Association of Postoperative Lateral Meniscal Extrusion With Cartilage Degeneration on Magnetic Resonance Imaging After Discoid Lateral Meniscus Reshaping Surgery

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Background: Although arthroscopic reshaping surgery for a discoid lateral meniscus (DLM) has good clinical results, it cannot completely prevent degeneration. The degree of DLM extrusion associated with degenerative changes is unclear.

Purpose/Hypothesis: To measure meniscal extrusion preoperatively and postoperatively in patients who underwent DLM-reshaping surgery and examine factors associated with knee articular cartilage degeneration. It was hypothesized that meniscal extrusion existed preoperatively, progressed postoperatively, and was related to knee joint degeneration.

Study Design: Case-control study; Level of evidence, 3.

Methods: We retrospectively reviewed the medical records of patients who underwent DLM-reshaping surgery and attended $\geq$2 years of follow-up. Magnetic resonance imaging (MRI) was performed preoperatively and at 24 months postoperatively, and residual midbody meniscal extrusion was measured. Cartilage degeneration was detected when the Whole-Organ Magnetic Resonance Imaging Score (WORMS) of the lateral compartment was grade $\geq$3 at 2 years postoperatively. Factors associated with MRI cartilage degeneration were evaluated.

Results: Included in this study were 48 knees in 39 patients; the mean patient age at the time of surgery was 12.0 years. The mean midbody meniscal extrusion significantly increased from 0.8 mm preoperatively to 1.6 mm at 24 months postoperatively ($P < .001$). According to the WORMS cartilage score, 16 patients were categorized as having MRI cartilage degeneration. Multivariate logistic analysis showed that an inferior preoperative Lysholm score (odds ratio, 0.89; $P = .024$) and postoperative extrusion (odds ratio, 6.18; $P = .010$) significantly increased the risk of cartilage degeneration. The receiver operating characteristic curve showed that a residual meniscal extrusion of 2.0 mm was the cutoff value indicating cartilage degeneration (sensitivity, 87.5%; specificity, 78.1%).

Conclusion: DLM extrusion significantly increased from 0.8 mm preoperatively to 1.6 mm at 2 years postoperatively. Postoperative extrusion and a lower preoperative Lysholm score were factors related to MRI cartilage degeneration postoperatively. A postoperative extrusion of 2.0 mm was the cutoff value for MRI cartilage degeneration.

Keywords: discoid lateral meniscus; magnetic resonance imaging; reshaping surgery; extrusion

The meniscus plays an important role in distributing weight loads and protecting the articular cartilage of the knee by converting axial loads into circumferential hoop stresses. Meniscal extrusion, in which the peripheral border of the meniscus is substantially located outside the knee joint margin, is associated with hoop tension loss and the inability to function.[8] Similarly, meniscal extrusion is reportedly associated with the development of osteoarthritis (OA).[8,19] Meniscal extrusion has been reported in patients with posterior root tears or radial tears[5] and as a complication of partial meniscectomy,[24,26] meniscal transplantation,[50] or saucerization of a discoid lateral meniscus (DLM).[11,35] A DLM is a congenital anatomic variant of the knee joint. In patients with a symptomatic DLM, surgical treatment should be indicated. Saucerization, which removes only the central portion of the DLM and preserves the peripheral rim,[16,21,40] is preferably selected as a surgical procedure for a DLM. It is possible to

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repair the meniscus after saucerization and consequently stabilize it in patients with an unstable meniscal peripheral rim.[1-3,9,10,18] These reshaping techniques, including saucerization with or without repair, have shown good postoperative clinical results. However, knee joint degeneration is reported after such procedures.[2,10,51]

Limited evidence is available regarding the degree of extrusion in patients with a symptomatic DLM, and the relationship between DLM extrusion and articular cartilage degeneration is similarly unclear. The general protocol for an OA diagnosis includes the assessment of clinical symptoms and radiographic criteria. However, there is a considerable interval between disease onset and the time at which OA can be diagnosed using plain radiography. This implies that when physical or radiographic OA evidence is established, significant and irreversible disease progression may have already occurred, preventing early treatment.[33] Magnetic resonance imaging (MRI) is a well-established modality for the evaluation of cartilage in patients with OA[7] and can help assess morphological characteristics.[13] Diagnostic criteria for early knee OA include cartilage degeneration, meniscal degeneration, and/or subchondral bone marrow lesions on MRI.[32] The Whole-Organ Magnetic Resonance Imaging Score (WORMS) can facilitate the evaluation of cartilage degeneration.[42]

Hence, this case-control study aimed to measure meniscal extrusion preoperatively and postoperatively in patients who underwent DLM reshaping surgery and examine factors associated with knee articular cartilage degeneration. We hypothesized that knees with preoperative extrusion and the progression of extrusion postoperatively would have higher WORMS cartilage scores.

METHODS

This study was approved by a hospital ethics committee and our institutional review board, and informed consent was obtained from the parents of all patients. We retrospectively reviewed the medical records and MRI findings of patients who were treated arthroscopically for a symptomatic DLM by a single surgeon and attended follow-up for a minimum of 2 years from May 2009 to March 2017. The inclusion criteria were patients (1) with a symptomatic DLM requiring surgery and (2) aged <15 years with an open physis. Exclusion criteria were patients (1) with prior meniscal surgery, (2) with <2 years of follow-up, (3) lacking medical records, (4) who underwent subtotal meniscectomy, (5) who underwent osteochondral autograft transplantation for concurrent osteochondritis dissecans, and (6) with an incomplete type of DLM.

The diagnosis of a DLM was suspected based on existing symptoms, including pain and locking and catching of the knee; physical examination findings, such as extension loss, effusion, snapping, or clunking with extension from flexion; a positive McMurray test result; and tenderness at the lateral joint space, and then confirmed with MRI findings. The final criteria for requiring surgery were the presence of the aforementioned symptoms and imaging findings indicating that the condition had been refractory to nonoperative treatment for at least 3 months.

Surgical and Rehabilitation Procedures

A routine arthroscopic examination of the knee joint began with placing a 30° oblique arthroscope through anterolateral and anteromedial portals. After diagnostic arthroscopic surgery confirmed a DLM, saucerization was started at the free edge of the meniscus using a standard arthroscopic punch or forceps, marking circumferential fibers at the anterior part of the DLM. The central portion of the DLM was subsequently resected piece by piece to restore the peripheral margin by 6 to 8 mm, as previously recommended.[4] Preservation of the peripheral rim was confirmed using a ruler. After saucerization, residual meniscal rim instability was assessed by probing. If meniscal instability, defined as a longitudinal tear in the vascular area of the meniscus or abnormal meniscocapsular attachments, was observed, surgical meniscal stabilization was performed. When horizontal tears reached the peripheral area, additional sutures were indicated. All knees that were unstable at the anterior part were treated with an outside-in arthroscopic repair technique, whereas those that were unstable at the posterior part were treated with an inside-out arthroscopic repair technique. Sutures were placed at 3-mm intervals using No. 2-0 nonabsorbable suture material.

Postoperative rehabilitation was scheduled according to the surgical procedure. Patients who underwent saucerization alone were immediately allowed to perform weight-bearing and knee range of motion exercises. Jogging was allowed at 2 months postoperatively, and patients were allowed to return to previous sports at 3 months. Patients who underwent saucerization with stabilization were immobilized in a brace for 1 week postoperatively and subsequently limited to a knee range of motion of 0° to 90° for 3

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Ethical approval for this study was obtained from the Osaka City University Graduate School of Medicine (No. 2728).

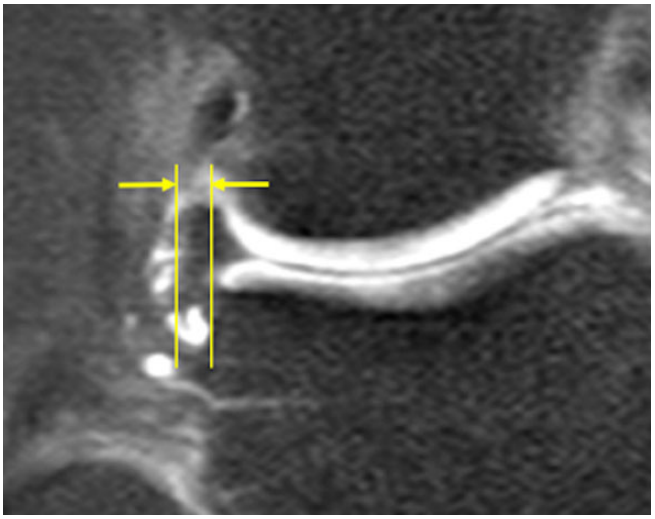

Figure 1. Magnetic resonance imaging (MRI) of meniscal extrusion in the right knee. A vertical line was drawn through the peripheral margin of the lateral tibial plateau, excluding osteophytes, and another was drawn tangential to the outer margin of the lateral meniscus. Maximal meniscal extrusion was the distance between the lines.

weeks, followed by protected weightbearing for 6 weeks. These patients were permitted to jog at 3 months postoperatively and return to previous sports at 6 months postoperatively.

Clinical and MRI Evaluations

The clinical assessment consisted of evaluating the patients' Lysholm scores preoperatively and at final follow-up. MRI was performed preoperatively and at 24 months postoperatively using a 3.0-T scanner (Achieva 3.0T TX; Philips). During the examination, patients lay in the supine position on the MRI table with a triangular wedge under the knee and a strap over the thighs to maintain a knee flexion of 10°. The knee joint of each patient was centered in an 8-channel SENSE knee coil (Philips). Sequences used for image interpretation were coronal and sagittal T2-weighted fat-saturated scans (repetition time/echo time, 3460/80 milliseconds; field of view, 16 cm; matrix, 256 × 9 × 192; slice thickness, 3.3 mm).

Midbody meniscal extrusion was measured using midcoronal images preoperatively and at 24 months postoperatively, as previously described[26] (Figure 1). On MRI, a vertical line was drawn through the peripheral margin of the lateral tibial plateau, excluding osteophytes, and another was drawn tangential to the outer margin of the lateral meniscus. The vertical distance between both lines was defined as maximal meniscal extrusion. In addition, the midbody meniscal width was measured at 2 years postoperatively, as previously described.[38] The measurements were conducted independently by 3 orthopaedic surgeons (K.N., Y.H., and K.I.).

As described by Ahn et al,[4] a preoperative meniscal shift, indicating a peripheral tear, was categorized using sagittal and coronal MRI scans as follows: no shift, anterocentral shift, posterocentral shift, and central shift. In the present study, anterocentral, posterocentral, and central shifts were combined and categorized as a single shift. On preoperative MRI, an increased intrameniscal signal, indicating a horizontal cleavage tear, was identified, as previously described.[20,22,44,52]

To assess cartilage morphology, the WORMS was administered preoperatively and at 24 months postoperatively.[42] Cartilage scores of grade ≥3 (WORMS grades 3-6) and Boston Leeds Osteoarthritis Knee Score (BLOKS) meniscus grades 3 to 4 were considered to indicate MRI cartilage degeneration.[32] In this study, all patients underwent DLM reshaping surgery, indicating having a BLOKS meniscus grade 3. Therefore, when combined with a WORMS cartilage score of grades 3 to 6, the case would meet the MRI criteria of cartilage degeneration. Preoperative and postoperative parameters, including age, sex, body mass index, preoperative meniscal shift, preoperative intrameniscal signal, preoperative and postoperative Lysholm scores, type of surgical procedure, and preoperative and postoperative meniscal extrusion, were assessed as factors associated with cartilage degeneration.

Statistical Analysis

Meniscal extrusion and the Lysholm score were compared preoperatively and at 2 years postoperatively using a paired *t* test. The Student *t* test was used to compare continuous variables, including age, body mass index, Lysholm score, and meniscal extrusion. A logistic regression model was used to obtain univariate and multivariate odds ratios (ORs) with 95% CIs for cartilage degeneration. The receiver operating characteristic (ROC) curve for postoperative meniscal extrusion, examined as a factor related to MRI cartilage degeneration, was determined to set the cutoff value of meniscal extrusion as an objective variable.

The correlation between the change in WORMS grades and postoperative extrusion was assessed using Pearson correlation analysis. The intraclass correlation coefficient was used to assess the intraobserver and interobserver reliability of the 3 reviewers regarding the MRI measurements; for intraobserver reliability, one of the reviewers (K.N.) performed measurements twice during a 1-month interval. Agreement strength was interpreted as follows: >0.80, almost perfect agreement; 0.61-0.80, substantial agreement; 0.41-0.60, moderate agreement; 0.21-0.40, fair agreement; and ≤0.20, slight agreement. All hypotheses were tested with a *P* value of .05, indicating statistical significance and a 2-sided alternative hypothesis.

A power analysis was performed with the power, α, difference and SD set at 0.8, 0.05, 0.69, and 1.1, respectively, according to midbody meniscal extrusion. Analysis revealed that a minimum of 36 patients was required for the Wilcoxon test to detect a difference between extrusion values preoperatively and at 24 months postoperatively. EZR Software Version 1.38 (Saitama Medical Center, Jichi Medical University) was used for statistical analysis.

TABLE 1
Characteristic Data and Clinical Outcomes (n = 48)[a]

	Mean ± SD, n (%), or n
Age, y	12.0 ± 2.2
Sex	
Male	23 (47.9), 1 bilateral
Female	25 (52.1), 8 bilateral
Follow-up, y	4.0 ± 1.6
Body mass index, kg/m^2	18.7 ± 2.9
Meniscal shift (Ahn classification[4])	
None	26 (54.2)
Anterocentral	9 (18.8)
Posterocentral	11 (22.9)
Central	2 (4.2)
Intrameniscal degeneration	31 (64.6)
Surgical procedure	
Saucerization alone	18 (37.5)
Saucerization with repair	30 (62.5)
Lysholm score	
Preoperative	64.1 ± 15.9
Postoperative	95.1 ± 7.3
Meniscal extrusion, mm	
Preoperative	0.8 ± 1.2
Postoperative	1.6 ± 1.0
Preoperative WORMS, grades 0/1/2/3/4/5/6	
Lateral femoral condyle	30/13/3/2/0/0/0
Lateral tibial plateau	29/18/1/0/0/0/0
Postoperative WORMS, grades 0/1/2/3/4/5/6	
Lateral femoral condyle	12/11/10/14/1/0/0
Lateral tibial plateau	13/23/7/4/0/1/0

[a]WORMS, Whole-Organ Magnetic Resonance Imaging Score.

RESULTS

We retrospectively recruited 46 consecutive patients, for a total of 55 knees, with a symptomatic DLM to participate in this study. Overall, 5 knees were excluded because of a lack of MRI data or because the corresponding patients attended the follow-up for <2 years. One patient was excluded because of osteochondritis dissecans in the lateral femoral condyle and undergoing osteochondral autograft transplantation. One patient with an incomplete type of DLM was excluded. Finally, 48 knees in 39 patients were included in this study. The mean patient age at the time of surgery was 12.0 years (range, 6-15 years). Among these patients, 23 were male, 25 were female, and 9 had bilateral involvement. The mean follow-up period was 4.0 years (range, 2-8 years). Characteristic data are shown in Table 1.

Among the knees with complete menisci, no shifts were observed in 26 knees, anterocentral shifts in 9, posterocentral shifts in 11, and central shifts in 2. On preoperative MRI, high intrameniscal signal intensities were observed in 31 knees, and tears extending to the surface were observed in 27 knees. After saucerization, residual meniscal instability was identified in 30 knees, and the remaining 18 knees had stable peripheral rims. Saucerization alone was performed in 18 knees, and stabilization after saucerization was performed in 30 knees. The mean Lysholm score improved significantly from 64.1 ± 15.9 preoperatively to 95.1 ± 7.3 at final follow-up ($P < .01$).

The intraobserver and interobserver intraclass correlation coefficients for postoperative extrusion were 0.942 and 0.826, respectively, indicating almost perfect agreement for both. The mean midbody meniscal extrusion significantly increased from 0.8 ± 1.2 mm preoperatively to 1.6 ± 1.0 mm at 2 years postoperatively ($P < .001$). Representative preoperative and postoperative MRI results are shown in Figure 2. The residual midbody meniscal width at 2 years postoperatively was 5.5 ± 2.2 mm. There were 16 patients who had a WORMS cartilage score of grade ≥3 at 2 years postoperatively and were consequently categorized as having MRI cartilage degeneration (Table 1 and Figure 3). Only 1 patient had bone marrow edema in the lateral tibial plateau on postoperative MRI. No patient had bone cysts, bone attrition, and osteophytes.

Table 2 shows preoperative and postoperative factors associated with MRI cartilage degeneration according to univariate and multivariate logistic regression analyses. Multivariate logistic analysis showed that a lower preoperative Lysholm score (OR, 0.89; $P = .024$) and postoperative extrusion (OR, 6.18; $P = .010$) significantly increased the risk of MRI cartilage degeneration.

The area under the ROC curve for postoperative meniscal extrusion, which was considered a factor related to MRI cartilage degeneration, was 77.7%. Moreover, based on the ROC curve analysis, a cutoff value for meniscal extrusion of 2.0 mm was deemed the best to indicate MRI cartilage degeneration (sensitivity, 87.5%; specificity, 78.1%) (Figure 4). A significant negative correlation was found between the change in WORMS grades and postoperative extrusion ($r = 0.418$; $P = .003$).

DISCUSSION

This study was performed to evaluate the degree of meniscal extrusion of a symptomatic DLM preoperatively and postoperatively, which was a mean of 0.8 mm preoperatively and 1.6 mm at 2 years postoperatively. Furthermore, these assessed factors were related to MRI cartilage degeneration. Multivariate analysis showed that postoperative extrusion and lower preoperative Lysholm scores were related to MRI cartilage degeneration. A postoperative extrusion of 2.0 mm was the cutoff value for MRI cartilage degeneration. The strength of this study is that the DLM evaluation was started using MRI preoperatively to confirm the progression of postoperative extrusion and assess the relationship between lateral meniscal extrusion and knee articular cartilage degeneration using the WORMS cartilage score.

Most previous studies on meniscal extrusion have assessed the medial meniscus. Medial meniscal extrusion progresses, resulting in knee OA changes[8,45,46,49] related to osteonecrosis.[14,39] Biomechanical in vivo studies have demonstrated that meniscal extrusion caused by a posterior root or radial tear results in a decreased tibiofemoral contact area and consequently increases the tibiofemoral contact pressure.[15,29,34] A medial meniscal extrusion of ≥3 mm

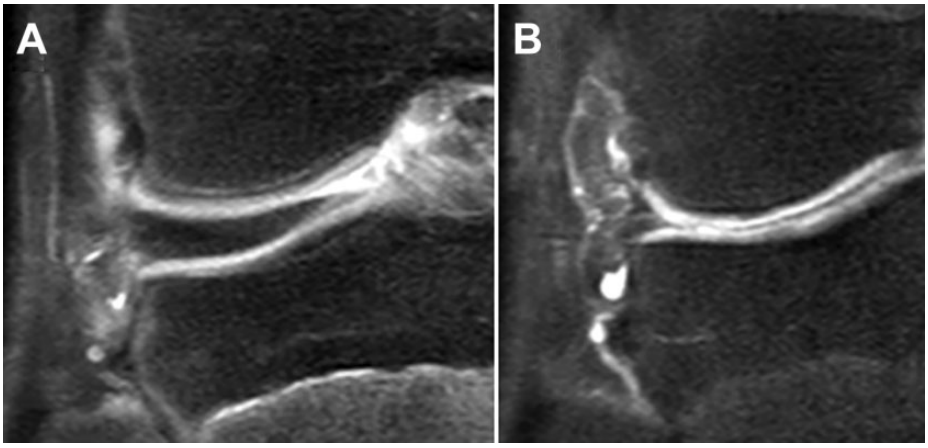

Figure 2. (A) Magnetic resonance imaging (MRI) of the right knee of a 13-year-old female patient showing a discoid lateral meniscus with an extrusion of 1 mm and no shift. (B) At 2 years after saucerization with repair, an MRI showed an extrusion of 2.5 mm.

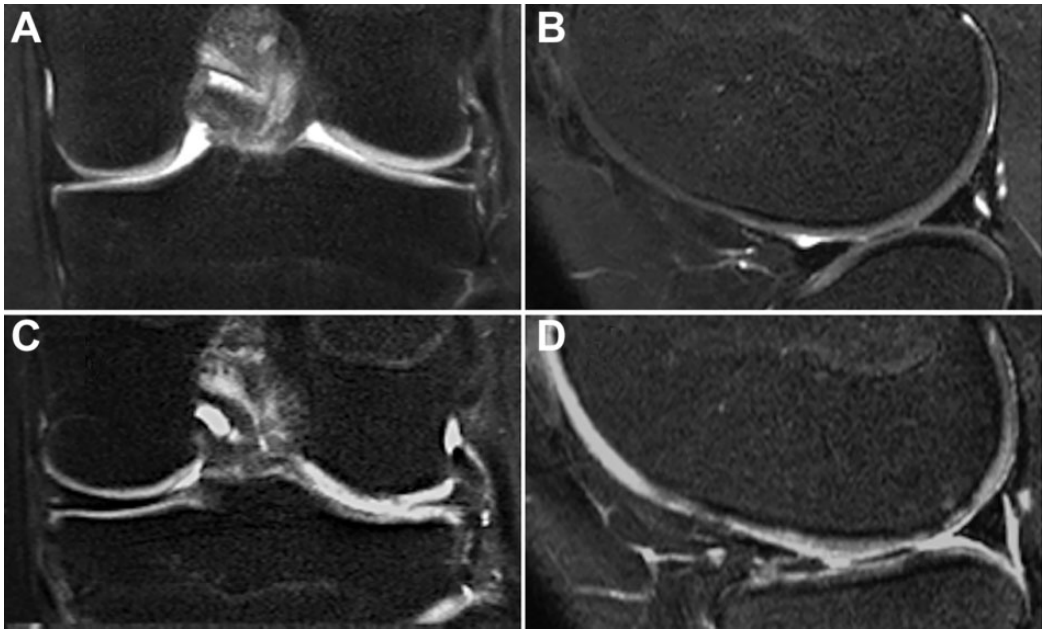

Figure 3. Representative postoperative magnetic resonance imaging (MRI) of the right knee. (A, B) A less-extruded residual meniscus with preserved knee articular cartilage. (C, D) An extruded residual meniscus with degenerative knee articular cartilage.

was suggested to be pathological,[12,17,41] and this measurement is probably the most widely acknowledged cutoff value for research purposes. The normal degree of lateral meniscal extrusion was reported to be 0.3 to 0.5 mm.[4,36,43] Most previous studies on lateral meniscal extrusion reported that this extrusion is related to lateral meniscal root tears[23,28,43,47] or is a complication of meniscal allograft transplantation.[30] The degree of lateral meniscal extrusion causing root tears was approximately 0.8 to 2.0 mm.[23,28,43,47] Svensson et al[48] reported a lateral meniscal extrusion of 1.8 mm, which is similar to the findings of our study. Their population age was 50 to 90 years; thus, we assumed that this extrusion did not occur in the juvenile population.[48] According to the study results, the degree of DLM extrusion was larger than that for a normal lateral meniscus and was similar to that for a root tear or in a middle-aged and older population.

Several studies have reported on the degree of DLM extrusion after reshaping surgery. Choi[11] reported that lateral meniscal extrusion and osteochondral damage occurred after saucerization of a DLM. Matsuo et al[35] measured the width, height, and extrusion of the meniscus using MRI at 2 weeks and 6 months postoperatively in 9 patients who underwent saucerization with DLM repair and indicated a decrease in the residual meniscal width, an increase in height, and progressive extrusion.

TABLE 2
Factors Associated With MRI Cartilage Degeneration[a]

	Crude OR (95% CI)	*P*	Adjusted OR (95% CI)	*P*
Age	1.07 (0.81-1.42)	.637	0.94 (0.56-1.60)	.820
Female sex	1.29 (0.34-4.30)	.683	0.25 (0.03-2.32)	.221
Body mass index	1.03 (0.84-1.27)	.777	—	—
Preoperative shift	0.88 (0.26-2.95)	.838	—	—
Intrameniscal degeneration	1.32 (0.37-4.73)	.670	—	—
Meniscal repair	1.00 (0.29-3.45)	>.999	—	—
Preoperative Lysholm score	0.93 (0.88-0.99)	**.027**	0.89 (0.80-0.98)	**.024**
Postoperative Lysholm score	0.94 (0.85-1.03)	.200	—	—
Preoperative extrusion	1.34 (0.80-2.24)	.267	—	—
Postoperative extrusion	3.07 (1.28-7.34)	**.012**	6.18 (1.55-24.60)	**.010**
Postoperative meniscal width	0.79 (0.56-1.10)	.166	—	—

[a]Bolded *P* values indicate statistical significance ($P < .05$). Dashes indicate not applicable. MRI, magnetic resonance imaging; OR, odds ratio.

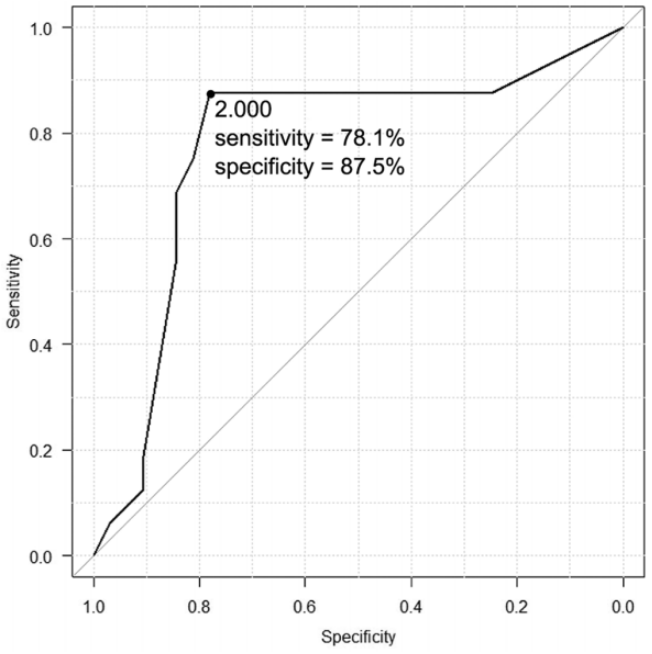

Figure 4. Receiver operating characteristic (ROC) curve of postoperative meniscal extrusion as a factor related to magnetic resonance imaging (MRI) cartilage degeneration. The area under the curve was 77.7%. Based on the ROC curve analysis, a cutoff value for meniscal extrusion of 2.0 mm was deemed the best to indicate MRI cartilage degeneration.

Mochizuki et al[37] investigated 46 patients with a symptomatic DLM who underwent arthroscopic surgery and reported that a short residual midbody meniscal width was a risk factor for meniscal extrusion. In the current study, some of the cases with a no shift–type DLM had peripheral instability and required meniscal repair. These cases tended to show the progression of extrusion postoperatively. Meniscal degeneration in the peripheral portion and resection of the central portion were considered among the factors affecting postoperative meniscal extrusion.

Recently, some studies reported an association between lateral meniscal extrusion and knee OA.[14,31] Although DLM-reshaping surgery has shown good clinical outcomes in many previous studies, 40% to 50% of patients reported postoperative OA progression.[2,10] However, a few studies have investigated the relationship between DLM extrusion and knee articular cartilage degeneration. Yamasaki et al[51] reported that meniscal extrusion at 2 years after reshaping surgery for a symptomatic DLM was related to degeneration on radiography and that a residual meniscal width of <5 mm was a risk factor for degeneration. The current study assessed knee articular cartilage degeneration more precisely using the WORMS cartilage score.[32] In the present case-control study, a single surgeon performed arthroscopic saucerization in the same manner, preserving the peripheral rim by 6 to 8 mm. This consistency was one of the strengths of our study. Considering the results of MRI, the meniscal width of the midbody was 5.5 mm at 2 years postoperatively, and 20 menisci showed <5 mm, which was considered a risk for extrusion and OA. We previously reported that the residual meniscal width shrank throughout the postoperative course.[38]

Moreover, this study revealed that the cutoff value of postoperative meniscal extrusion for MRI cartilage degeneration was 2.0 mm, which was 1 mm smaller than the pathological value for medial meniscal extrusion. We chose the appropriate lateral meniscal extrusion treatment according to the aforementioned cutoff value. Preoperative meniscal extrusion was not associated with MRI cartilage degeneration possibly because some patients had extrusion progression, despite not showing any preoperative extrusion. A DLM is characterized by a decrease in the number of collagen fibers and a heterogeneous course in fibers compared with normal menisci.[6] Therefore, histological fragility itself may cause the progression of DLM extrusion.

A lower preoperative Lysholm score was significantly associated with MRI cartilage degeneration, and lower preoperative clinical scores may indicate meniscal degeneration or early cartilage degeneration. Some environments may adversely affect cartilage. Kim et al[25]

reported that patients with high Outerbridge grades had significantly lower Lysholm scores than those with low grades.

According to our results, 16 patients had cartilage degeneration (according to the WORMS), which seemed to indicate a risk for developing OA, and a careful follow-up was needed. However, postoperative clinical scores were good, indicating that the patients did not have symptoms, such as knee pain and swelling. Only 1 patient had bone marrow edema on postoperative MRI, and no patient had any other bony abnormalities. This may be because the cohort of patients in the current study was young and had not yet experienced the progression of degenerative changes. When patients with cartilage degeneration according to the WORMS did not have any clinical symptoms, no special intervention was required. In this study, 2 mm of postoperative lateral meniscal extrusion was a risk factor for cartilage degeneration. Hence, surgeons should consider surgery for the reduction of extrusion, such as centralization, in patients with large extrusion with knee symptoms. Centralization, in which the margin between the lateral meniscal midbody and the joint capsule is sutured to the edge of the lateral tibial plateau and is centralized using suture anchors, has been employed to treat the extruded meniscus. Koga et al[27] reported successful arthroscopic centralization of an extruded DLM. They reported that DLM extrusion was significantly reduced from 1.6 to 0.3 mm and maintained at this value until 1 year after centralization. According to the preoperative values in the present study, centralization was apparently not required in all patients with a symptomatic DLM. The present study could not reveal the prognostic factor for postoperative meniscal extrusion. Our study cohort showed good clinical scores, implying that there was less pain and no effusion. Only a careful observation was needed. Nonetheless, patients with large extrusion with knee symptoms had a risk for knee articular cartilage degeneration; therefore, centralization might be necessary.

Limitations

This study had some limitations. First, the follow-up period was relatively short to assess the relationship between meniscal morphology and postoperative degeneration. Second, the retrospective design of this study presents inherent limitations. Third, other possible risk factors, such as knee alignment, sports activity, and family history, were not assessed. Nevertheless, this study presents new evidence on DLM extrusion. Fourth, there was a possibility that different postoperative rehabilitation protocols could affect both cartilage degeneration and meniscal extrusion. This difference could make the results milder in the repair group. Fifth, the lack of a control group, such as nonoperatively treated patients with a DLM or normal lateral meniscus, is an important limitation to this study. Further investigations are warranted to clarify whether lateral meniscal extrusion was unique to a symptomatic DLM.

CONCLUSION

DLM extrusion significantly increased from 0.8 mm preoperatively to 1.6 mm at 2 years postoperatively. Postoperative extrusion and a lower preoperative Lysholm score were factors that correlated with MRI cartilage degeneration postoperatively. A postoperative extrusion of 2.0 mm was the cutoff value for MRI cartilage degeneration.

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