Meniscus Allograft Transplantation for Discoid Lateral Meniscus: Clinical Comparison Between Discoid Lateral Meniscus and Nondiscoid Lateral Meniscus

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**Purpose:** This study was performed to compare the clinical results of meniscus allograft transplantation (MAT) after total meniscectomy in torn discoid lateral meniscus (DLM) and nondiscoid lateral meniscus (NLM). **Methods:** We conducted a retrospective study of 36 patients who underwent MAT. The discoid and nondiscoid groups consisted of 16 and 20 patients, respectively. The mean follow-up period was 32 months. We checked range of motion (ROM), visual analog scale (VAS) score, International Knee Documentation Committee (IKDC) subjective score, Lysholm score, Tegner activity score for clinical evaluation; magnetic resonance imaging (MRI) was checked for objective evaluation. **Results:** The mean last follow-up VAS score, IKDC subjective score, Lysholm score, Tegner activity score, and subjective satisfaction of the patient were not significantly different between the discoid group and the nondiscoid group. The ROM of the discoid group was significantly decreased compared with that of the nondiscoid group ($P < .05$). Follow-up MRI was performed in 17 patients (9 from the discoid group and 8 from the nondiscoid group). Mean extrusion of the graft was 2.0 mm in the discoid group and 2.4 mm in the nondiscoid group ($P = .344$). Relative percentage of extrusion (RPE) was 22.8% in the discoid group and 22.7% in the nondiscoid group ($P = .519$). **Conclusions:** According to the minimal 2-year follow-up observations, MAT in patients with a torn discoid meniscus is an effective method for reducing the pain caused by meniscal deficiency and improving the function of the knee joint. **Level of Evidence:** Level IV, therapeutic case series.

Irreparable meniscal injury is treated by meniscectomy. The long-term results of total meniscectomy have been reported previously, and it has been shown to be associated with a high incidence of degenerative changes and eventual development of arthritis. Meniscus allograft transplantation (MAT) is a recently developed treatment for patients who have undergone total meniscectomy; it provides relief of pain and functional improvement of the knee joint. MAT increases the contact area of the joints and reduces peak contact stress. The prevalence of discoid lateral meniscus (DLM) ranges from 0.4% to 17% and is reported more frequently in Asian populations. The traditional treatment for a torn DLM is total meniscectomy, and good results have been reported. In recent years, however, improved arthroscopic techniques have made possible preservation of meniscal function in DLM through partial meniscectomy and repair. Delayed diagnosis of DLM can result in more severe meniscal tears, and total meniscectomy is unavoidable in such cases. The results of total meniscectomy in DLM are favorable in midterm follow-up, but the long-term results show degenerative changes in the joint. Deformities in the discoid meniscus of the knee are well documented, and lateral joint space widening, hypoplasia of the lateral femoral condyle, hypoplasia of the lateral tibial spine, and cupping of the lateral tibial plateau have been reported. Peripheral instability and reduced vascular structures in DLM have also been reported, which make it difficult to repair the torn discoid meniscus. However, there have been few reports regarding MAT after total meniscectomy of a torn DLM.
The purpose of this study was to compare and analyze the clinical results of MAT between patients with a DLM and patients with a nondiscoid lateral meniscus (NLM). We hypothesized that MAT in patients with a torn DLM will lead to poorer clinical results than that in patients with a NLM because of anatomical deformities.

**Methods**

A total of 68 patients underwent lateral MAT between March 2000 and December 2010 at our hospital. The inclusion criteria for this study were patients younger than 45 years with pain after subtotal/total meniscectomy and normal alignment. In the nondiscoid group, we included one patient who was 51 years old because his cartilage status was very good. The incidence of discoid medial meniscus is low, and we have no experience of MAT in these patients, so we excluded medial MAT. The other exclusion criteria were as follows: surgery for concurrent injuries (27 patients), loss of follow-up before 24 months postoperatively (3 patients), and revision surgery (2 patients). In the case of cartilage injuries, we excluded patients with large defects. However, patients with cartilage defects less than one cm² and requiring microfractures were not excluded (6 patients). Accordingly, 36 patients were evaluated retrospectively (Fig 1). Ethical approval for the study was obtained by our institutional review board.

**Preoperative Sizing and Operative Technique**

Fresh-frozen meniscal allografts were used in all patients. All surgery was performed by a single surgeon using the keyhole method. For sizing of the graft, magnetic resonance imaging (MRI) was performed before surgery. Sizing was performed in an axial slice of tibial plateau showing the meniscus. The width of the lateral tibial plateau from the lateral tibial spine to the edge of the tibia condyle was the same width as the allograft (±5% mismatching was allowed).

The remnant preparation was performed arthroscopically. About 1 to 2 mm of the peripheral rim was preserved for graft healing. After remnant preparation, a miniarthroscopy for graft insertion was performed beside the patellar tendon and below the anterolateral portal in the fully extended knee. A tibial tunnel guide was inserted into the arthrotomy site, and a guidewire was positioned under C-arm image intensifier guidance. A bone tunnel 10 mm in diameter was created using a core reamer. The roof of the bone tunnel was removed using a rongeur and bur to create a keyhole-shaped tunnel. The tunnel was finally checked using a slot sizer. The joint capsule was exposed by a posterolateral approach, and the passing wire was inserted from the posterolateral capsule to the anterolateral arthrotomy opening. Nonabsorbable leading sutures were used for anchoring to the posterior horn of the graft, and the graft was inserted into the slot by the passing wire. Traditional inside-out sutures for graft fixation were placed using 8 to 10 double-arm needles (Fig 2).

For rehabilitation, a continuous passive motion machine was used for range of motion (ROM) exercise beginning 1 day after surgery in the following manner: 0° to 60° during the first 3 weeks, up to 90° in weeks 4 to 6, and up to 120° until 12 weeks, with full flexion after 3 months. Ambulation was started with partial weight bearing with the knee fully extended with a brace by 3 weeks after surgery. Full weight bearing was possible at weeks 4 to 6. A crutch was used until 6 weeks after surgery. After 6 weeks, full weight bearing and no-crutch ambulation was possible with the joint fully extended with the brace. After 3 months, ambulation without a crutch or brace was possible.

**Clinical Assessment**

Patients were followed at 6 weeks, 6 months, and 12 months after surgery, and then annually thereafter. For evaluation of the clinical results, the ROM, visual analog scale (VAS) score, International Knee Documentation Committee (IKDC) subjective score, Lysholm score, and Tegner activity score before surgery and at the time of the last follow-up were compared. The results of follow-up MRI were also compared.

**Follow-up MRI**

Postoperative MRI was performed in non–weight-bearing and supine positions. All MRI examinations were performed using 3T MRI (Philips Intera Achieva 3.0T; Philips, Eindhoven, the Netherlands) or 1.5T MRI...
MRI was performed at least 1 year after surgery. However, in symptomatic patients, it was performed earlier. Signal intensity and graft extrusion were evaluated.

The signal intensity within the allograft was evaluated with regard to degenerative changes and tearing of the allograft on the anterior, mid, and posterior horn using coronal and sagittal images. Classification included the following: normal, nearly normal, abnormal, severely abnormal, and tear.

Extrusion was measured as absolute extrusion and relative extrusion. Absolute extrusion was defined as extrusion of the graft by 3 mm. Relative percentage of graft extrusion (RPE), defined as the percentage width of the extruded graft relative to the entire allograft width, was used to determine relative extrusion of the graft (Fig 3).

Two independent investigators (G.Y.J and K.Y.C.) evaluated the MR images, and the averages of the measurements taken by the 2 investigators were used in the analyses. The intra- and interobserver reliability were assessed using the intraclass correlation coefficient. In this study, intraclass correlation coefficient values of all measurements were greater than 0.804 for both intra- and interobserver reliability.

**Statistical Analysis**

SPSS software, version 12.0, (SPSS, Chicago, IL) was used for the statistical analysis, and G-power 3 software, version 3.1.3 (University of Kiel, Kiel, Germany) was used for power analysis of statistical results of clinical scores and MRI. The statistics are presented as the mean ± standard deviation (SD). The paired t tests and the Wilcoxon signed-rank test were used for comparison of the preoperative results and the results of the final follow-up. The Student t test and the Mann-Whitney U test were used to compare the results of the discoid and nondiscoid groups. The \( \chi^2 \)-square test was used to compare MRI signals. In all analyses, \( P < .05 \) was taken to indicate statistical significance.

**Results**

**Demographics**

There were 16 cases of discoid meniscus (discoid group) and 20 cases of nondiscoid meniscus (nondiscoid group). The discoid group consisted of 10 male patients and 6 female patients with a mean age of 35.8 years (range, 21 to 45 years; SD, 8.05). The nondiscoid group consisted of 13 male patients and 7 female patients with a mean age of 35.3 years (range, 20 to 51 years; SD, 9.48). The mean follow-up period in the discoid group was 37 months (range, 24 to 88 months; SD, 20.02) and that in the nondiscoid group was 35
months (range, 24 to 75 months; SD, 17.11). The mean interval after meniscectomy to performance of MAT in the discoid group was 63.4 months (range, 0.5 to 243 months; SD, 70.20), and that in the nondiscoid group was 34.7 months (range, 1 to 146 months; SD, 32.75). The differences between the groups were not significant (power \(1 - \beta\) of sex, age, follow-up period, mean interval = 0.882, 0.907, 0.836, and 0.678, respectively). Demographic characteristics of the patients are summarized in Table 1.

### Overall Results

The ROM was decreased slightly from 142.7° ± 5.2° preoperatively to 136.9° ± 11.9° at last follow-up, but this was not significant (\(P = .179\)). The VAS score, IKDC subject score, Lysholm score, and Tegner activity score were improved, and differences were significant (all \(P < .05\)). The clinical results before surgery and at the last follow-up are summarized in Table 2.

### Comparison Between the Discoid and Nondiscoid Groups

With the exception of ROM at the final follow-up, there were no significant differences between parameters before surgery and at the last follow-up in the 2 groups (Table 3). The ROM at the final follow-up was slightly lower than that before surgery in both groups. The difference was statistically significant in the discoid group but was not significant in the nondiscoid group. The difference in ROM between the discoid and nondiscoid groups was significant (\(P < .05\), power \(1 - \beta\) = 0.547). The clinical scores (i.e., VAS score, IKDC subjective score, Lysholm score, and Tegner activity score) at the last follow-up were decreased significantly compared with the preoperative scores in both groups. However, there were no differences between the 2 groups.

### Follow-up MRI

Follow-up MRI was performed between 6 months and 6 years after surgery in 17 patients (9 in the discoid group and 8 in the nondiscoid group), and the mean time was 17.3 months (range, 7.3 to 32.1; SD, 8.25) in the discoid group and 19.0 months (range, 6.0 to 60.1; SD, 16.57) in the nondiscoid group (Fig 4). The signal intensities are summarized in Table 4.

There was no significant difference in signal between the 2 groups (\(P = .266\), power \(1 - \beta\) = 0.98). We classified the results as normal (includes normal and nearly normal) and abnormal (includes abnormal and severely abnormal). There was also no significant difference between the 2 groups (\(P = .153\), power \(1 - \beta\) = 0.99).

Extrusion of the transplanted allograft was 2.0 mm in the discoid group and 2.4 mm in the nondiscoid group; the difference was not statistically significant (\(P = .344\), power \(1 - \beta\) = 0.579). RPE was 22.8% in the discoid group and 22.7% in the nondiscoid group; the difference was not statistically significant (\(P = .519\)). The number of absolute extrusions (i.e. extrusion more than 3 mm) was 2 cases in the discoid group (2 of 9 [22.2%]) and 3 cases in the nondiscoid group (3 of 8 [37.5%]); the difference was not statistically significant (\(P = .619\), power \(1 - \beta\) = 0.778).

### Complications

One patient in the discoid group had a longitudinal tear of the posterior horn at 1 year 4 months postoperatively, which was repaired using double-arm needles. Another patient in the discoid group had a longitudinal tear in the posterior horn at 2 years postoperatively, and repair was performed. One patient in the nondiscoid group had a radial tear in the midhorn at 1 year 7 months postoperatively, and repair was performed. However, the symptom recurred at 5 years postoperatively, and subtotal meniscectomy was performed. Another patient in the nondiscoid group had a complex tear because of failure of healing at 4 years 5 months postoperatively, and total meniscectomy was performed.

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### Table 1. Patients Demographics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Discoid Group</th>
<th>Nondiscoid Group</th>
<th>(P) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases</td>
<td>16</td>
<td>20</td>
<td>.877</td>
</tr>
<tr>
<td>Male/female</td>
<td>10/6</td>
<td>13/7</td>
<td>.877</td>
</tr>
<tr>
<td>Age (y)</td>
<td>35.8 (21.45; SD, 8.05)</td>
<td>35.3 (20.51; SD 9.48)</td>
<td>.861</td>
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<tr>
<td>Follow-up (mo)</td>
<td>38 (24-88; SD, 20.02)</td>
<td>41 (24-75; SD, 17.11)</td>
<td>.696</td>
</tr>
<tr>
<td>Period after total meniscectomy to meniscus transplantation (mo)</td>
<td>63.4 (0.5-243; SD, 70.20)</td>
<td>34.7 (1-146; SD, 32.75)</td>
<td>.147</td>
</tr>
</tbody>
</table>

SD, standard deviation.

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### Table 2. Average Preoperative and Postoperative Clinical Outcomes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Preoperative Score</th>
<th>Last Follow-Up Score</th>
<th>(P) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROM</td>
<td>142.7 ± 5.2</td>
<td>136.9 ± 11.9</td>
<td>.179</td>
</tr>
<tr>
<td>VAS</td>
<td>4.5 ± 2.2</td>
<td>2.7 ± 1.6</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>IKDC (subjective)</td>
<td>55.7 ± 14.2</td>
<td>69.7 ± 16.5</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Lysholm</td>
<td>60.0 ± 20.5</td>
<td>78.1 ± 12.5</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Tegner</td>
<td>3.0 ± 1.3</td>
<td>4.3 ± 1.3</td>
<td>&lt;.05</td>
</tr>
</tbody>
</table>

IKDC, International Knee Documentation Committee; ROM, range of motion; VAS, visual analog scale.
Discussion

We hypothesized that discoid MAT would show inferior results compared with nondiscoid MAT because of the peripheral insufficiency and chronic degenerative deformities of the tibial and femoral condyles in patients with discoid meniscus. With the exception of ROM, the clinical results at the final follow-up indicated improvement in both groups. In the discoid group, ROM was decreased from the preoperative range and was less than that in the nondiscoid group at the final follow-up. There was no difference in signal or subluxation in MRI findings between the 2 groups. The traditional treatment for a symptomatic DLM is total meniscectomy. Ikeuchi7 reported that 78% of 23 knees (average age, 27.2 years) were rated as excellent or good at an average follow-up period of 4.3 years. Many other authors also reported good results of total meniscectomy in patients with discoid meniscus at short to midterm follow-up.9,10 However, the long-term results of total meniscectomy in discoid meniscus are controversial. Habata et al.15 reported the long-term results of total meniscectomy (mean 14.5 years) to be satisfactory with mild postoperative arthritic changes, but they recommended careful monitoring of arthritic progression and valgus change. Okazaki et al.16 also reported good clinical results for longer than 10 years in younger patients; however, older patients showed degenerative changes.

With the advent of improved arthroscopic techniques, current treatment recommendations favor meniscal preservation through partial meniscectomy, “saucerization,” and repair.13 Adachi et al.15 reported good outcomes with torn discoid meniscus treated with partial meniscectomy and repair in 4 of 5 patients at 2 years postoperatively. Ahn et al.12 reported good clinical results after partial meniscectomy with repair; the mean follow-up period was 50.9 months (range, 24 to 94 months). Other reports regarding partial meniscectomy in discoid meniscus also showed good clinical results.12,23,24 In a comparison between partial and subtotal/total meniscectomy in patients with discoid meniscus, Lee et al.14 recommended partial meniscectomy, although there were no differences in clinical results between the partial and subtotal/total meniscectomy groups, because partial meniscectomy yielded better radiologic results than did subtotal/total meniscectomy for torn DLMs in children.

However, not all cases of discoid meniscus can be treated by partial meniscectomy or repair. In a study of partial meniscectomy, Ahn et al.13 reported repairable peripheral tears of the DLM in only 30 (34%) of 84 knees. Bin et al.25 reported that 29.6% of cases of torn discoid meniscus required total meniscectomy according to tear patterns. A delay in the diagnosis of torn discoid meniscus allowed the meniscal tear to become more extensive, involving the peripheral capsule, and

Table 3. Comparison of Outcome Score Between Discoid Group (n = 16) and Nondiscoid Group (n = 20)

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Preoperative Score</th>
<th>Last Follow-up Score</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Discoid</td>
<td>Nondiscoid</td>
<td></td>
</tr>
<tr>
<td>ROM</td>
<td>143.1 ± 6.0</td>
<td>142.5 ± 4.7</td>
<td>.348</td>
</tr>
<tr>
<td></td>
<td>132.8 ± 15.7</td>
<td>140.0 ± 6.6</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>VAS</td>
<td>4.2 ± 2.1</td>
<td>4.8 ± 2.2</td>
<td>.149</td>
</tr>
<tr>
<td></td>
<td>2.6 ± 1.7</td>
<td>2.8 ± 1.6</td>
<td>.385</td>
</tr>
<tr>
<td>IKDC (subjective)</td>
<td>54.7 ± 15.4</td>
<td>55.5 ± 14.0</td>
<td>.871</td>
</tr>
<tr>
<td></td>
<td>70.0 ± 16.9</td>
<td>69.4 ± 16.6</td>
<td>.928</td>
</tr>
<tr>
<td>Lysholm</td>
<td>57.2 ± 17.9</td>
<td>62.2 ± 22.5</td>
<td>.480</td>
</tr>
<tr>
<td></td>
<td>78.8 ± 14.0</td>
<td>77.7 ± 11.5</td>
<td>.796</td>
</tr>
<tr>
<td>Tegner</td>
<td>3.1 ± 1.6</td>
<td>2.9 ± 1.1</td>
<td>.499</td>
</tr>
<tr>
<td></td>
<td>4.5 ± 1.4</td>
<td>4.2 ± 1.4</td>
<td>.280</td>
</tr>
</tbody>
</table>

IKDC, International Knee Documentation Committee; ROM, range of motion; VAS, visual analog scale.

Fig 4. The same patient as in Fig 3 was checked with magnetic resonance imaging (MRI) at 1 year 2 months after operation. Good signal and positioning was seen in coronal proton density and sagittal fast spin echo images.
could result in aggravated degenerative changes of the tear margin and the lateral compartment. In such cases, total meniscectomy was unavoidable. The long-term results of total meniscectomy in children are poor because of early degenerative changes and lateral instability.

MAT has recently become a treatment option for symptomatic patients after subtotal/total meniscectomy. The aim of MAT is to reconstruct the load transmission system and to restore the normal kinetics of the knee joint. Several studies have reported that MAT reduces pain and improves the function of the knee joint. In this study, with the exception of ROM, there were no differences in objective or subjective results between the 2 groups.

MAT has been approved for the treatment of knees after total meniscectomy because of its provision of pain relief. For treatment of torn discoid meniscus, partial meniscectomy and repair will remain the first choice for treatment, with MAT as the second choice when total meniscectomy is unavoidable.

**Limitations**

This study had several limitations. First, it was a retrospective study with a relatively short-term follow-up period, and the evaluation time points were not homogeneous because we evaluated the results at last follow-up. Second, the sample size was small, so the statistical power was insufficient. However, MAT is an ongoing procedure, and there have been insufficient reports of long-term results. The major strength is that this was the first comparative study of MAT between discoid and nondiscoid groups.

**Conclusions**

Comparison of the clinical results of MAT between discoid meniscus and nondiscoid meniscus showed no differences between the 2 groups except in ROM. According to the minimal 2-year follow-up observations, MAT in patients with torn discoid meniscus is an effective method for reducing the pain caused by meniscal deficiency and improving the function of the knee joint.

**References**