal signal changes were seen in this study for the lateral meniscus.

There were no ACL tears seen in the asymptomatic population. In addition, there were no subchondral bone bruises. Other findings included two male patients, aged 25 and 35, with early patellofemoral joint articular cartilage degenerative changes. The prevalence of early patellofemoral joint arthritis was 3.7% (95% CI: 0.0, 8.7). Two patients

TABLE 1
Results of MRI vs. arthroscopy for symptomatic knees

Site	MRI		Arthroscopy		Accuracy (%)	Sensitivity (%)	Specificity (%)
	Normal	Torn	Normal	Torn			
Medial meniscus	37	35	38	34	98.6	100	97.4
Lateral meniscus	57	15	52	20	90.3	70.0	98.1
ACL	45	27	44	28	98.6	96.4	100

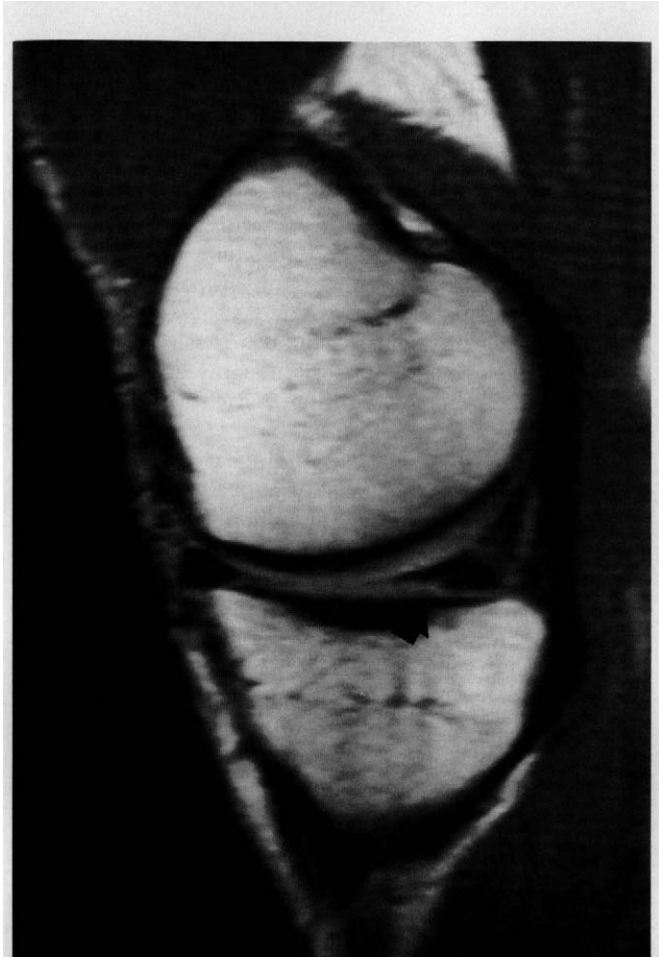

Figure 1. Sagittal section MRI scan demonstrating a posterior horn tear of the medial meniscus (arrow) in an asymptomatic 31-year-old man.

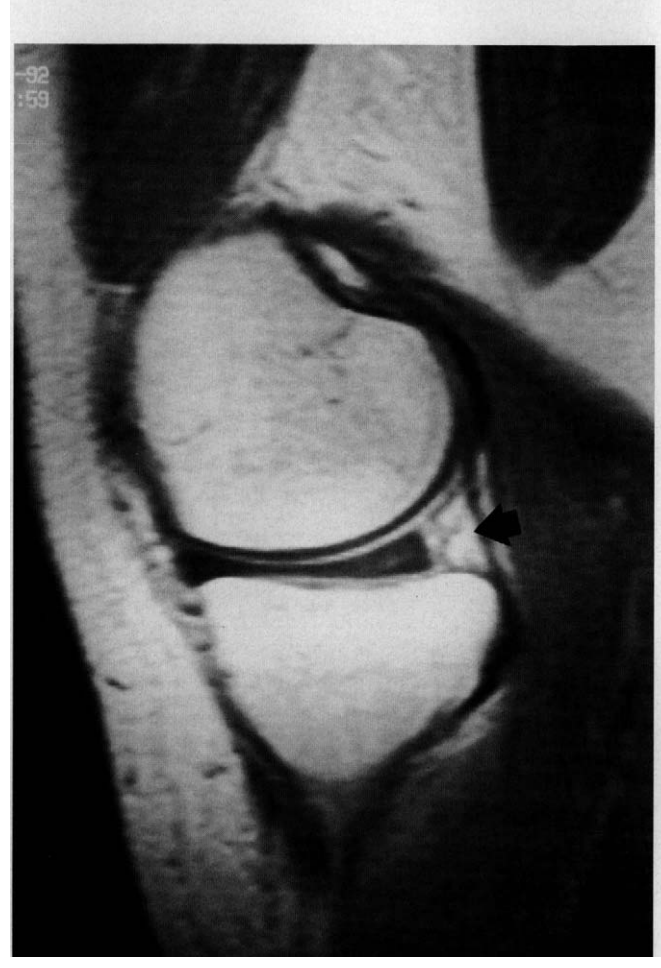

Figure 2. Sagittal section MRI scan demonstrating Grade II signal change of the posterior horn of the medial meniscus (arrow) in an asymptomatic 29-year-old woman.

had ganglion cysts (both were 30-year-old women) (Fig. 3). The prevalence of ganglion cysts was 3.7% (95% CI: 0.0, 8.7). One subject, a 27-year-old man, had early degenerative changes of his medial femoral condyle articular cartilage for a prevalence of 1.9% (95% CI: 0.0, 5.4).

For the symptomatic portion of this study, arthroscopy was the standard against which the MRI results were compared. For the medial meniscus, there was 1 false-positive and 34 true-positive MRI reports, and 37 true-negative and no false-negative reports. There were four Grade II signal changes of the posterior horn of the medial meniscus read, and all were found to be normal at arthroscopy. There were 14 true-positive and 1 false-positive, and 51 true-negative and 6 false-negative lateral meniscus MRI reports. Magnetic resonance imaging reports and arthroscopic correlation for the ACL revealed no false-positive and 27 true-positive results. In addition, there were 44 true-negative reports and 1 false-negative report. Contingency tables were constructed for the MRI and arthroscopic results. Fisher's exact testing on all three contingency tables revealed statistically significant results ($P < 0.0001$), which indicated that the MRI results and arthroscopic results were related.

For the medial meniscus, the accuracy (the percentage of patients for whom the diagnosis based on the MRI was correct) was 98.6% (95% CI: 95.4, 100.0), sensitivity (the percentage of patients with positive MRIs who were found to have tears at arthroscopy) was 100%, and the specificity (the percentage of patients with normal MRI readings who were found to have normal menisci at arthroscopy) was 97.4% (95% CI: 91.4, 100.0). The accuracy for the lateral meniscus was found to be 90.3% (95% CI: 82.3, 99.0), the sensitivity was 70.0% (95% CI: 49.3, 99.4), and the specificity was 98.1% (95% CI: 93.6, 100.0). Anterior cruciate ligament findings had a 98.6% accuracy (95% CI: 95.4, 100.0), a sensitivity of 96.4% (95% CI: 88.4, 100.0), and a specificity of 100.0%. Statistical comparison with previous studies (Bonferroni fix) was also performed (Table 2). Statistically significant improved findings were found compared with some studies, and no study was found to have statistically significant improved findings in any category compared with our study.

DISCUSSION

This study was done to document the prevalence of asymptomatic subjects with intraarticular knee lesions.[26] As al-

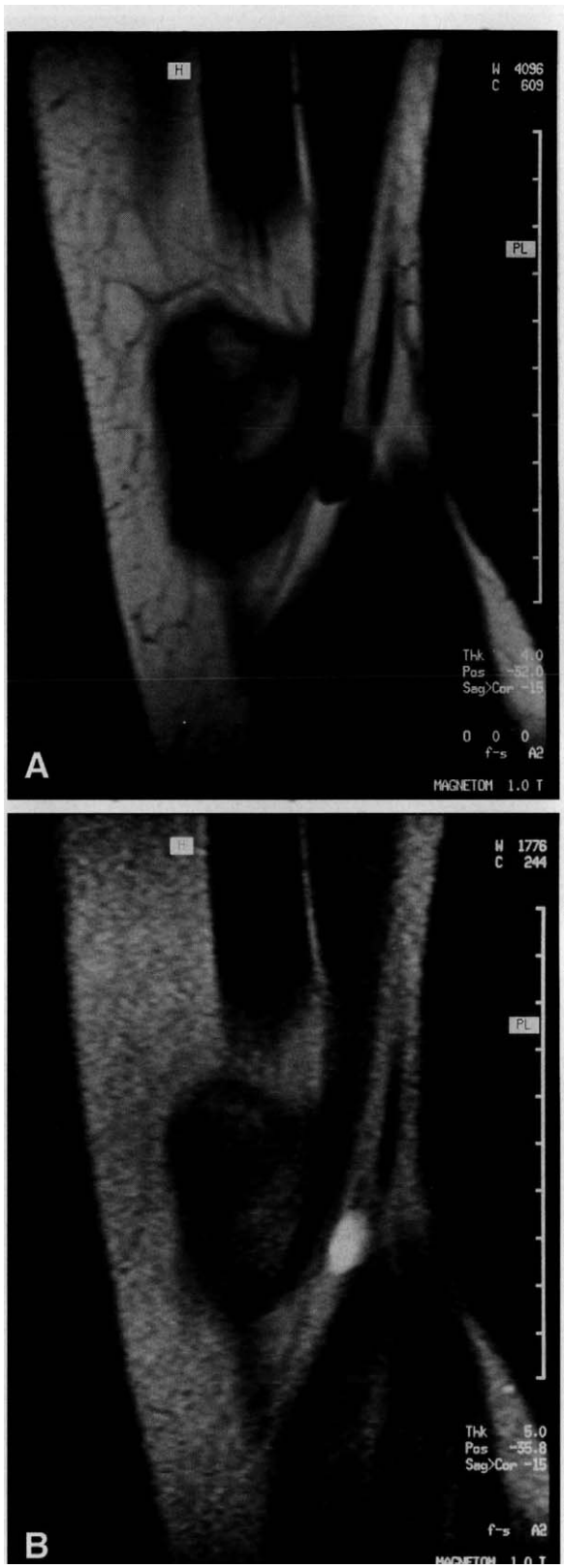

Figure 3. Ganglion cyst in an asymptomatic 30-year-old woman. A, sagittal T1-weighted spin echo sequence revealing low signal intensity of cyst. B, sagittal T2-weighted spin echo sequence demonstrating high signal intensity of cyst.

ready mentioned, previous studies in the spine literature have revealed that there is a significant percentage of asymptomatic individuals with documented positive radiologic findings on testing for the cervical and lumbar spine, but this type of information was not available for lesions about the knee. While Brunner et al.[4] did perform MRI scans on 20 subjects who were currently asymptomatic, at least five of their patients had a history of previous knee injuries or surgeries. Kornick et al.[14] reported on MR imaging of the meniscus for 64 patients between the ages of 10 and 74. No physical examination was performed on these patients to evaluate possible meniscal lesions. In addition, a large proportion of their patients appeared to be children or older patients, with both of these age groups having previously mentioned findings that may affect the outcome. In light of this, it is difficult to assess how these findings relate to the truly asymptomatic population.

We chose to review a large group of subjects in a narrow age group that would be more likely to be involved in high-demand activities, would desire a quicker return to activity, and would therefore be more likely to obtain a knee MRI scan than an older population. In addition, this age group was chosen because of the low chance of having asymptomatic degenerative changes of the knee.[5,15,19,20]

Like all studies that are performed on asymptomatic patients, in this study we could not perform arthroscopy to confirm the MRI readings. When we initiated our study protocol, we also prospectively recorded all patients who had knee MRI scans and arthroscopies by the authors over the same time period as the protocol. This allowed us to document the current accuracy, sensitivity, and specificity of MRI readings on intraarticular knee abnormalities for our community (Table 1) and to establish confidence intervals for our asymptomatic study MRI findings. All MRI scans in our study were randomly mixed with each other and other studies performed for other physicians in our community before diagnostic interpretation.

MRI versus arthroscopic surgery results

The accuracy, sensitivity, and specificity of the MRI readings for the medial meniscus, lateral meniscus, and ACL in our study were compared with previous studies (Table 2) and revealed similar overall findings for MRI readings. The accuracy for the medial meniscus ranged from 72% to 98%, 72% to 96.6% for the lateral meniscus, and 72% to 100% for the ACL in these studies. Our accuracies were similar to previously published articles at 98.6% for the medial meniscus, 90.3% for the lateral meniscus, and 98.6% for the ACL. Most importantly, while our study had statistically significant improved accuracies, sensitivities, or specificities compared with some studies, there were no studies that had a statistically significant improved reading in any category compared with our study.

The accuracy, sensitivity, and specificity for MRI readings of the medial meniscus and ACL for symptomatic knees were very high and imply that the MRI readings for the asymptomatic knee portion of the study were correct (Table 1). The readings for the lateral meniscus revealed a sensitivity of 70% and a specificity of 98.1% for symptom-

TABLE 2
Review of the accuracy, sensitivity, and specificity for MRI vs. arthroscopic surgery for the medial meniscus, lateral meniscus and ACL

Study	No. of knees	Medial meniscus			Lateral meniscus			ACL		
		Accuracy (%)	Sensitivity (%)	Specificity (%)	Accuracy (%)	Sensitivity (%)	Specificity (%)	Accuracy (%)	Sensitivity (%)	Specificity (%)
Current Study	72	98.6	100	97.4	90.3	70.0	98.1	98.6	96.4	100
Fischer et al.[8]	1014	89[a]	93[a]	84[a]	88	69	94	93[a]	93	93[a]
Kelly et al.[13]	60	88[a]	97	77[a]	88	90	87	93	87	94
Raunest et al.[23]	50	72[a]	94	37[a]	72[a]	78	69[a]			
Glashow et al.[9b]	50	74[a]	77[a]	71[a]	94	93	94	72[a]	61[a]	82[a]
Jackson et al.[11]	87	93.1	97.6	89.1	96.6	84.6	98.7	96.6	100	96.3
Mink et al.[18c]	242	94	97	89	92	92	91	95	92	95[a]
Polly et al.[21]	50	98	95.8	100	90	66.7	95.1	97.3	100	96.9
Mandelbaum et al.[17]	105	90[a]	95.7	81.8	91	75	95	100	100	100

[a] Statistical significance demonstrated for this category subject in this study compared with our current study (Bonferroni fix).
[b] Some portions of table calculated from data presented in this article.
[c] We were unable to perform statistical analysis on the meniscal portion of this study from the data presented in the article.

atic knees. There were one false-positive and six false-negative reports in this portion of the study. An analysis of this data implies that, for our asymptomatic knee MRI scans, if a lateral meniscus scan is read as a tear, it is highly probable that is it a tear, but not all true tears may be identified. To summarize, asymptomatic knee lateral meniscus MRI scans may have been underread but not overread for tears in this study. This finding concurs with the literature cited here (Table 2).[8,9,11,13,17,18,21,23]

Asymptomatic knee MRI analysis

The importance of MRI in the diagnosis of knee pathologic changes has been increasing in recent years.[7,8,13,23,33,34] It has also helped to identify new areas of abnormalities, such as subchondral bone bruises,[33] that were not appreciated previously. However, we have found it to be increasingly used as a screening tool for knee problems without a proper history and physical examination. Because of this, we thought that it was necessary to help identify the prevalence of asymptomatic knees with abnormal MRI findings in the population.[26] Knowing the underlying prevalence of intraarticular knee changes in the asymptomatic population can aid the clinician in decision-making when MRI and clinical results do not correlate.

The 5.6% prevalence of meniscal tears in the asymptomatic population attests to the need to match the history and physical examination results to the MRI report. The average age of our study group was 28.5 years, and one could assume that the prevalence of asymptomatic findings in an older population would be increased.[5,15,19,20] While the average age of the subjects with asymptomatic meniscal tears was older (35.3 years) than the overall average age, there were too few patients to determine statistical significance. Although not proven statistically, our data suggest a trend for patients to have an increased incidence of degenerative meniscal tears with increasing age for the age group studied.

There were no ACL tears found in the study population. In addition, there were no subjects with subchondral bone bruises.[33] This finding was consistent with the history of no significant knee injuries and our pre-MRI physical examination.

We believe that the findings of ganglion cysts and early patellofemoral and medial femoral condyle articular cartilage degenerative changes in this study may not have clinical relevance. They were reported here only for completeness.

Significance of intrasubstance Grade II MRI meniscal signal changes

Grade II meniscal signal changes represent intrasubstance increased signal intensity within the meniscus that does not extend to the joint surface.[6,11,28] Hajek et al.[10] compared MRI signal changes with histologic studies in cadavers and reported that the central high-intensity signals (Grade I or II) within the meniscus on MRI indicated meniscal degeneration. Kaplan et al.[12] reported on the histologic analysis of a meniscus with intrasubstance changes seen on MRI and found that collagen degeneration and separation of collagen bundles was present without extension to a joint surface. Stoller et al.[31] also reported that they thought intrasubstance meniscal changes on MRI (Grades I or II) represented a continuum of degenerative changes that would culminate in a complete Grade III tear.

A compilation of studies reporting intrasubstance Grade II meniscal signal changes with arthroscopic correlation revealed an overall tear rate of 14.3% at arthroscopy[6,8,12,13,24,28] (Table 3). Intrasubstance meniscal signal changes were seen more commonly in the medial meniscus (58%) compared with the lateral meniscus (42%), but some studies do report these intrasubstance meniscal signal changes to be more common in the lateral meniscus.[12,13,24] In addition to the above studies, there were four Grade II signal changes of the posterior horn of the medial meniscus in our study. None of our Grade II signal changes demonstrated a meniscal tear at arthroscopy. No intrasubstance tears were found for the lateral meniscus. It is possible that in a larger study these signal changes may be present. Arnoczky (personal communication, 1993) has found similar results with MRI scans of cadaveric knees.

The significance of the Grade II MRI signal changes of the medial meniscus in asymptomatic knees seen in our study is unknown at this time. None of these subjects had any history of significant knee trauma and all had normal

TABLE 3
Summation of studies with arthroscopic correlation of Grade II MRI meniscal changes

Study	Medial meniscus		Lateral meniscus		Total	
	MRI Grade II findings	Tears found at arthroscopy	MRI Grade II findings	Tears found at arthroscopy	MRI Grade II findings	Tears found at arthroscopy
Reicher et al.[24]	4	0	6	2	10	2
Crues et al.[6]	**26**	**5**	**24**	1	50	**6**
Silva and Silver[28]	**8**	**3**	**0**	0	8	**3**
Fischer et al.[8]	**147**	25	**72**	12	219	**37**
Kaplan et al.[12a]	**1**	0	**12**	0	13	**0**
Kelly et al.[13a]	**21**	1	**36**	2	57	3
Total	**207**	34	150	17	357	51
Percentage tears		16.4		11.3		14.3

[a] Grade I and II intrasubstance meniscal changes were not separated in these studies.

physical examinations. It is possible that this finding is a normal variant or represents early, normal meniscal degeneration for this age group (19 to 38 years). It may also represent a history of a prior minor traumatic event. We believe that those patients who demonstrate Grade II meniscal signal changes should undergo appropriate nonoperative treatment initially. Based on our results, it appears that these signal changes occur frequently, at least in the medial meniscus, in the asymptomatic population. However, if symptoms persist over the course of several months, an arthroscopic evaluation may be considered in these patients because of the 14.3% incidence of meniscal tears documented at arthroscopy in the current literature (Table 3).

Clinical relevance of asymptomatic knee positive MRI findings

Because of the presence of abnormal MRI findings in the asymptomatic population we found in this study and false-positive scans found in this and other studies,[6,8,9,11,13,17,18,21,23,28] a positive MRI result should not be an indication for surgery unless the history and physical examination were found to be consistent with the MRI results. Knee arthroscopy is not a totally benign procedure and has its associated complications.[3,27,29] These complications must be considered when assessing whether a patient's history and physical examination justify arthroscopic surgery. Magnetic resonance imaging should not be used as a screening device to replace the history and physical examination and should only be used when a patient has symptoms and the diagnosis is in doubt.

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DISCUSSION

Walton W. Curl, MD, *Winston-Salem, North Carolina:* This was a well-controlled clinical study. The authors demonstrated a 14.9% overall prevalence of abnormal findings in their population. Not surprisingly, there was also a high number of Grade II changes in the medial meniscus of the patients. The authors stated that, at this time, these changes are still not an indication for surgical intervention. We need to have more long-term prospective studies done to determine the true nature of these Grade II findings.