We reviewed retrospectively the MRI examinations of 108 knees of 80 children to identify the prevalence of a high signal in the menisci of those without symptoms. There were 51 boys and 29 girls with a mean age of 12.2 years (8 to 15).

The prevalence of a high signal within the menisci was 66%, significantly higher than that in an adult group (29%). The prevalence decreased with age: grade-2 and grade-3 changes were observed in 80% of menisci at ten years of age, in 65% at 13 years and in 35% at 15 years. The prevalence of high signals also decreased with increased skeletal maturity at the knee.

We emphasise the importance of awareness of the high prevalence of a high signal intensity in the menisci of children, especially in early adolescence.

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MRI of the knee has a sensitivity and specificity of over 90% for the detection of meniscal tears in adults and uses a grading system which classifies a high signal intensity within the meniscus as degenerative change or a tear. In children there is frequently a high signal within the meniscus which reflects the normal vascularity. This may confuse the diagnosis of meniscal abnormality. We have investigated the prevalence of a high signal within the meniscus in asymptomatic children and examined whether this prevalence changes with age.

Patients and Methods

We reviewed retrospectively the MR images of 108 knees of 80 children. There were 51 boys and 29 girls with a mean age of 12.2 years (8 to 15). None had complaints related to the knee. MRI had been carried out in 76 knees as a control for studies of lesions in the opposite knee and in 32 for extra-articular problems such as Osgood-Schlatter’s disease or bone tumours. All the examinations were performed using either a Toshiba 0.5T MRT50A (13 knees) or Toshiba 1.5T MRT 200 FXIII (95 knees) scanner (Toshiba Medical, Tokyo, Japan). Sequences included sagittal T1-weighted spin-echo imaging (TR 500 ms; TE 25 ms), sagittal T2*-weighted gradient-echo imaging (TR 500 ms; TE 15 ms; flip angle 30°), coronal T1-weighted spin-echo imaging (TR 500 ms; TE 15 ms; flip angle 30°). The images had a 15 cm field of view, 5 mm section thickness, and a 256 × 256 matrix. The children lay supine in the scanner with the knee in approximately 10 to 15° of external rotation. Studies were performed with a high-resolution circumferential surface coil.

The images were interpreted retrospectively by two orthopaedic surgeons with experience of MRI and skeletal radiology who made a joint assessment. The menisci were graded by a modification of the classifications proposed by Lotysch et al and Crues et al. Grade 0 is normal (Fig. 1a), grade 1 shows an intrameniscal globular or ovoid signal not communicating with the articular surface of the meniscus (Fig. 1b), grade 2 describes an intrameniscal linear or wedge-shaped signal not communicating with the articular surface of the meniscus (Fig. 1c), grade 3a has an intrameniscal signal that equivocally communicates with the articular surface (Fig. 1d) and in grade 3b the intrameniscal signal clearly communicates with the articular surface (Fig. 1e). The grades observed were compared with the skeletal maturity of the knee which was assessed according to the staging system of Ehrenborg for the development of the tibial tuberosity. There are four stages: cartilaginous (C) before the ossification centres are seen, apophyseal (A) when these centres appear in the tongue of cartilage, epiphyseal (E) when the centres have coalesced to form a tongue of bone which has fused with the tibial epiphysis, and bony (B) when the epiphyseal lines have closed. Sixteen knees were classified as stage C with a mean age of 10.3 years (8 to 13), 12 as stage A with a mean age of 11.8 years (9 to 14), 64 as stage E with a mean age of 12.8 years (9 to 15) and 16 as stage B with a mean age...
of 13.7 years (12 to 15). As a control group we evaluated the MR images of 25 knees of 21 asymptomatic adults with a mean age of 22.1 years (12 to 25).

The location of the high signal intensity in the menisci was described as anterolateral, posterolateral, anteromedial or posteromedial.

Statistical analysis of the data was performed using the Mann-Whitney and Kruskal-Wallis tests, and the Spearman rank correlation.

**Results**

Of the 108 knees 66% had a high intrameniscal signal on T1-weighted spin-echo or T2*-weighted gradient-echo.
imaging. The appearance of the signal varied with the pulse sequence (Table I). A high intrameniscal signal on T1-weighted spin-echo images was seen in 40 knees (37%): two (2%) were grade 1, 24 (22%) grade 2, 12 (11%) grade 3a, and 2 (2%) were grade 3b. T2*-weighted gradient-echo images showed areas of high signal intensity more frequently (70 knees, 65%): 3 (3%) were grade 1, 32 (30%) grade 2, 31 (29%) grade 3a, and 4 (4%) grade 3b. In the control group of asymptomatic adults there was no significant difference in the prevalence of high signal intensity in the two types of image. The overall prevalence of high signal intensity within the meniscus was significantly higher in children than in adults (Table I).

The prevalence of high signal intensity on both images decreased with age in the children (Fig. 2). In those under ten years of age, grade-0 signal changes were seen in only 14% of knees, grade 2 in 57% and grades 3a and 3b in 14% each. Changes classified as grade 2 or higher were noted in 80% of knees of ten year-old children and in approximately 65% of knees of those aged between 11 and 13 years. The prevalence of high signal intensities was significantly lower (33%) in the knees of adolescents of 14 and 15 years of age.

The prevalence of a high signal within the meniscus also correlated with the skeletal maturity of the knee (Fig. 3). In stage-C or stage-A knees, changes of grades 2 and 3a were evident in nearly 75%. At stage E, changes of grade 2 or
higher were seen in approximately 50%, while at stage B these changes were present in 44%.

A high signal was seen most often in the posterior horn of the medial meniscus (Table II), with grade-2 or higher seen in the posterior horn in 62 (57%) and in the anterior horn in only 12 (11%) knees. In the lateral meniscus, 24 (22%) showed changes of grades 2 or higher in the posterior horn and 18 (17%) in the anterior horn.

No difference was found between boys and girls and the type of imaging system used did not influence the results.

Discussion

The prevalence of abnormal signal intensity in the menisci of knees which are free from symptoms has seldom been studied. Kornick et al. investigated 64 volunteers aged between 10 and 74 years and found that at least 25% had abnormal signals in their menisci. Only ten of these individuals were in their teens. LaPrade et al. also studied the prevalence of abnormal MRI findings in asymptomatic knees, but excluded children and adolescents from the study because they wanted to differentiate the prevalence of a high signal in the meniscus due to degeneration or a tear from that due to normal vascularity. We have shown a high intensity of signal in two-thirds of the children investigated, much higher than in asymptomatic adults or in previous studies. Although some of our children had extra-articular lesions such as Osgood-Schlatter’s disease none had evidence of intra-articular abnormality and no difference was found between the MRI appearance in these knees and that of the normal contralateral knees examined.

High signal intensity in the menisci of children may reflect normal vascularity which decreases with age. In a study of cadaver knees from subjects ranging in age from 3 months to 14 years, Clark and Ogden showed that vascularity in the menisci decreased with age before skeletal maturity. In our children a high intensity of signal was seen in the menisci in more than 60% under 13 years of age and in approximately 30% over the age of 14. The rate of growth in childhood varies considerably among individuals of the same chronological age and it is probably better to assess the intensity of signal with respect to skeletal age as determined by the appearance of the tibial tuberosity. Abnormalities on MRI were seen in more than 80% of menisci in stages A and C, in 55% in stage E and in 44% in stage B.

The grading system of MRI appearance introduced by Lotysch et al. and Crues et al. is now widely used. Kaplan et al. have pointed out, however, that not all abnormalities of signal fit clearly into one of these categories. We have found that some changes are neither clearly confined to the substance of the meniscus nor do they extend definitely to the meniscal surface. We have adopted a modification of the classification proposed by Zobel et al. in which a grade-3 signal was classified as one which equivocally communicated with the articular surface of the meniscus (grade 3a) or one which clearly did so (grade 3b). Several studies have indicated that a grade-2 signal in children often represents normal vascularity. King, Carty and Brady at arthroscopic examination in 21 symptomatic children also found no evidence of injury in any meniscus with signal intensity of grade 1 or 2. There are only two studies which referred to a grade-3 signal in menisci of children. In both, the grade-3a signal was defined as a possible and the grade-3b signal as a definite tear. Zobel et al., however, found a normal appearance in several menisci with a grade-3a signal at arthroscopy while all with grade-3b changes were torn. We noted that a grade-3a signal was often seen in our asymptomatic patients, especially in childhood and preadolescence whereas a grade-3b appearance was rare. Clinically, a grade-2 signal does not pose a significant problem, but arthroscopic examination is often indicated for menisci with grade-3 changes, although these may still represent no more than normal vascularity.

We found a higher prevalence of increased signal in the posterior horn of the medial meniscus in which degeneration and tears are most often found, and the differentiation of a high signal intensity from a meniscal tear at this site is of great clinical importance. Arnoczky observed that in adults the medial meniscus has a somewhat wider peripheral vascular penetration compared with that of the lateral meniscus, but this has not been shown in children. The reason for the increased prevalence of a high signal intensity in the posterior horn of the medial meniscus remains unclear, but it may be due partly to partial volume imaging which is more commonly seen in the medial meniscus.

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References


Table II. Prevalence of intrameniscal high signal intensity in asymptomatic knees according to meniscal location, by number of knees

<table>
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<th>2</th>
<th>3a</th>
<th>3b</th>
</tr>
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<td>8</td>
<td>9</td>
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<tr>
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<td>14</td>
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<td>1</td>
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<tr>
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<td>44</td>
<td>2</td>
<td>42</td>
<td>16</td>
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</tbody>
</table>

* anterior horn of the lateral meniscus  † posterior horn of the lateral meniscus  ‡ anterior horn of the medial meniscus  § posterior horn of the medial meniscus  p < 0.0001 (Kruskal-Wallis test)


