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Magnetic resonance imaging of meniscal degeneration in torn menisci: a comparison between anterior cruciate ligament deficient knees and stable knees

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Abstract Signal anomalies observed in magnetic resonance imaging of the intrameniscal tissue adjacent to the tear were compared between stable knees (group 1, 54 menisci) and anterior cruciate ligament (ACL) deficient knees (group 2, 98 menisci). The histological significance of these signal anomalies was also studied (n = 25). The frequency of intrameniscal signal anomalies adjacent to the tear was significantly lower in ACL-deficient knees than in ACL-stable knees (P = 0.0022). There was a close correlation between the imaging anomalies and the presence of histological lesions (fissures, degeneration) within meniscal tissues adjacent to the tear (sensitivity: 0.95, specificity: 0.60). Our results suggest that the severity of intrameniscal degenerative changes adjacent to the tear are lower in ACL-deficient knees than in ACL-stable knees.

Key words Meniscus · Degeneration · Magnetic resonance imaging · Histology · Chronicity of the meniscal tear

Introduction

The outcome of meniscal repair depends upon many factors, including tear location, extent and type of tear, chronicity, patient age, and knee stability [2, 4, 14, 18, 20]. Several authors have reported that the results of meniscal repair in anterior cruciate ligament (ACL) reconstructed knees are significantly better than those in isolated repairs in ACL-stable knees [3, 9, 21]. The healing rate of meniscal repairs is also determined by other factors at the time of surgery. The conditions of the torn menisci (deformed, superficial damage, and locking) at the time of repair are reported to affect the results of meniscal repair [1, 12]. Henning and coworkers have [8–10] shown that rasping not only the rim side but also the handle side of the tear site improves results. However, less information is known regarding the intrameniscal degenerative change adjacent to the tear. In this study we compared signal anomalies observed in magnetic resonance imaging (MRI) of the intrameniscal tissue adjacent to the opposing edges of the tear between ACL-deficient knees and stable knees. Furthermore, we investigated the histological significance of these signal anomalies in meniscal tear fragments.

Materials and methods

Patients

The criterion for inclusion in this study was a full-thickness longitudinal tear in the peripheral third zone diagnosed by arthroscopy. Between April 1992 and March 1998, 152 torn menisci (80 medial menisci and 72 lateral menisci) in 120 patients met the criteria. The average age of patients was 27.3 years (range 14–61). Of the 152 menisci, 54 torn menisci in 53 patients were in the ACL-stable knee group (group 1; average age 29.2 years, range 17–61), and 98 torn menisci in 67 patients were combined with ACL tears (group 2; average age of 25.7 years, range 14–50). There was no significant difference in the age between two groups (P = 0.076). Twenty-six patients in group 1 had experienced no episodes of trauma, and the other 27 patients had had a clear episode of trauma. However, most of them had mild symptoms (such as intermittent knee pain or catching) at the time of trauma, and these had gradually worsened. In these 27 patients the average time from initial injuries to MRI was 3.9 years. In the 67 patients of group 2 the average time from their ligamentous injury to MRI was 1.5 years. The frequencies of signal anomalies in the intrameniscal tissue adjacent to the opposing edges of the tear in torn menisci were compared between groups 1 and 2. Twenty-five meniscal fragments from 25 menisci (group 1, 15 menisci; group 2, 10 menisci) in 21 patients obtained by arthroscopic partial meniscectomy were studied histologically using conventional light microscopy. The histological findings were compared with their corresponding MRI appearances.

MRI

MRI was performed in all patients within 2 weeks before arthroscopy. All MRI examinations were performed on a 0.5-T system (Shimazu SMT-100) using a transmit-receive coil. Slices were 5 mm thick, with an interslice gap of 1.5 mm. Spin-echo imaging was used. Proton density weighted sequences of 2500/25 (TR/TE) were used. Coronal and sagittal images were obtained in all patients. The intrameniscal signal anomalies in the body and rim of torn menisci were classified into four grades: grade 1, defined as a hyperintense zone, was neither in the body nor in the rim; grade 2, defined as a hyperintense zone, was in the rim; grade 3, defined as a hyperintense zone, was in the body; and grade 4, defined as a hyperintense zone, was both in the body and in the rim (Fig. 1). Each MRI was evaluated by two observers without knowledge of the arthroscopic findings or histological findings.

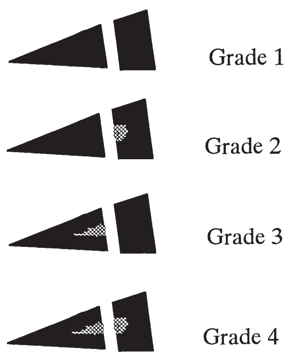

Fig. 1 Schematic illustration of the grading of meniscal signals adjacent to the tear

Table 1 MRI evaluation of torn menisci

Group	Grade 1	Grade 2	Grade 3	Grade 4
1 (n = 54)	4	12	2	36
2 (n = 98)	28	28	8	34

Histological examination

For each meniscus 10-μm sections perpendicular to the horizontal anatomical plane of the meniscus were made, and these sections were stained with hematoxylin and eosin, alcian blue, and Masson's trichrome stain. Histological examination consisted of defining the lesions in terms of two criteria: degeneration and fissuring. Degeneration was defined by the presence of foci of mucoid material within zones of low chondrocyte content and/or cyst formation. Fissuring was defined by the presence of lines of cleavage within the meniscal architecture.

Statistical analysis

Student's *t* test was used to compare differences in mean ages between two groups. Mann-Whitney's *U* test and χ^2 test were used to test for significant differences in the frequencies of the signal anomalies between two groups.

Results

Intrameniscal signal anomalies

The frequency of the various grades differed significantly between the two groups (P = 0.0003, Table 1). The proportion of intrameniscal signal anomalies adjacent to the tear (grades 2–4) was significantly lower in group 2 than in group 1 (P = 0.0022). In group 1 the frequency of grade 4 was higher in both lateral and medial menisci than any of the other grades. In group 2 the frequency of grade 1 was higher in lateral menisci, and the frequency of grade 4 was higher in medial menisci than any of the other grades (Fig. 2).

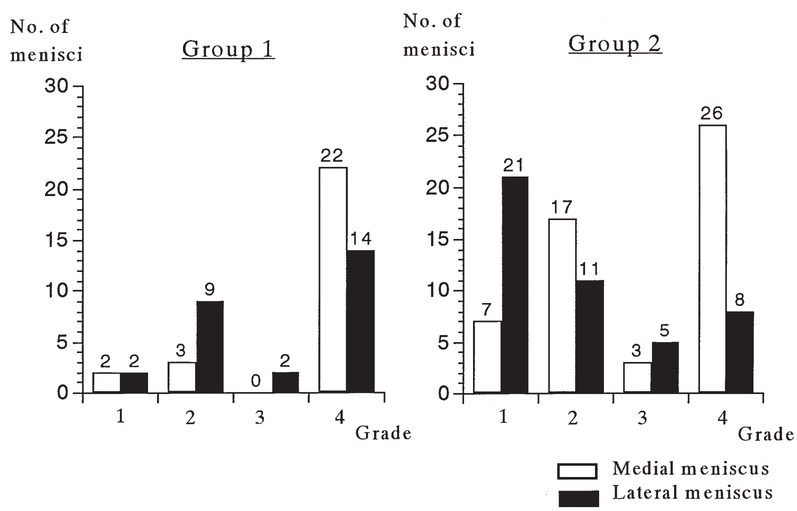

Fig. 2 Incidence of intrameniscal signal abnormalities. A comparison between medial and lateral menisci in each group

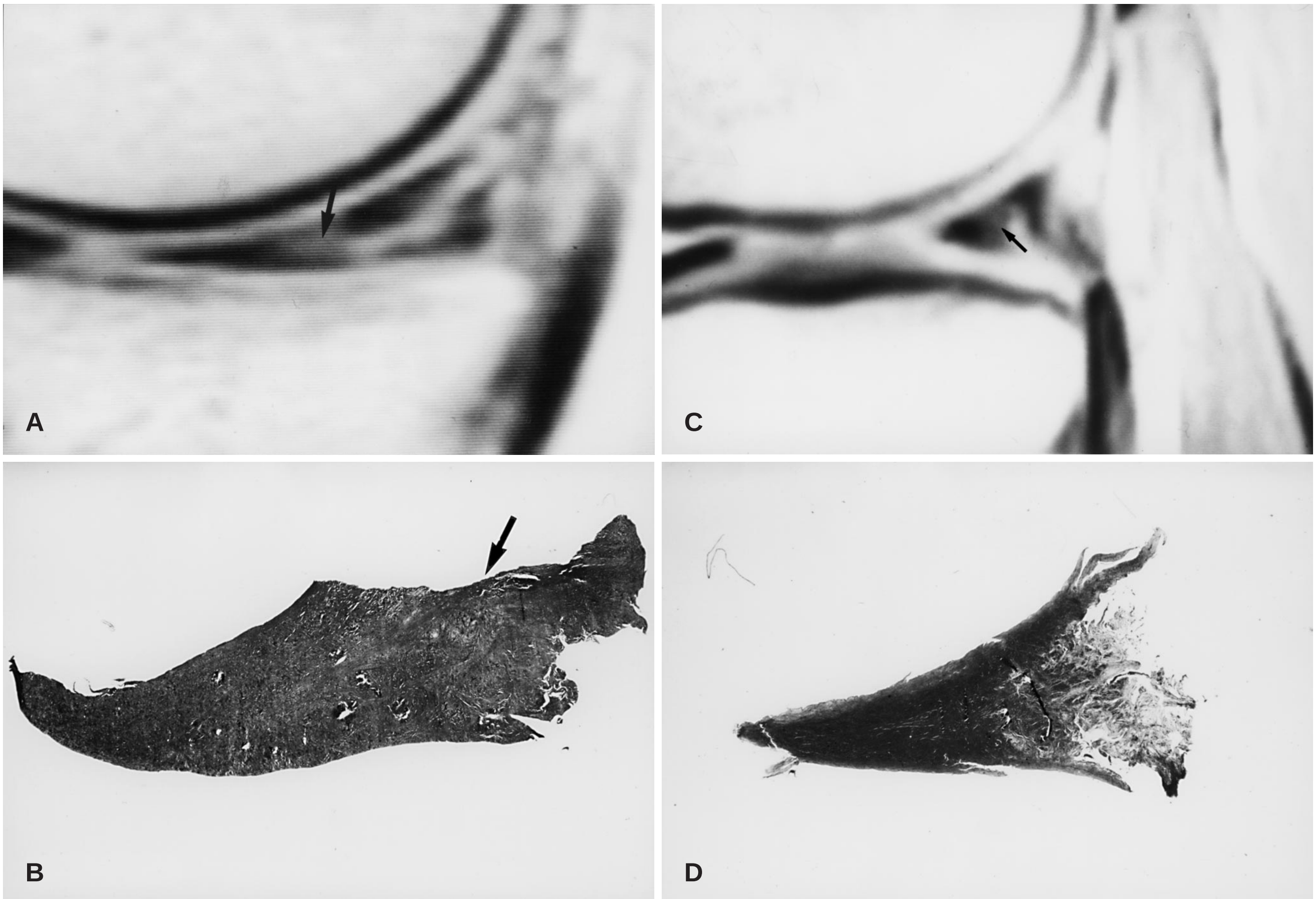

Fig. 3 **A, C** MRI (group 1), showing the zone of homogeneous hyperintensity adjacent to the tear (*arrow*). **A** Medial meniscus tear. **C** Lateral meniscus tear. **B, D** Histology, showing the zone of myxoid degeneration corresponding to distribution of images observed in MRI (*arrow* in **B**). Trichrome stain, × 17

Table 2 Incidence of fissures and degeneration within the resected meniscal segments (*n* = 25) related to signal abnormalities

Signal	Normal	Fissures	Degeneration	Fissures and degeneration
Normal	3	0	1	0
High	2	2	2	15

Histological significance of signal anomalies

Hyperintense signal zones adjacent to the tear were observed in 21 resected meniscal segments. Histological anomalies were observed in 20 of these 21 segments (Fig. 3). The respective incidence of histological lesions (fissures, degeneration) within the meniscal tissue adjacent to the opposing edges of the tear was related to the hyperintense zones on MRI (Table 2). The results of statistical analysis are given in Table 3.

Table 3 MRI compared with histology (*n* = 25)

MRI finding	Histology abnormal	Histology normal
Abnormal	19	2
Normal	1	3

Sensitivity 0.95; specificity 0.60; positive predictive value 0.90; negative predictive value 0.75

Discussion

MRI has been found to be an effective noninvasive method for diagnosing meniscal tears. Several authors have recently reported a similarity between the extent of abnormal meniscal signals on MRI and the extent of degeneration on histopathology [5, 6, 7, 11, 16, 17, 19]. In the present study we obeserved a close correlation between imaging anomalies and the presence of histological lesions within meniscal tissues adjacent to the tear. These results indicated the potential and reliability of MRI for evaluating intrameniscal degenerative changes adjacent to the tear in torn menisci.

Several authors have reported the presence of a natural, age-related meniscal degenerative process and the fact that preexisting meniscal degenerative changes predispose the development of spontaneous and traumatic meniscal tears in ACL-stable knees [5, 13, 15, 16]. On the other hand, menisci associated with an ACL injury were injured at the same time as the ACL was torn, or the meniscal tears followed, caused by ACL deficiency. For these reasons the frequency and/or severity of the intrameniscal degenerative changes adjacent to the tear are thought to differ between these two groups.

In the present study the frequency of intrameniscal signal anomalies adjacent to the tear was significantly lower in ACL-deficient knees than in ACL-stable knees, and also lower in the lateral menisci than in the medial menisci in ACL-deficient knees. These findings indicate that the severity of intrameniscal degenerative changes adjacent to the tear may be lower in ACL-deficient knees than in ACLstable knees, and lower in lateral menisici than in medial menisci. One Half of patients with ACL-stable knees had no episode of trauma; in the other half the average time from injury to MRI was longer than in ACL-deficient knees. We considered that the higher frequency of intrameniscal degenerative changes adjacent to the tear in ACL stable knees might be caused by preexisting meniscal degeneration or higher chronicity of the meniscal tear.

Several authors report that the results of meniscal repair in ACL reconstructed knees are significantly better than in isolated repairs in ACL stable knees [3, 9, 21]. They explain that this difference in healing rates may be secondary to extensive hemarthrosis following ligament reconstruction. In addition, lateral meniscal repairs are reported to have better healing results than medial meniscal repairs [3, 14]. Our results suggest that the severity of intrameniscal degenerative changes adjacent to the tear are one of the factors affecting the healing rate of meniscal repairs.

One of the limitations of this study is the absence of clinical data on meniscal healing. A prospective randomized study would be needed to clarify this problem.

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