



# Prognostic Factors of Mid- to Long-term Clinical Outcomes after Arthroscopic Partial Meniscectomy for Medial Meniscal Tears

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**Background:** Arthroscopic partial meniscectomy (APM) continues to be the popular treatment for meniscal tears, but recent randomized controlled trials have questioned its efficacy. To provide more evidence-based criteria for patient selection, we undertook this study to identify prognostic factors associated with clinical failure after APM for medial meniscus tears.

**Methods:** Medical records of 160 patients followed up for at least 5 years after APM for medial meniscal tears were retrospectively reviewed. Demographic data (age, sex, and body mass index), radiographic variables (Kellgren-Lawrence [K-L] grade and hip-knee-ankle [HKA] angle), and clinical scores (International Knee Documentation Committee score, Tegner activity scale score, Lysholm score, and Knee injury and Osteoarthritis Outcome Score) were recorded. Clinical failure was defined as the need for an additional surgical procedure (arthroscopy, osteotomy, or arthroplasty) or the presence of intolerable pain. Survivorship analysis with clinical failure as an end point was performed using Kaplan-Meier survival curves. Factors related to clinical failure were analyzed using a Cox proportional hazard model. Cutoff values were determined using areas under receiver operating characteristic (ROC) curves. Radiographic progression of osteoarthritis was analyzed using the chi-square test, and serial changes of clinical scores were analyzed using a linear mixed model.

**Results:** Clinical success rates were 95.7% at 5 years, 75.6% at 10 years, and 46.3% at 15 years. Age, HKA angle, and K-L grade ( $p = 0.01$ ,  $p = 0.02$ , and  $p = 0.04$ , respectively) were found to be significant risk factors of clinical failure. Cutoff values at 10 years postoperatively as determined by ROC analysis were 50 years for age (sensitivity = 0.778, 1-specificity = 0.589), grade 2 for K-L grade (sensitivity = 0.778, 1-specificity = 0.109), and  $5.5^\circ$  for HKA angle (sensitivity = 0.667, 1-specificity = 0.258). In patients who had clinical success until 10 years after APM, radiological osteoarthritis progressed gradually. However, the clinical scores of patients who achieved clinical success did not decrease significantly over the 10-year follow-up.

**Conclusions:** The poor prognostic factors found to be related to clinical failure after APM for a medial meniscal tear were patient age ( $\geq 50$  years), preoperative K-L grade ( $\geq$  grade 2), and preoperative HKA angle ( $\geq$  varus  $5.5^\circ$ ).

**Keywords:** Knee, Arthroscopic meniscectomy, Prognostic factor, Clinical failure

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Menisci within knee joints significantly contribute to lubrication, weight distribution, cartilage protection, joint stability, and proprioception.<sup>1-4)</sup> Thus, a meniscal injury leads to altered mechanics and biochemical changes, which combine to trigger a cascade of changes leading to the development of posttraumatic osteoarthritis.<sup>2)</sup> Although meniscal tear symptoms can be treated conservatively, they are often treated surgically and represent one of the most common reasons for orthopedic surgery.<sup>5)</sup> If a meniscus tear cannot be repaired and causes pain and/or a locking sensation, it is removed by arthroscopic partial meniscectomy (APM), but more than half of all patients who undergo partial meniscectomy will exhibit changes in articular cartilage as early as 6 months after surgery<sup>6)</sup> and develop osteoarthritis within 10 to 20 years.<sup>7)</sup> Furthermore, due to the variability of outcomes, it is difficult to properly manage patient expectations for surgery.

Although several high-quality randomized controlled trials have consistently shown no benefit in function or pain relief after APM as compared with physical therapy or sham surgery in patients with degenerative meniscal tears, these studies did not evaluate the predictive values of the indications for APM.<sup>8-12)</sup> In contrast, one recent study reported that among patients with meniscal damage complicated by OA, those who underwent knee arthroscopy were 30% more likely to have partial or total knee replacement surgery at any given time than those who had physical therapy alone. This study suggests that optimal patient selection for APM is very important.<sup>13)</sup>

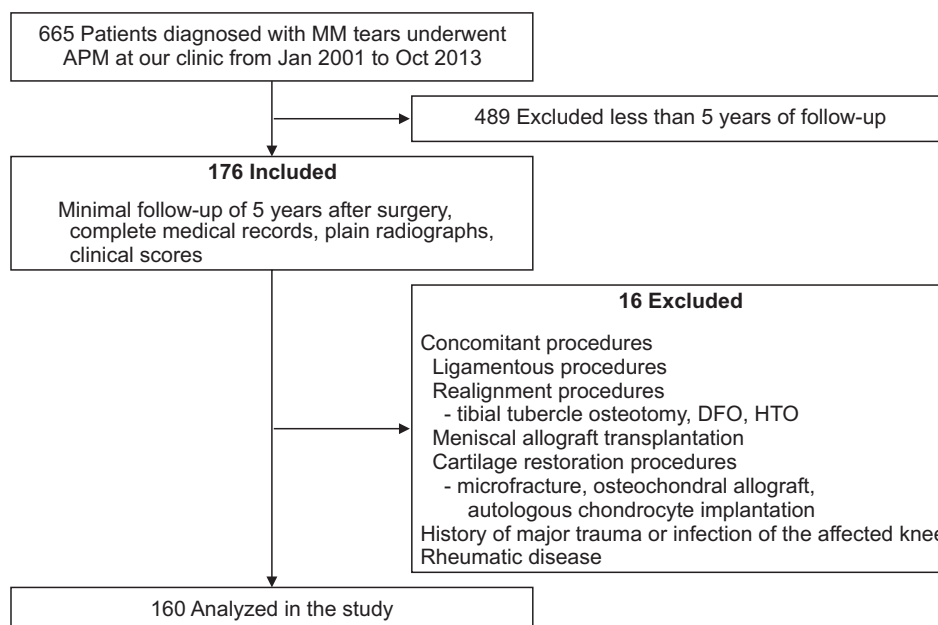
Many studies have already been conducted on prog-

nostic factors of APM. To the best of our knowledge, however, this is the first study to present the factors and cutoff values related to clinical failure. Accordingly, the purpose of this study was to identify prognostic factors and cutoff values of clinical outcome after APM for medial meniscal tears. Our hypothesis was that the patient's clinical and radiological characteristics before surgery would have predictive values related to clinical failure.

## METHODS

This study was approved by the Institutional Review Board of Seoul National University Hospital (No. H-2007-036-1139). Due to the retrospective nature of this study, the requirement for informed consent was waived.

This retrospective, observational study was performed by reviewing the medical records of patients with diagnosed medial meniscus tears that underwent APM at a single hospital from January 2001 to October 2013. All meniscal tears were confirmed by preoperative magnetic resonance imaging and arthroscopy. The indications for surgical treatment were as follows: (1) mechanical symptoms such as locking and giving way and (2) failure of at least 6 months of conservative treatment due to consistent pain or loss of function. Patients were included if they had a minimal follow-up of 5 years after surgery, complete medical records, plain radiographs, and clinical scores. Patients were excluded if they had undergone any of the following concomitant procedures (a ligamentous procedure, a realignment procedure [tibial tubercle osteotomy, distal



**Fig. 1.** Study flowchart. MM: medial meniscus, APM: arthroscopic partial meniscectomy, DFO: distal femoral osteotomy, HTO: high tibial osteotomy.

femoral osteotomy, or high tibial osteotomy], meniscal allograft transplantation, and a cartilage restoration procedure [microfracture, osteochondral allograft, or autologous chondrocyte implantation]) or had a history of major trauma or infection of the affected knee or rheumatic disease. Patients with subtotal meniscectomy, which was defined as meniscectomy involving the peripheral rim, were also excluded. In total, 160 patients were analyzed (Fig. 1).

Demographic data (age, sex, body mass index [BMI], symptom duration, and injury history) were obtained from medical records, and data on the type of meniscal tear and surrounding cartilage status were obtained from surgical records and arthroscopic pictures or videos. The type of meniscus tear was classified into a horizontal tear, longitudinal tear, complex tear, and radial tear. The status of the femoral and tibial articular cartilage was classified using the modified Outerbridge grading system. Clinical data including Knee injury and Osteoarthritis Outcome Score (KOOS), International Knee Documentation Committee (IKDC) score, Lysholm score, visual analog scale (VAS) score for pain, and Tegner activity scale score were evaluated preoperatively and annually after surgery. Radiological evaluations including hip-knee-ankle (HKA) angles and Kellgren-Lawrence (K-L) grades were performed using whole lower extremity standing anteroposterior (AP) and standing AP, Rosenberg, lateral, and axial views of both knees by two independent orthopedic surgeons (SYH and JL). Interobserver reliability was confirmed using intraclass correlation coefficients. Clinical failure was defined as the need for an additional surgical procedure (e.g., arthroscopy, osteotomy, or arthroplasty) or presence of intolerable pain requiring continuous use of analgesics.

### Statistical Analysis

Survivorship analysis with clinical failure as an end point was performed using Kaplan-Meier survival curves. Factors related to clinical failure were identified by Cox proportional hazard model analysis. Cutoff values were determined by receiver operating characteristic (ROC) analysis using area under the curve (AUC). Radiographic progression of osteoarthritis was analyzed using the chi-square test, and serial changes in clinical scores were analyzed using the linear mixed model. The analyses were performed using IBM SPSS ver. 22.0 (IBM Corp., Armonk, NY, USA), and statistical significance was accepted for  $p$ -values < 0.05.

## RESULTS

Demographic and preoperative data are summarized in Table 1. Patients' mean age at the time of surgery was 52.0

years (range, 19–76 years) and the mean follow-up period was 9.8 years (range, 5.0–19.3 years). Preoperative radiographic K-L grades were grade 0 in 37 cases (23.1%), grade 1 in 47 cases (29.4%), grade 2 in 54 cases (33.8%), and grade 3 in 22 cases (13.8%). Horizontal tear was the most common type (109 cases, 68.1%), followed by complex tear (30 cases, 18.8%), longitudinal tear (16 cases, 10.0%), and radial tear (5 cases, 3.1%). Only 13 cases (8.1%) had a low-grade chondral wear (grade 0, 1, or 2) on both the femoral and tibial sides; patients with a high-grade chondral lesion (grade 3 or 4) were subdivided into those with unipolar lesions (either the femoral or tibial side) and bipolar lesions (both the femoral and tibial sides). Unipolar high-grade chondral lesions were found in 46 cases (28.8%) and bipolar high-grade chondral lesions in 101 cases (63.1%).

Clinical failure at 10 years after APM occurred in 39 patients, and these patients received arthroscopic surgery, high tibial osteotomy, unicompartmental knee arthroplasty, or total knee arthroplasty (TKA) and had intolerable pain without analgesics. Of these, TKA was

**Table 1.** Patients' Demographic and Preoperative Characteristics

Variable	Value
No. of patients	160
Age at surgery (yr)	52.0 ± 12.4 (19 to 76)
Sex (female : male)	106 : 54
Body mass index (kg/m <sup>2</sup> )	24.8 ± 3.2 (17.5 to 33.7)
Side (right : left : bilateral)	71 : 87 : 2
Follow-up period (yr)	9.8 ± 3.6 (5.0 to 19.3)
Cause of tear	
Trauma	60 (37.5)
Degenerative	100 (62.5)
Duration from symptom onset to surgery (mo)	14.3 ± 6.3
Preoperative K-L grade	
Grade 0	37 (23.1)
Grade 1	47 (29.4)
Grade 2	54 (33.8)
Grade 3	22 (13.8)
Grade 4	0
Preoperative hip-knee-ankle angle (°; varus +/valgus -)	3.3 ± 3.3 (-5.1 to 12.3)

Values are presented as mean ± standard deviation (range) or number (%). K-L grade: Kellgren-Lawrence grade.

most commonly performed for cases with clinical failure (43.6%). Although there was a difference in the ratio, the most common procedure for failure was TKA at 5, 10, and 15 postoperative years. The modes of clinical failure are summarized in Table 2. Overall clinical success rates were 95.7% at 5 years, 75.6% at 10 years, and 46.3% at 15 years postoperatively (Fig. 2). Regarding the factors related to clinical failure in the Cox proportional hazard model, age, HKA angle, and K-L grade ( $p = 0.01$ ,  $p = 0.02$ , and  $p = 0.04$ , respectively) were significant risk factors of clinical failure. Interaction analysis showed age was an independent factor, but HKA angle and K-L grade were interrelated. BMI, sex, symptom duration, chondral lesion, type of meniscus tear and the cause of tear (traumatic vs. degenerative) were not related to clinical failure. ROC/AUC analysis results for cutoff values at 5 and 10 years postoperatively are summarized in Table 3 and Fig. 3.

**Table 2.** Modes of Clinical Failure after 5, 10, and 15 Years

Variable	No. of patients (%)
Clinical failure after 5 years	
Arthroscopic surgery	1 (14.3)
HTO	2 (28.6)
UKA	1 (14.3)
TKA	3 (42.9)
Total	7
Clinical failure after 10 years	
Arthroscopic surgery	6 (15.3)
HTO	4 (10.3)
UKA	2 (5.1)
TKA	17 (43.6)
Intolerable pain without analgesics	10 (25.6)
Total	39
Clinical failure after 15 years	
Arthroscopic surgery	10 (12.5)
HTO	6 (7.5)
UKA	3 (3.8)
TKA	48 (60.0)
Intolerable pain without analgesics	13 (16.3)
Total	80

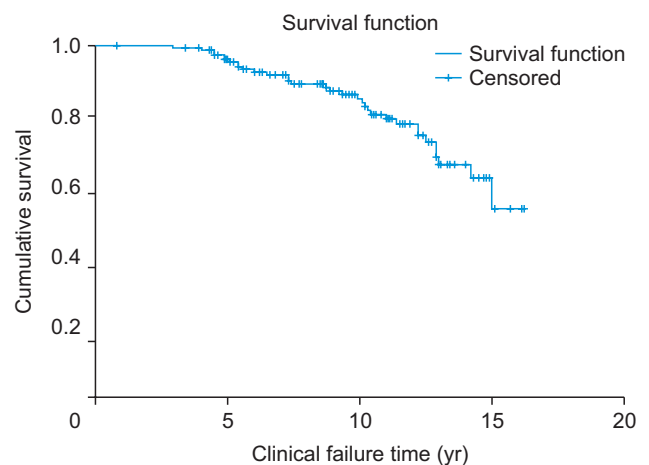
HTO: high tibial osteotomy, UKA: unicompartmental knee arthroplasty, TKA: total knee arthroplasty.

In patients who achieved clinical success at 10 years after APM, radiological osteoarthritis gradually progressed (Fig. 4). Interestingly, the proportion of patients showing radiological progression was significantly dependent on preoperative K-L grade (from grade 0 to grade 1 or 2, 10.8%; from grade 1 to grade 2 or 3, 54.8%; and from grade 2 to grade 3, 57.4%;  $p < 0.001$ ). However, clinical scores showed no significant decrease during the 10-year follow-up period and those that achieved clinical success at 10 years postoperatively showed immediate improvements after APM (Fig. 5).

## DISCUSSION

The most important findings of the present study are that (1) patient age ( $\geq 50$  years), preoperative K-L grade ( $\geq$  grade 2), and HKA angle ( $\geq$  varus  $5.5^\circ$ ) were found to be significant factors of clinical failure and (2) patients who achieved clinical success did not show deterioration in pain relief and functional recovery despite progression of radiological osteoarthritis during the 10-year follow-up period.

A majority of studies were conducted to identify factors related to clinical outcomes after APM or to determine degrees of radiologic deterioration after surgery and related factors.<sup>14-20</sup> Most studies involved a short-term follow-up of  $< 2$  years and reported 80%–90% satisfactory clinical result rates after APM. However, several long-term studies contradicted these results. Fauno and Nielsen<sup>14</sup> reported osteoarthritic radiographic changes occurred in 53% of knees that underwent APM as compared with 27% of untreated contralateral knees at 8 years postoperatively. Englund et al.<sup>15</sup> found that degenerative meniscal tears resulted in poorer clinical and radiological outcomes at 16

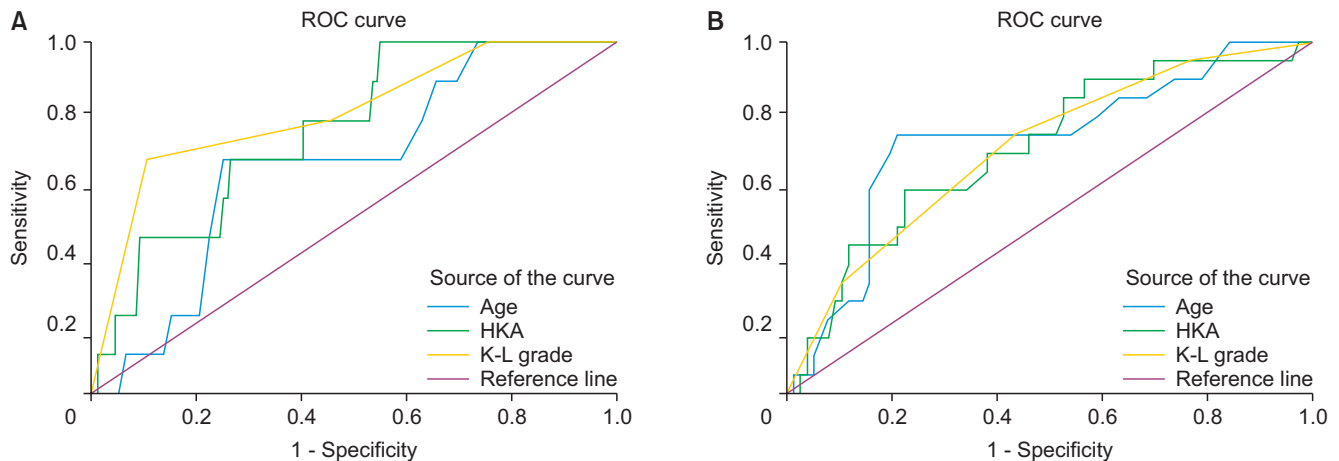


**Fig. 2.** Clinical success rates after arthroscopic partial meniscectomy.

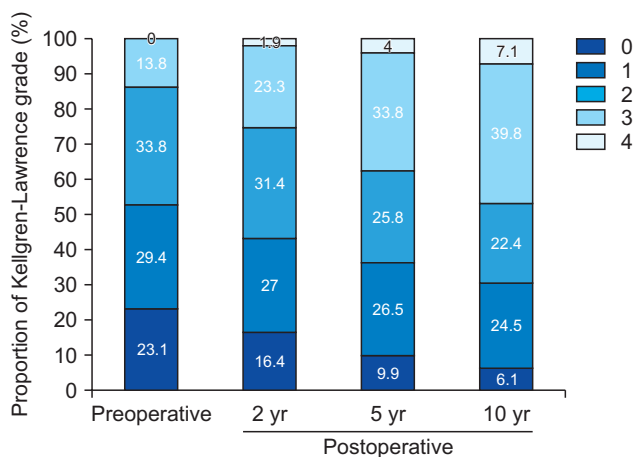
**Table 3.** AUC/ROC Analysis Results for the Cutoff Value of Clinical Failure at Postoperative 5 and 10 Years

Variable	AUC	Discrimination	Cutoff value	Sensitivity	1-Specificity	Odds ratio ( <i>p</i> -value)
Postoperative 5 yr						
Age (yr)	0.658	Poor	50	0.778	0.589	3.1 (0.048)
HKA angle (°)	0.752	Fair	4.5	0.667	0.258	4.6 (0.039)
K-L grade	0.809	Good	2	0.778	0.109	7.1 (0.038)
Postoperative 10 yr						
Age (yr)	0.720	Fair	50	0.642	0.592	2.6 (0.048)
HKA angle (°)	0.707	Fair	5.5	0.632	0.342	4.0 (0.018)
K-L grade	0.720	Fair	2	0.737	0.105	3.6 (0.018)

AUC: area under the curve, ROC: receiver operating characteristic, HKA: hip-knee-ankle, K-L grade: Kellgren-Lawrence grade.



**Fig. 3.** Receiver operating characteristic (ROC) curves for clinical failure at 5 years (A) and 10 years (B) postoperatively. Diagonal segments are produced by ties. HKA: hip-knee-ankle, K-L grade: Kellgren-Lawrence grade.

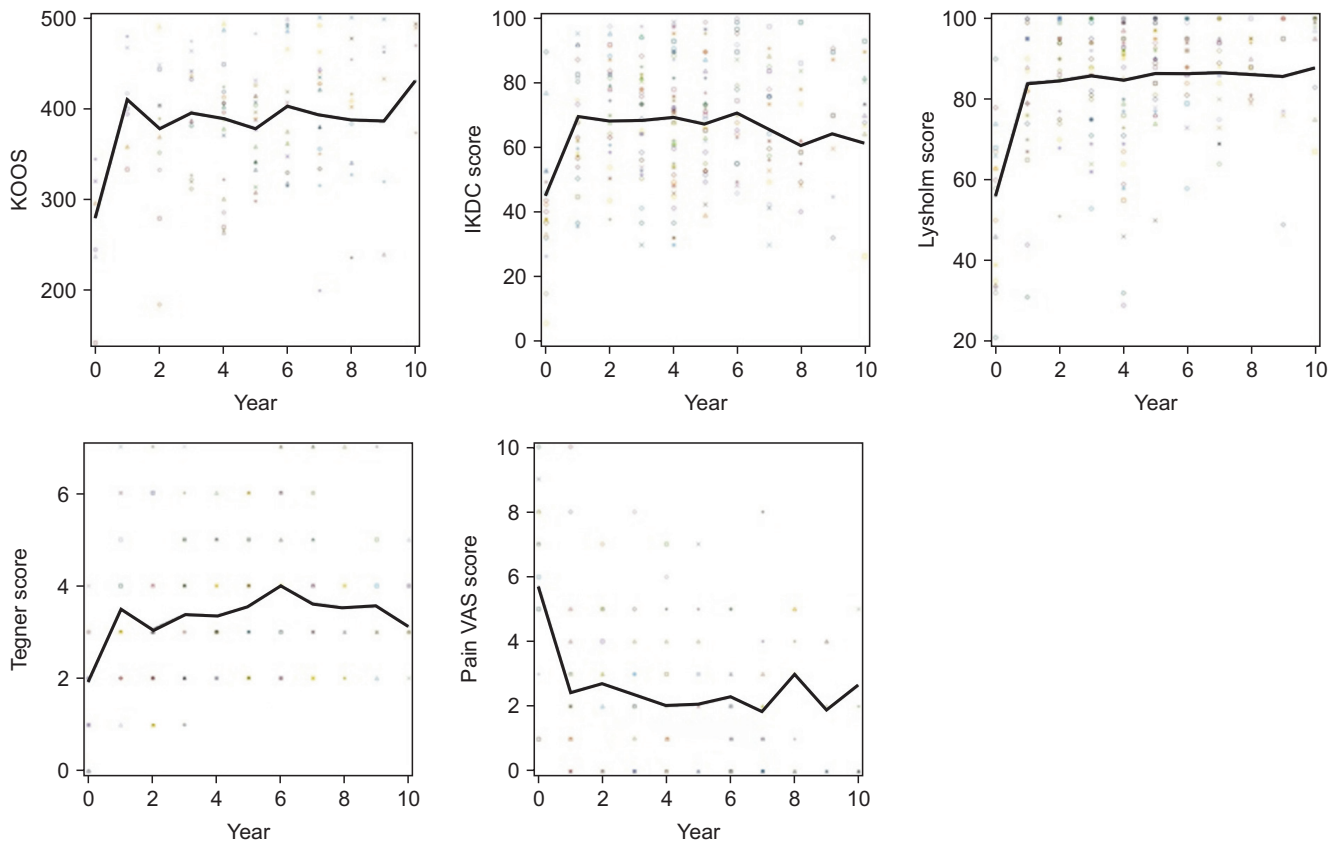


**Fig. 4.** Radiologic progression in patients who achieved clinical success at 10 years after arthroscopic partial meniscectomy.

years in 155 patients after APM. Salata et al.<sup>16)</sup> conducted a systematic review on radiological and clinical outcomes after APM and reported that degenerative meniscal tears were significantly associated with negative postoperative outcomes, which is a highly relevant finding, as most APMs are performed in middle-aged and elderly patients who typically have degenerative meniscal tears.<sup>21-24)</sup> However, the type of meniscus tear was not a risk factor in the present study. Degenerative horizontal tears were the most common type (68%) and the other types were relatively rare in the subjects.

Several authors reported that concomitant osteoarthritic changes were found to be associated with a slower rate of short-term recovery and inferior clinical outcomes, as well as patient satisfaction levels in mid-term and long-term follow-ups after APM.<sup>25)</sup> Regarding APM for painful





**Fig. 5.** Clinical scores of the patients who achieved clinical success at 10 years after arthroscopic partial meniscectomy. KOOS: Knee injury and Osteoarthritis Outcome Score, IKDC: International Knee Documentation Committee, VAS: visual analog scale.

degenerative meniscal tears in the presence of knee osteoarthritis in patients older than 50 years of age, Rodriguez-Merchan et al.<sup>19)</sup> reported Outerbridge grade III and IV of the patient group were 61% and cartilage status was a risk factor, which is contradictory to our finding. We think this result was obtained by classifying the condition of the cartilage status based on the most severe part even if there was only one focal lesion regardless of the area. On the other hand, Bin et al.,<sup>26)</sup> reported that meniscal tear symptoms in patients with grade IV osteoarthritis can be improved using arthroscopic medial meniscectomy, and the mean time to further surgery was 49.8 months. In a study reported by Lee et al.,<sup>27)</sup> 94.4% of their patient group had Outerbridge grade III or higher lesions. They reported that arthroscopic meniscectomy was an effective treatment for degenerative medial meniscus posterior root tears with a favorable long-term survival and chondral status according to Outerbridge classification was not a risk factor related to joint survivorship. Similar to the study of Lee et al.,<sup>27)</sup> the patient group in our study had severe chondral lesions. Because of this, it is questionable whether the chondral status was not a risk factor. The classification according to

the Outerbridge grade may be considered inappropriate to reflect the overall chondral status, and there may be limitations to consider it as a prognostic factor before APM surgery. Therefore, the effect of the chondral status on the prognosis of APM is still debatable, warranting further research.

It has been reported in several studies that obesity is a risk factor for APM failure. Erdil et al.<sup>28)</sup> reported that the obese group had a high early complication rate after meniscectomy, and Krych et al.<sup>29)</sup> reported that the obese group showed a statistically significantly higher failure rate than the non-obese group. However, BMI was not a significant risk factor in the present study. The average BMI of the subjects was 24.8 kg/m<sup>2</sup> ( $\pm$  3.2), and the number of subjects with 25 to 30 kg/m<sup>2</sup> and more than 30 kg/m<sup>2</sup> of BMI was 29 (18.1%) and 10 (6.2%), respectively.

In a systemic review undertaken to identify prognostic factors, a larger amount of resected tissue, the presence of radiological knee osteoarthritis at baseline, and a longer complaint duration were found to be associated with poorer clinical outcomes after APM whereas sex, preoperative sport level, a traumatic versus degenerative

onset, and type of meniscal tear did not influence clinical outcomes. However, the study was limited by a high risk of bias and the use of short-term clinical scores.<sup>17)</sup> In another systematic review, it was concluded that patients with symptomatic meniscal tears and degenerative changes might benefit from arthroscopic meniscectomy, particularly when the osteoarthritis is mild. However, the patient selection criteria used for APM were not detailed.<sup>18)</sup> Sofu et al.<sup>30)</sup> reported that Outerbridge grade III or IV chondral lesions should be considered as the major predictors of the clinical outcome after APM performed for acute trauma-related symptomatic medial meniscal tears in patients more than 60 years of age. On the other hand, some other studies have shown that even in patients with Outerbridge grade IV chondral lesions, meniscal tear symptoms could be improved using arthroscopic meniscus surgery.<sup>26)</sup>

The European Society for Sports Traumatology, Knee Surgery, and Arthroscopy reached consensus on the surgical management of degenerative meniscus lesions in 2016.<sup>31)</sup> Although they suggested a clear framework for the management of degenerative meniscus lesions, no precise surgical treatment algorithm was proposed. The British Association for Surgery of the Knee also presented an evidence-based treatment guideline for patients with meniscal lesions of the knee in 2019,<sup>32)</sup> but this guideline lacks details of specific approaches for individual patients. A retrospective cohort study compared patients aged > 50 years who underwent or did not undergo early conversion to TKA within 5 years of APM for the treatment of painful degenerative meniscal tears and reported that the K-L grade determined by preoperative radiography was the primary predictor of TKA conversion.<sup>19)</sup> However, subjects were limited to patients aged > 50 years, and no cutoff values were provided for factors related to early failure.

Despite developments in surgical techniques and minimization of resection extent during meniscectomy, the risks of clinical failure and symptomatic or asymptomatic radiologic progression of knee osteoarthritis remain unacceptably high. Osteoarthritis is well recognized as a cause of failure, but the influences of other variables on the clinical outcomes of APM in middle-aged individuals with painful meniscal tears are controversial. Also, no specific cutoff values have been suggested for these factors. Although the present study cannot be described as a high-

evidence study due to its retrospective design, we believe it is reasonable to suggest cutoff values for risk factors. Furthermore, although osteoarthritis progressed radiographically in patients who achieved clinical success at 10 years postoperatively, preoperative symptoms and clinical scores improved after surgery and these improvements persisted for 10 years. We believe that if surgeons carefully consider indications, APM provides a good treatment option for painful medial meniscal tears.

This study has several limitations. First, the present study is a retrospective observational one and included only cases followed up for more than 5 years postoperatively for the evaluation of prognostic factors. Due to the follow-up loss, there can be a selection bias. However, we analyzed the mean 10-year follow-up data. Second, there was no control group. Therefore, we could not show the natural history of meniscal tears with mechanical symptoms that were not treated with meniscectomy. A third limitation is that the follow-up rate was as low as 26.5%, with 176 patients followed up for more than 5 years out of a total of 665 patients.

The prognostic factors related to clinical failure after APM for a medial meniscal tear were patient age ( $\geq 50$  years), preoperative K-L grade ( $\geq$  grade 2), and HKA angle ( $\geq$  varus  $5^\circ$ ). Although osteoarthritis progressed radiographically in patients without clinical failure, pain relief and functional recovery did not deteriorate over the 10-year follow-up period. Finally, we advise more attention be paid to the indications for APM.

## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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