

Osteochondral Autograft Transplant as a Potential Salvage Procedure for Articular Cartilage Defects of the Lateral Compartment in Lateral Meniscus–Deficient Knees

Results From a Country With Limited Availability of Meniscal Transplant

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Background: The treatment of a meniscus-deficient knee is challenging, especially when patients are young and active and are not favorable candidates for prosthetic joint replacement.

Hypothesis: We hypothesized that osteochondral autologous transplant (OAT) alone can be considered a salvage treatment for patients with cartilage damage of the lateral compartment of the knee, even with lateral meniscal deficiency, if the knee alignment is close to neutral.

Study Design: Case series; Level of evidence, 4.

Methods: Patients with lateral meniscal deficiency, whose femorotibial angle was 170° to 180° and who underwent OAT on the lateral compartment of the knee without concomitant realignment osteotomy, were retrospectively included in this study. The International Knee Documentation Committee (IKDC) subjective score and the Japanese Orthopaedic Association score for knee osteoarthritis (JOA knee score) were recorded. The International Cartilage Repair Society (ICRS) cartilage repair assessment was used to evaluate the repaired cartilage at second-look arthroscopy.

Results: The study included 10 patients (mean ± SD age, 31.7 ± 19.7 years; 3 men and 7 women) who had ICRS grade 4 cartilage lesions (mean size, 3.5 ± 1.7 cm²); the mean follow-up was 73.8 ± 42.5 months. From preoperative assessment to final follow-up, the mean IKDC subjective score improved significantly from 53.5 ± 10.0 to 85.4 ± 10.1, and the mean JOA knee score improved significantly from 81.0 ± 8.4 to 95.6 ± 5.3 ($P = .004$ for both). One patient with a femorotibial angle of 170° underwent revision distal femoral osteotomy owing to prolonged symptoms and progression of the valgus deformity, and 2 other patients with femorotibial angles of 170° and 171° also exhibited progression of valgus malalignment or low clinical scores postoperatively. Patients with a favorable femorotibial angle (174°–178°) exhibited relieved symptoms and preservation of femorotibial angle alignment within 1° of change at follow-up. At second-look arthroscopy ($n = 8$ patients), 6 patients had an ICRS score of nearly normal or normal.

Conclusion: In the study patients, for which a meniscal allograft was unavailable, the OAT procedure was able to relieve the symptoms associated with cartilage lesions, even with lateral meniscal deficiency, when the femorotibial angle alignment was close to neutral.

Keywords: knee; osteochondral autologous transplant; cartilage; lateral meniscal deficiency

The meniscus is a fibrocartilage structure that is important for load distribution and joint stability. The medial and lateral menisci transmit 50% and 70% of their

compartmental loads in extension, increasing to 85% and 90% in knee flexion, respectively.²⁹ Since 1948, when Fairbank⁷ described radiographic changes after meniscectomy, research has found that the meniscus is important for chondroprotection by decreasing weight distribution on the articular cartilage and enhancing joint stabilization, lubrication, and proprioception.^{17,18,32,33} Meniscal deficiency is a

The Orthopaedic Journal of Sports Medicine, 8(11), 2325967120962753

DOI: 10.1177/2325967120962753

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strong risk factor for subsequent cartilage lesions and progression of osteoarthritis at long-term follow-up.²⁹

The treatment goal for the meniscus-deficient knee is to provide symptomatic relief during daily activities, because relief with higher level activities is less predictable. Meniscal allograft transplant,^{8,13,21} realignment osteotomy such as high tibial osteotomy (HTO)^{6,21} and distal femoral osteotomy (DFO),^{5,13} and prosthetic joint replacement²⁹ are reported as treatments for symptomatic meniscus-deficient knees. Ideally, joint preservation surgery for the meniscus-deficient knee would prevent further progression of osteoarthritis, although the current literature has not reliably proven this.²⁹

Patients who require salvage surgeries to alleviate severe symptoms from chondral lesions with meniscal deficiency (due to inadequate meniscectomy) have been referred (although infrequently) to our hospitals. Because meniscal allograft is very limited in Japan, osteochondral autologous transplant (OAT) has been performed in our hospitals as a time-saving or salvage surgery to improve the symptoms of patients with meniscal deficiency, only when the alignment of the knee was close to neutral. This is especially the case if patients are too young or have physical demands that are too high for a total joint arthroplasty.

OAT is one of the most common surgical treatments for focal cartilage lesions^{12,22} and the most reliable treatment for osteochondral disease.^{10,16} Moreover, OAT can be considered for some patients with early osteoarthritis who cannot tolerate the decline in quality of life from total or unilateral knee arthroplasty.^{2,11} However, it is not known whether OAT for the meniscus-deficient knee could relieve patients' symptoms and improve their quality of daily life. The purpose of this study was to evaluate the clinical results of OAT for patients with lateral meniscal deficiency. The hypothesis was that OAT alone could be considered as a salvage treatment for patients with cartilage damage of the lateral compartment of the knee, even when the lateral meniscus was deficient, if the femorotibial angle (FTA) was 170° to 180°.

METHODS

Patients

This retrospective case series was performed with the approval of the ethics committee of our hospitals. The requirement for informed consent was waived, and opt-out was offered. The study was conducted under the principles of the Declaration of Helsinki. Patients who had undergone OAT at our hospitals were retrospectively included in this study if they exhibited lateral meniscal deficiency due to the previous surgery, underwent OAT on the lateral femoral

condyle and/or lateral tibial plateau between 2002 and 2015 without concomitant osteotomy, and had been followed up for >2 years. Meniscal deficiency was defined as present when at least the inner two-thirds of the meniscus was resected so that the hoop stress mechanism of the meniscus was lost. There was no exclusion due to patient age, but patients with FTA of <170° or >180° were excluded, because knee osteotomy was indicated for such patients.

Surgery and Postoperative Rehabilitation

For patients who had experienced severe knee pain, knee swelling, and limited knee motion that had disturbed daily activities and for whom nonoperative treatment was unsuccessful, OAT was performed using the Osteochondral Autograft Transfer System (Arthrex) as previously described.²³ In brief, diagnostic arthroscopy was performed to evaluate the condition of the entire knee joint and to confirm that the location and size of the lesions were adequate for OAT. Then, with a lateral parapatellar approach, OAT was performed using the nonweightbearing area in the patellar groove as the donor site. During the procedure, the size of the articular cartilage defect was measured, and plug size (diameter) and number were recorded. The plug size was expressed as the diameter of the recipient site; thus, the diameter of the donor site was 1 mm larger. At the end of the surgery, suction drainage was placed in the knee joint. The operated knee was not immobilized, and after removal of the drain on postoperative day 2, range of motion rehabilitation was initiated. Weightbearing was prohibited for 3 weeks, and full weightbearing was allowed at 7 weeks postoperatively.

Radiographical and Clinical Evaluation

The preoperative and latest FTA, which was defined as the angle between the distal femoral anatomic axis and the proximal tibial anatomic axis, and the Kellgren-Lawrence (KL) grading system were used for the radiographic evaluation. The International Knee Documentation Committee (IKDC) subjective score¹⁵ and the Japanese Orthopaedic Association score for knee osteoarthritis (JOA knee score)²⁷ were both recorded before OAT and at final follow-up and were used to evaluate the clinical outcome. For the patients who underwent a second-look arthroscopy, the International Cartilage Repair Society (ICRS) cartilage repair assessment was used to evaluate the repaired cartilage.⁴ Briefly, the plugs were evaluated using the following criteria: degree of defect repair (protocol B for OAT; 0-4 points), integration with a border zone (0-4 points), and macroscopic appearance (0-4 points). The scores of these 3 criteria were summed, and an overall repair assessment was

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Final revision submitted April 21, 2020; accepted May 29, 2020.

The authors declared that there are no conflicts of interest in the authorship and publication of this contribution. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval for this study was obtained from Kyoto University and from the National Hospital Organization Kyoto Medical Center, Kyoto, Japan.

TABLE 1
Patient Characteristics^a

Patient No.	Age, y	Sex	Body Weight, kg	BMI, kg/m ²	Knee	Follow-up Period, mo	Cartilage Lesion	ICRS Grade	Recipient Size, cm ²	Plug Size Diameter × Number
1	14	Female	53	20.2	Left	62	LFC	4	4.0	8 mm × 4
2	64	Male	61	21.4	Right	134	LFC	4	4.5	9 mm × 4; 6 mm × 2
3	14	Female	65	26.7	Left	134	LFC; LTP	4 (LFC); 4 (LTP)	4.0	9 mm × 1 (LFC); 9 mm × 1 (LTP)
4	12	Female	40	16.0	Left	118	LTP	4	2.3	6 mm × 1; 7 mm × 2
5	57	Male	70	23.7	Right	26	LFC	4	7.0	9 mm × 2; 10 mm × 3
6	51	Female	48	20.9	Right	86	LFC	4	4.5	7 mm × 1; 8 mm × 3
7	21	Female	53	18.3	Right	70	LFC	4	3.0	8 mm × 4
8	17	Female	53	20.8	Left	43	LFC; LTP	4 (LFC); 4 (LTP)	2.0	8 mm × 1 (LFC); 8 mm × 1 (LTP)
9	38	Male	70	22.8	Left	41	LFC	4	3.0	6 mm × 1; 9 mm × 3
10	24	Female	52	21.3	Left	24	LTP	4	1.0	8 mm × 1

^aBMI, body mass index; ICRS, International Cartilage Repair Society; LFC, lateral femoral condyle; LTP, lateral tibial plateau.

defined as follows: grade 1, normal (12 points); grade 2, nearly normal (8-11 points); grade 3, abnormal (4-7 points); and grade 4, severely abnormal (0-3 points).

Statistical Analysis

To compare the preoperative and postoperative clinical outcomes, we used the nonparametric Wilcoxon matched-pairs signed-rank test, and $P < .05$ was deemed significant.

RESULTS

A total of 10 patients (mean \pm SD age, 31.7 ± 19.7 years; body mass index, 22.0 ± 3.8 kg/m²; 3 men and 7 women) met the inclusion and exclusion criteria. All patients had undergone a meniscectomy; 5 had a failed meniscectomy for discoid meniscus and 5 had undergone total meniscectomy for lateral meniscal tear in previous hospitals and were referred to our hospitals due to intolerable symptoms. The characteristics of the 10 patients at the time of OAT surgery are shown in Table 1. OAT was performed on the cartilage lesions (size, 3.5 ± 1.7 cm²) on the lateral femoral condyle and/or lateral tibial plateau using 3.5 ± 1.5 plugs (minimum 1, maximum 6 plugs) (Table 1). One patient (patient 3) underwent DFO to correct valgus deformity 13 months after the first OAT surgery because of persistent pain. This patient was excluded from the statistical comparison of the clinical scores. Clinical scores were improved for all patients at final follow-up, with an average increase of 31.9 points on the IKDC subjective score (Figure 1) and 14.6 points on the JOA knee score (Figure 1). The change of FTA was within 1° in 7 patients but $>2^\circ$ in the remaining 3 patients (Table 2). The results of the KL grade indicated that 4 patients showed deterioration of osteoarthritis (Table 2). Among these 4 patients, 3 had the lowest FTAs (170° , 170° , 171°) at initial surgery.

A total of 8 patients underwent second-look arthroscopy 14.6 ± 4.0 months after the initial OAT surgery, and 6 patients exhibited a score of normal or nearly normal with the ICRS cartilage repair assessment (Table 3). However, patient 4 had

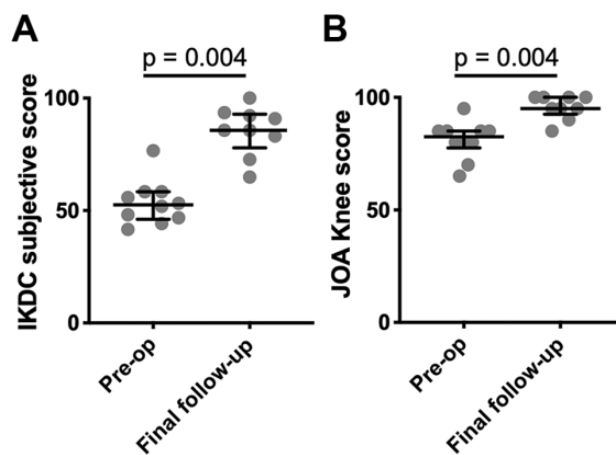


Figure 1. Results of the (A) International Knee Documentation Committee (IKDC) subjective score and (B) Japanese Orthopaedic Association score for knee osteoarthritis (JOA knee score). Shown are means with SDs (bars). From preoperative assessment to final follow-up, the mean IKDC subjective score improved from 53.5 ± 10.0 to 85.4 ± 10.1 and the mean JOA knee score improved from 81.0 ± 8.4 to 95.6 ± 5.3 ($P = .004$ for both; Wilcoxon matched-pair signed-rank test).

an abnormal score and patient 3 had a severely abnormal assessment that required additional surgery (DFO). Images for a representative case (patient 10) are presented in Figure 2. Although alignment was almost neutral, the lateral meniscus was not detected on magnetic resonance imaging. Only a thin, fiberlike structure was seen in the location of the lateral meniscus. Second-look arthroscopy showed that the tibial cartilage defect had been repaired and demonstrated favorable healing.

DISCUSSION

In this study, OAT on the lateral condyle of the knee improved symptoms in more than two-thirds of patients,

even those with lateral meniscal deficiency. Although the clinical scores were improved at final follow-up, a few patients had poor outcomes. Patient 3 required DFO surgery at 13 months after OAT, patient 4 showed abnormal cartilage repair at second-look arthroscopy, and patient 6 had a low IKDC subjective score of 64.9 points at final follow-up. These 3 patients had the lowest FTAs (170°, 170°, and 171°, respectively) before OAT surgery, and their FTAs became more valgus during follow-up. The other patients, who had FTAs between 174° and 178° before OAT surgery, exhibited good clinical outcomes and little change in FTA ($\leq 1^\circ$) at final follow-up.

Alignment is a very important factor in cartilage degeneration and cartilage repair, and it is evident that malalignment plays an important role in disease development and progression. In a study of preservation therapy for spontaneous osteonecrosis of the medial femoral condyle of the

knee, an FTA $>180^\circ$ on the initial radiograph was a risk factor for poor diagnosis, for which patients required surgeries such as total knee arthroplasty, unilateral knee arthroplasty, or HTO.²⁴ In a study of primary knee osteoarthritis, varus alignment was associated with a 4-fold increase in the progression of medial arthritis, and valgus alignment was associated with a 5-fold increase in the progression of lateral arthritis.³¹ Malalignment is also a risk factor for failure of cartilage repair. In a previous study of OAT for medial compartment, varus malalignment resulted in worse clinical outcomes if the malalignment was not corrected, which suggests that correction is very important in protecting the resurfaced area.¹¹ In a study of osteochondral allograft transplant, malaligned cases demonstrated significantly higher clinical failure rates compared with well-aligned cases, because varus alignment in medial compartment transplant and valgus alignment in lateral transplant were likely to overstress the graft.⁹ Although most studies report that malalignment is a risk factor for the failure of cartilage repair, most of these cases concern cartilage repair of the medial compartment, not the lateral compartment. In terms of pressure on the lateral compartment cartilage, Agneskirchner et al¹ found that the contact pressure in the lateral compartment was 60% of the total pressure in neutral alignment and that the contact pressure increased as the alignment became valgus. In our series, alignment was also critical for the outcome of our patients, as the patients with low FTA (170° or 171°) did not heal well due to various factors.

We included FTA between 170° and 180° in this study because the average FTA of the Japanese population is about 175°¹⁴; however, the definition of neutral alignment is controversial. Previous reports have defined malalignment as $\geq 5^\circ$ valgus or varus from neutral alignment.³ LaPrade et al²⁰ described 5° valgus alignment (FTA of 170°) as acceptable after correction by HTO. Ogura et al²⁶ defined malalignment as an alignment outside of 2° or 3° from neutral and performed realignment procedures on these cases. In that study, patients with an alignment of about 5° valgus tended to have poor clinical outcomes,

TABLE 2
Radiographic Evaluation^a

Patient No.	Femorotibial Angle, deg		KL Grade	
	Before OAT	Latest Follow-up	Before OAT	Latest Follow-up
1	176	176	1	1
2	175	174	1	2
3	170	168 ^b ; 177 ^c	1	2
4	170	165	1	2
5	176	176	2	2
6	171	169	2	3
7	178	178	2	2
8	178	179	2	2
9	178	178	2	2
10	174	174	2	2

^aKL, Kellgren-Lawrence; OAT, osteochondral autologous transplant.

^bFemorotibial angle before distal femoral osteotomy.

^cFemorotibial angle at final follow-up after distal femoral osteotomy.

TABLE 3
ICRS Cartilage Repair Assessment at Second-Look Arthroplasty (n = 8 patients)^a

Patient No.	Timing of Second Look, mo	ICRS Score ^b				Total Score	Overall Repair Assessment
		Degree of Defect Repair	Integration With Border Zone	Macroscopic Appearance			
1	11	4	2	3	9	Nearly normal	
2	15	4	4	4	12	Normal	
3	14	2	0	0	2	Severely abnormal	
4	14	2	2	2	6	Abnormal	
6	24	4	2	4	10	Nearly normal	
8	13	4	4	3	11	Nearly normal	
9	13	4	3	4	11	Nearly normal	
10	13	4	2	4	10	Nearly normal	

^aICRS, International Cartilage Repair Society.

^bThe 3 criteria were each scored from 0 to 4 for a possible total of 12 points; 12 = normal, 8-11 = nearly normal, 4-7 = abnormal, and 0-3 = severely abnormal.

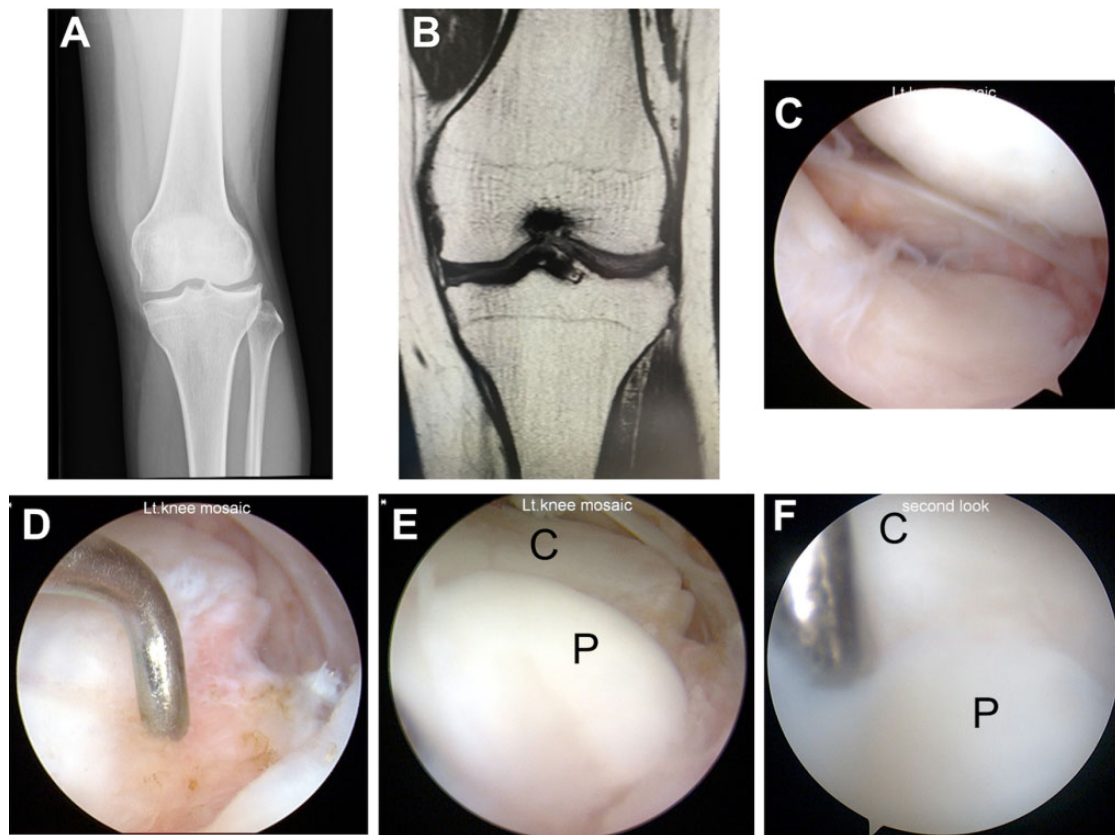


Figure 2. Representative case (patient 10). (A) Plain radiograph showed slight osteophyte formation at the lateral tibial condyle without joint space narrowing, and (B) T1-weighted MRI showed the disappearance of the lateral meniscus. (C) During arthroscopy, only a thin, fiberlike structure was observed where the lateral meniscus should have existed. (D, E) An International Cartilage Repair Society grade 4 cartilage defect on the tibial plateau was repaired using an osteochondral plug. (F) Second-look arthroscopy at 13 months after initial surgery showed good integrity among native cartilage and the transplanted osteochondral plug. C, native cartilage; P, osteochondral plug.

although the patients with more neutral alignments exhibited improved clinical outcomes and maintained their alignments at final follow-up. This result indicates that malalignment should be strictly corrected in patients with a lateral meniscal deficiency.

Meniscal deficiency is a strong risk factor for subsequent cartilage lesions and progression of osteoarthritis at long-term follow-up, and the ultimate goal of treatment for meniscal deficiency is to prevent these poor outcomes. To this end, joint-preserving surgery, meniscal allograft transplant (MAT), and osteotomy around the knee are reported as effective treatments. Although the ideal candidates for MAT are patients with preserved cartilage whose Outerbridge grade is ≤ 2 , as described in an earlier paper,³⁰ recent reports do not exclude advanced cartilage lesions as an indication for MAT.^{13,25} Additionally, acceptable results for MAT have been reported with concomitant surgeries, including cartilage repair.¹⁹ According to the latest evidence, some of our patients might have had indications for MAT with or without cartilage repair, however the unavailability of allografts in our country made it difficult to perform MAT on our patients. Osteotomy around the

knee is also an effective surgery that can be performed on patients with damaged or degenerated cartilage. Because, in our hospitals, HTO or DFO is performed for patients with severe malalignment (ie, $>5^\circ$ varus or valgus malalignment), our series included only patients with FTA alignments between 170° and 180° without any concomitant osteotomy.

This study had some limitations. First, only lateral meniscal deficiencies were studied, as we did not have a patient with a medial meniscal deficiency who underwent only OAT. In all cases of medial meniscal deficiency, FTA was $>180^\circ$ and HTO had been performed with or without OAT. Second, this study lacked a control group, but because we were performing salvage surgery for severe symptoms, a nonoperative treatment group was not available. Third, the patient population was heterogeneous in both age and causative disease for the original meniscectomy. This study included 5 patients with failed meniscectomy for discoid meniscus and 5 patients with meniscectomy for lateral meniscal tear. Further, 2 patients with discoid meniscus exhibited lower FTA, 170° or 171° , and further deterioration. Patients who undergo meniscectomy for discoid

meniscus may be at particular risk of failure, and a recent study reported that 9% of meniscectomies for children, including those with discoid meniscus, required reoperation at a mean of 23 months.²⁸ Given the small number of patients, subgroup analysis was not performed, and we could not determine whether patients with discoid meniscus had higher risk of OAT failure. Fifth, FTA was measured using a short knee radiograph instead of a long radiograph of the lower extremity. Sixth, this cohort did not include any obese patients. Thus, we have no data as to whether this surgery can be effective for obese patients, who receive less benefit from a cartilage repair strategy, especially without lateral meniscus. Seventh, the timing of the second-look arthroscopy varied from 11 to 24 months. The longer the repaired cartilage remains, the more likely it is to break down and thus have an inferior ICRS grade. Eighth, although the follow-up period was an average of 73.8 months, for some patients the follow-up was as short as 24 to 26 months. Even 73.8 months may not be long enough for cartilage repair, especially in patients with meniscal deficiency. Further follow-up is needed to ascertain the long-term outcome and efficiency of OAT in these patients.

CONCLUSION

OAT relieved symptoms and provided good cartilage repair even in patients with lateral meniscal deficiency, as long as the FTA alignment was within 174° to 178°. Although this technique may not be an ideal procedure, OAT can be considered as a rescue or salvage procedure for symptomatic patients with cartilage lesions and lateral meniscal deficiency, especially when meniscal allografts are unavailable. However, for cartilage lesions of the meniscus-deficient knee, osteotomy around the knee should be considered even for knees with mild malalignment compared with knees that have normal menisci.

ACKNOWLEDGMENT

The authors thank Dr Takashi Nakamura, Shogo Mukai, Shinichi Kuriyama, and Shinichiro Nakamura for their daily clinical cooperation and thoughtful discussion.

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