Lateral Meniscal Allograft Transplant via a Medial Approach Leads to Less Extrusion

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Background: Accurate positioning of the bony bridge is crucial to prevent extrusion of meniscal allografts after transplant. However, oblique or lateralized placement of the bony bridge of the lateral meniscal allograft may occur due to technical error or a limited visual field. The patellar tendon may be an obstacle to approaching the anterior horn of the lateral meniscus, resulting in a laterally placed allograft. Therefore, lateral meniscal transplant through a medial arthrotomy would be an alternative approach. However, no report exists regarding allograft extrusion when comparing medial and lateral arthrotomy techniques in lateral meniscal transplants.

Hypothesis: Extrusion of the midbody of the allograft is less severe and the rotation of the bony bridge is less oblique in lateral meniscal allograft transplants through the medial parapatellar approach than those through the lateral approach.

Study Design: Cohort study; Level of evidence, 3.

Methods: A bony bridge was used to perform 55 lateral meniscal transplants through either a medial or a lateral arthrotomy. Thirty-two allografts were transplanted through a medial arthrotomy and 23 were transplanted through a lateral arthrotomy, not randomly. Because correct positioning of the bony trough through the medial arthrotomy was easier than that through the lateral arthrotomy, the method of the arthrotomy was changed for the latter. The procedure for both groups was identical except for the arthrotomy technique, and rehabilitation was identical for both groups. Follow-up magnetic resonance imaging was conducted for all patients to measure the postoperative extrusion and obliquity of the bony bridge of the allograft. On the coronal view, extrusion was measured as the distance between the outer edge of the articular cartilage of the lateral tibial plateau and the outer edge of the meniscal allograft. On the axial view, a line (line B) was drawn along the longitudinal axis of the bony bridge. The posterior tibial condylar tangential line was drawn between the medial and lateral posterior tibial condylar cortices. A line (line T) was drawn perpendicular to the posterior tibial condylar tangential line. The angle (trough angle) between lines B and T was measured. Postoperative extrusion and the trough angle were compared between the medial and lateral arthrotomy groups.

Results: The median extrusion of the midbody of the allograft was 2.2 mm (interquartile range [IQR], 2.4 mm; range, 0-4.6 mm) in the medial arthrotomy group and 3.1 mm (IQR, 1.5 mm; range, 0-5.3 mm) in the lateral arthrotomy group ($P = .001$). Seven (21.9%) patients demonstrated extrusion in the medial arthrotomy group, and 15 (65.2%) patients had extrusion in the lateral group ($P = .002$). The median trough angle was 0.9° (IQR, 9.3°; range, -8.8-15.8°) in the medial arthrotomy group and 11.6° (IQR, 2.8°; range, 3-19.8°) in the lateral arthrotomy group ($P < .001$).

Conclusion: Based on this experience, lateral meniscal allograft transplant through a medial arthrotomy is preferred to decrease postoperative extrusion of the allograft.

Keywords: extrusion; meniscal allograft transplant; medial arthrotomy; lateral meniscus

Meniscal allograft transplants have been performed to prevent the development of osteoarthritis in young, active patients with deficient menisci after surgery. Although meniscal allograft transplants generally resulted in significant improvements in terms of pain and function at long-term follow-up, patients demonstrated progression of degenerative changes as rated by the Kellgren-Lawrence scale.[4,19] Several reasons may account for the progression of degenerative joint disease. Significant degeneration, tear, and structural changes of the transplanted allograft may develop during the remodeling process.[10] A recent study reported that second-look arthroscopy revealed 7 meniscal tears from 20 knees after meniscal transplant.[6] Extrusion of the meniscal allograft may develop after transplant. Verdonk et al[18] reported that 59% of patients demonstrated

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progressive extrusion of the transplanted meniscus at a minimum 10 years' follow-up. Lee et al[11] reported that 47% of patients had extrusion of more than 3 mm on follow-up magnetic resonance imaging (MRI) on postoperative day 2. Extrusion of the lateral meniscus is significantly associated with cartilage volume loss, decreases in cartilage thickness, and increases in denuded bone in the lateral compartment of the knee.[17] Although extrusion of the transplanted meniscus may develop as a result of degeneration of the allograft during the remodeling period, recent studies reported that postoperative extrusion can develop as a technical pitfall.[3,11,12]

Recent studies demonstrated that lateralized or oblique placement of the bony bridge of the allograft can occur during lateral meniscal transplant.[3,11] Traditionally, lateral meniscal transplant is performed through a lateral arthrotomy.[6,16] However, the patellar tendon can be a significant obstacle in lateral meniscal allograft transplant. The patellar tendon can prevent an easy approach to the insertion of the anterior horn of the lateral meniscus and may result in inaccurate drilling of a guide pin along the insertions of the anterior and posterior horns of the lateral meniscus.[11,20]

To overcome the obstacle presented by the patellar tendon, a medial parapatellar approach rather than the lateral approach could be an alternative to place the lateral meniscal allograft more easily. The medial parapatellar approach may help the surgeon transplant the allograft more anatomically, resulting in less extrusion of the midbody after surgery. Until now, only one article has reported lateral meniscal transplant via medial arthrotomy; the subjects were 2 pediatric patients.[8] However, no study has been published comparing midbody extrusion between medial and lateral parapatellar approaches in lateral meniscal allograft transplant. Therefore, the purpose of this retrospective study was to compare the midbody extrusion between two approaches. The hypotheses of this study were that extrusion of the midbody of the allograft is less severe and rotation of the bony bridge is less oblique in lateral meniscal allograft transplants through the medial parapatellar approach than those through the lateral approach.

METHODS

Subjects

Between April 2005 and December 2010, 55 consecutive patients underwent lateral meniscal allograft transplant with a fresh-frozen graft. All patients underwent subtotal or total lateral meniscectomy for complex tear or irreducible bucket-handle tear of the lateral meniscus in previous surgeries. The inclusion criteria were as follows: young (15-50 years) patients with pain in the lateral compartment more than 6 months after subtotal or total meniscectomy. Exclusion criteria were patients with diffuse chondromalacia more than grade III of the lateral compartment as rated by Outerbridge or lower limb valgus malalignment more than 3°. Patients with untreated ligament instability were excluded. All patients signed an informed consent form. This retrospective study protocol was reviewed and approved by our institutional review board.

Surgical Technique

Preoperatively, the size of the meniscal allograft was measured by use of the radiographic method proposed by Pollard et al.[15] Lead-shot magnification markers placed 100 mm apart were used to correct for magnification. Markers were placed at the lateral femoral epicondyle, and anteroposterior and lateral radiographs were checked to measure the size of the allograft. The lateral meniscal allograft was prepared by use of a bony bridge. A transosseous hole was made on the bony bridge, and No. 2 nonabsorbable passing sutures were placed for each anterior and posterior horn insertion. A No. 1 absorbable suture was placed in the posterior horn to facilitate pulling the graft into the posterolateral compartment (Figure 1). The recipient meniscus was debrided by use of a motorized shaver and meniscal rasp to expose the meniscocapsular junction of the posterior horn and midbody (Figure 2). A mini-arthrotomy was performed, and the anterior horn of the recipient meniscus was excised. The lateral arthrotomy was made in 23 patients between April 2005 and August 2007 and the medial arthrotomy in 32 patients between November 2007 and December 2010 in a consecutive manner, not randomly. Because correct positioning of the bony trough through the medial arthrotomy was easier than that through the lateral arthrotomy, the method of the arthrotomy was changed. A bony trough was made just lateral to the anterior cruciate ligament (ACL) insertion on the tibia along the line between the anterior and posterior horns of the lateral meniscus through either a medial or a lateral arthrotomy (Figure 3). A transtibial hole was made on the floor of the bony trough by use of an ACL guide. No. 2 nonabsorbable sutures for each of the anterior and posterior horns of the allograft were retrieved with a flexible looped wire that was passed through the transtibial hole. A No. 1 absorbable suture that was placed in the posterior horn of the allograft was retrieved by use of the flexible looped wire through a small incision on the lateral aspect of the knee. The bony bridge of the allograft was inserted into the bony trough. By pulling the absorbable and nonabsorbable sutures, the surgeon placed the allograft precisely on the lateral tibial plateau, and arthroscopy confirmed the correct position of the meniscal allograft. Open meniscal repair with No. 2 absorbable sutures was done for the anterior horn of the allograft, and the arthrotomy was closed. The rest of the meniscal repair for the midbody and posterior horn was performed with an arthroscopic inside-out technique with multiple No. 1 absorbable sutures (Figure 4).

After surgery, both groups underwent identical rehabilitation. Partial weightbearing was permitted as soon as tolerated. Closed kinetic chain exercises were started as early as possible. Full weightbearing was allowed after 6 weeks and squatting after 12 weeks. Jogging began after 4 to 5 months. Return to sports activity was allowed after 10 to 12 months.

Magnetic Resonance Imaging

Postoperatively, the meniscal allografts were evaluated via follow-up MRI. Follow-up MRI scans were obtained at an

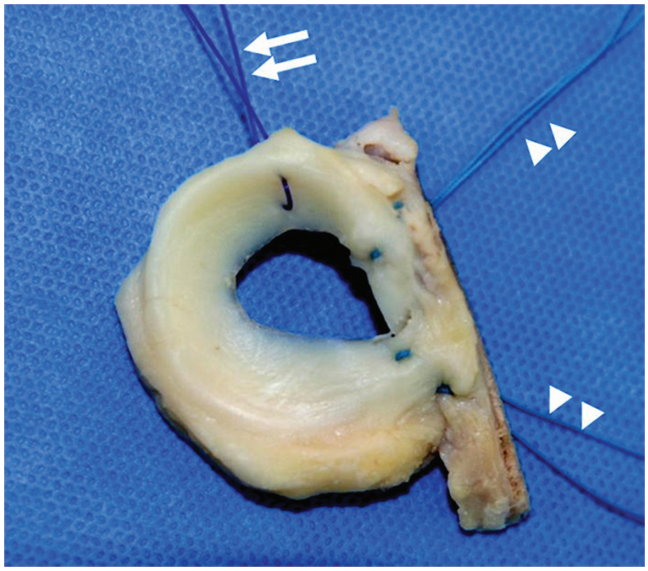

Figure 1. Prepared lateral meniscal allograft for the right knee. Nonabsorbable sutures (arrowheads) were placed for each anterior and posterior horn insertion. An absorbable suture (arrows) was placed in the posterior horn to pull the graft into the posterolateral compartment.

average of 6 months postoperatively for all patients to measure extrusion of the midbody of the allograft, although the patients were asymptomatic. All MRI examinations were performed with a 1.5-T unit (Signa; GE Medical System). MRI consisted of an axial proton-density (PD) sequence, sagittal inversion recovery sequence, sagittal fat suppressed T2W1, coronal PD, and coronal fast spin echo T2. After all coronal images were reviewed, extrusion of the midbody of the meniscal allograft was measured on the image demonstrating maximal extrusion. Extrusion was measured as the distance between the outer edge of the lateral tibial plateau and the outer edge of the meniscal allograft. Extrusion was defined as subluxation of greater than 3 mm.[3,11] On the axial view showing the bony bridge clearly, a line (line B) was drawn along the longitudinal axis of the bony bridge. The posterior tibial condylar tangential line was drawn between the medial and lateral posterior tibial condylar cortices. A line (line T) was drawn perpendicular to the posterior tibial condylar tangential line (Figure 5). The angle (trough angle) between line B and line T was measured as described by Lee et al.[11] If line B was rotated externally to line T, the trough angle was designated positive. If line B was rotated internally, the trough angle was designated negative.

Statistical Analysis

The extrusion of the allograft and the trough angle were represented with median and interquartile range (IQR). The extrusion of the allograft and the trough angle were compared between the medial and lateral arthrotomy groups by use of the Mann-Whitney test. Incidence of the extrusion, as defined by subluxation of 3 mm or more, was compared between the two groups with a chi-square test. Analysis was performed with SPSS software (SPSS for Windows, release 12.0; SPSS Inc), and significance was assumed at $P < .05$. In a pilot study of 10 patients from both groups, extrusion of the midbody of the allograft was measured and the mean and standard deviation were calculated. For a power of 0.8 and an alpha value of .05, the sample size required was 20 patients per group. Therefore, the numbers of patients in the two groups had a sufficient power for statistical analysis without type II error.

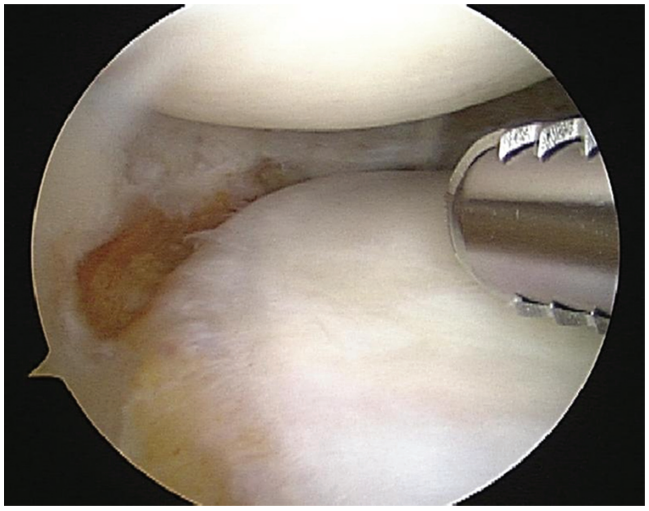

Figure 2. The recipient meniscus was debrided to expose the meniscocapsular junction of the posterior horn and midbody in the right knee.

RESULTS

The mean age of the patients was 30.8 years (range, 15-49 years) at the time of the procedure. Four patients were treated with meniscal allograft transplant and ACL reconstruction concomitantly. Two patients underwent microfracture for a focal chondral defect on the lateral tibial plateau simultaneously. One patient underwent posterior cruciate ligament and posterolateral corner reconstruction, and a staged meniscal allograft transplant was performed. The demographic characteristics of the two groups are shown in Table 1. Age and sex showed no significant differences between the two groups.

The median extrusion of the midbody of the allograft was 2.2 mm (IQR, 2.4 mm; range, 0-4.6 mm) in the medial arthrotomy group and 3.1 mm (IQR, 1.5 mm; range, 0-5.3 mm) in the lateral arthrotomy group. The extrusion of the midbody of the allograft that was transplanted through the medial arthrotomy group was significantly less than that through the lateral group ($P = .001$). Seven (21.9%) patients in the medial arthrotomy group showed extrusion, as defined by subluxation of 3 mm or more, and 15 (65.2%) patients in the lateral group showed

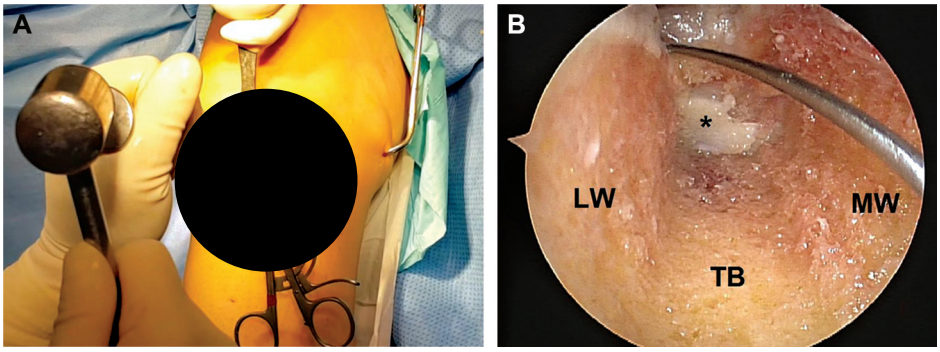

Figure 3. (A) A mini-arthrotomy was performed in the right knee through the medial approach, and a bony trough was made just lateral to the anterior cruciate ligament by use of a U-shaped chisel. (B) Prepared bony trough in the right knee. A flexible wire was placed for an absorbable suture that was positioned at the posterior horn of the prepared allograft. LW, lateral wall; MW, medial wall; TB, bed of the trough. The black asterisk indicates the posterior capsule.

Figure 4. Transplanted lateral meniscus in the right knee.

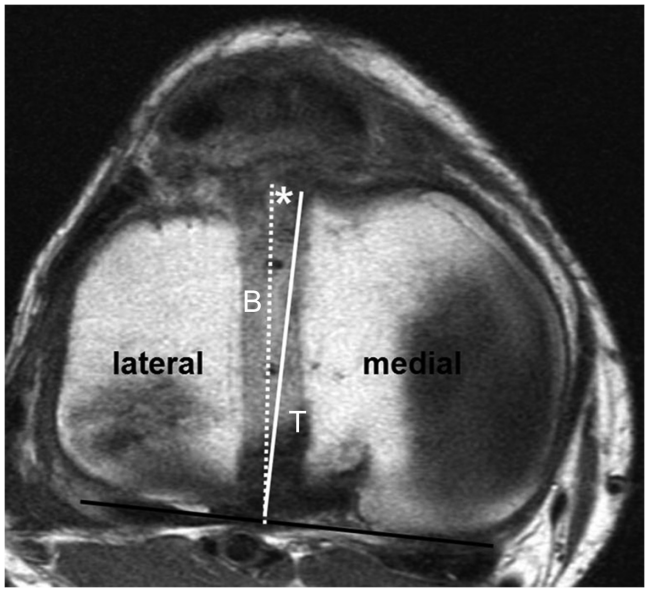

Figure 5. View of the right knee on axial magnetic resonance imaging. The white dotted line (B) is the longitudinal axis of the bony bridge, and the black line is the posterior tibial condylar tangential line. The white solid line (T) was drawn perpendicular to the black line. The trough angle (white asterisk) between the white solid line and the dotted line was measured.

extrusion by the same definition (P = .002). The median trough angle was 0.9° (IQR, 9.3°; range, -8.8-15.8°) in the medial arthrotomy group and 11.6° (IQR, 2.8°; range, 3-19.8°) in the lateral arthrotomy group (P < .001). The bony bridge in the lateral arthrotomy group was positioned more obliquely than that in the medial arthrotomy group.

DISCUSSION

The important findings of this study were that extrusion of the midbody of the allograft at 6 months postoperatively is less severe and rotation of the bone bridge is less oblique in lateral meniscal allograft transplants performed through the medial parapatellar approach than those performed through the lateral approach. Therefore, the hypotheses were confirmed. In this study, the lateral arthrotomy was performed in the initial 23 lateral meniscal transplants. During 23 meniscal transplants, the patellar tendon prevented correct placement of the bony bridge of the allograft

TABLE 1
Demographic Data

	Medial Arthrotomy (n = 32)	Lateral Arthrotomy (n = 23)	*P* Value
Age, y, mean ± SD	29.1 ± 9.3	33.1 ± 7.7	.100
Sex, n, male/female	23/9	17/6	.558

along the line between the centers of the anterior and posterior horns of the lateral meniscus. After 23 meniscal transplants through a lateral arthrotomy, a medial arthrotomy was then used for the following 32 patients. Correct positioning of the bony trough through the medial arthrotomy was easier than through the lateral arthrotomy.

Accurate placement of the starting point of the tibial trough or keyhole at the anterior horn of the lateral meniscus is complicated. The center of the anterior horn can be marked by use of a radiofrequency device.[14] However, it is difficult to identify the center of the insertion of the anterior horn unless the anterior horn is dissected. The guide wire for the keyhole is drilled under arthroscopic evaluation or through an arthrotomy. Several researchers used fluoroscopic views to determine the direction of the guide wire, and they used the lateral tibial spine as a landmark for the direction of the guide wire.[7,12,14,20] However, a recent study demonstrated that the lateral tibial spine is not a reliable marker for the bony trough in lateral meniscal transplant. The direction of most guide pins drilled along the lateral tibial spine was not coincident with the line connecting the centers of both the anterior and posterior horns of the lateral meniscus.[2]

Other researchers have experienced similar difficulty in achieving a correct position for the guide pin when making a keyhole during lateral meniscal transplant. Yoon et al[20] reported that the guide wire placement performed commonly through use of a parapatellar approach was not in the anatomic direction of the meniscal horn bony insertions. These investigators reported that the parapatellar approach had a tendency to make the tibial bony trough at a more lateral position than the original bony insertion point. Lee et al[11] suggested that the patellar tendon could be an obstacle to approaching the anterior horn of the lateral meniscus. Kim et al[7] retracted the patellar tendon medially because the ideal entry point of the guide wire for the keyhole was partially covered by the patellar tendon in the lateral parapatellar approach.

The bony trough of the allograft can be placed obliquely in an axial plane due to the patellar tendon. Lee et al[11] measured the trough angle (the angle between a line along the center of the bony trough and the posterior tibial condylar tangential line) to evaluate the obliquity of the bony trough of the allograft on an MRI axial plane. Their mean (±SD) axial trough angle was 7.8° ± 4.3°, indicating that the bony trough direction headed medially with a more lateral starting point from anterior to posterior on the axial plane. These investigators found that the trough angle was the only independent predictor associated with extrusion using a multiple linear regression analysis. Another study demonstrated that increased axial plane trough angle was a significant risk factor for major graft extrusion.[1] However, to our knowledge, no study has investigated the angle between a line connecting the anterior and posterior insertions of the lateral meniscus and the posterior tibial condylar line in the normal population. One study investigated the relationship between the line connecting the anterior and posterior insertions and other lines including the Akagi line.[9] However, those investigators did not measure the angle between a line connecting the anterior and posterior insertions of the lateral meniscus and the posterior tibial condylar line.

To overcome the difficulty caused by the patellar tendon in approaching the anterior horn of the lateral meniscus, Yoon et al[20] suggested using a transpatellar tendon approach rather than a lateral parapatellar approach during insertion of the guide wire for the tibial trough. Then, the knee was brought into extension to reduce tension on the patellar tendon, and it was retracted medially to expose the guide wire and drill the bony trough. Kim et al[7] recommended the transpatellar approach rather than the lateral parapatellar approach in lateral meniscal transplant. They reported that the mean extrusion of the transplanted meniscus was 3.0 ± 0.6 mm in the transpatellar approach and 4.3 ± 0.6 mm in the lateral parapatellar approach at 2 years postoperatively. Kim et al also demonstrated that the transpatellar approach had lower maximum contact stress on the menisci than did the lateral parapatellar approach using a finite element analysis. The above two articles[7,20] recommended the transpatellar approach rather than lateral arthrotomy. However, the transpatellar tendon approach could potentially lead to the development of patellar tendon adhesion. Patellar tendon adhesion is associated with patella baja.[5] Lee et al[11] used the lateral arthrotomy in lateral meniscal transplant and suggested using full extension of the knee to retract the patellar tendon as much as possible when drilling the guide wire. They reported that 47% of patients demonstrated extruded grafts with a mean extrusion of 4.1 ± 0.8 mm after transplant on postoperative day 2.

In the present study, a medial arthrotomy was performed rather than either full extension of the knee with medial retraction of the patellar tendon or a transpatellar tendon approach. The median extrusion of the midbody of the allograft was 2.2 mm (IQR, 2.4 mm) in the medial arthrotomy group, and 21.9% of patients showed the extrusion. The studies by Lee et al[11] and Kim et al[7] could not be compared with the present study because surgical techniques differed among surgeons. However, the median extrusion in the present study was superior to the values reported by those studies. Considering postoperative extrusion and its potential later effects on the progression of arthritic changes, lateral meniscal transplant through a medial arthrotomy may be preferred to the conventional, lateral parapatellar approach or the transpatellar tendon approach. The present study demonstrated that a difference in postoperative extrusion between the two types of arthrotomy was 0.9 mm, which was relatively small. However, an effect of extrusion on the progression of arthritic degeneration may be considerable, because the volume of the outer 0.9 mm width of the meniscus is significantly greater than that of the inner 0.9 mm width.

This study had several limitations. First, meniscal transplants with the two different approaches were not randomly assigned, because technical difficulty in approaching both anterior and posterior horns was identified during the first 23 transplants. Second, a learning curve may affect the amount of extrusion after surgery, because meniscal transplant is a technically demanding procedure. However, the author (N-H.C.) had performed more than 50 meniscal transplants before this study. The learning curve, therefore, may not affect the extrusion of

the allograft. Third, both groups contained a relatively small number of patients. However, the sample size had acceptable statistical power. Fourth, a longer follow-up MRI could demonstrate different results in postoperative extrusion. However, another study did report progression of extrusion according to the postoperative time. In that study, the investigators measured extrusion of the allograft using MRI at 6 weeks and 3, 6, and 12 months after lateral meniscal transplant. The mean extrusion on serial MRI was 2.9, 2.9, 3.0, and 3.0 mm at 6 weeks, 3 months, 6 months, and 12 months after surgery, respectively. The investigators' results demonstrated that extrusion does not progress, although they did not perform follow-up MRI beyond the first postoperative year.[13] Fifth, the degree of the extrusion and the trough angle of both groups in the present study were not correlated with clinical outcomes such as pain, knee function, or activity. However, a recent study showed that graft extrusion was not correlated with early clinical outcomes after the lateral meniscal transplant.[13] Sixth, a significant difference in activity levels can affect outcomes. However, fast running was not allowed for any of the patients until 6 months after surgery, and follow-up MRIs were checked at 6 months after surgery. Therefore, a significant difference in activity levels would not have affected the reported outcomes.

CONCLUSION

Our experience indicates that lateral meniscal allograft transplant through a medial arthrotomy is preferred to decrease postoperative extrusion of the allograft.

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