Lateral Capsular Stabilization in Lateral Meniscal Allograft Transplantation

Young-Jin Seo,* MD, Nam-Hong Choi,†‡ MD, Byung-Hun Hwangbo,† MD, Ji-Sun Hwang,† MD, and Brian N. Victoroff,§ MD

Investigation performed at Eulji Medical Center, Seoul, Republic of Korea

Background: Stabilization of the lateral capsule to the tibial plateau may decrease midbody extrusion after lateral meniscal allograft transplantation (MAT). However, there is a paucity of literature reporting on postoperative magnetic resonance imaging (MRI) findings after lateral capsular stabilization (LCS) at the time of lateral MAT.

Purpose/Hypothesis: The purpose was to describe MRI findings after LCS and compare postoperative extrusion between isolated lateral MAT and lateral MAT with LCS. It was hypothesized that allograft extrusion would be reduced after MAT with LCS but that the stabilized capsule would increase the risk of tears to the capsule or allograft.

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

Methods: Included were patients who underwent lateral MAT with 6-month follow-up MRI. Concomitant LCS was performed for patients with redundant lateral capsule displaced from the lateral tibial plateau as evident on coronal MRI or arthroscopic examination (MAT+LCS group); otherwise, patients underwent MAT only (isolated MAT group). The Lysholm score, Tegner score, and lateral joint space on radiographs were compared between the 2 groups at 2 years postoperatively, and the stabilized lateral capsule and allograft were evaluated using 6-month follow-up MRI. Extrusion, rotation, and position of the allograft bridge were compared between the 2 groups. Regression analysis was performed to identify factors predictive of degree of extrusion.

Results: There were 10 patients in the MAT+LCS group and 13 patients in the isolated MAT group. No significant differences were found between groups in preoperative patient characteristics or postoperative Lysholm score, Tegner score, lateral joint space, or MRI parameters. Postoperative extrusion was not related to obliquity angle, position of the bony bridge, or presence of LCS. In the MAT+LCS group, 1 patient showed a tear of the lateral capsule and a radial tear of the allograft, and 3 patients had a meniscocapsular separation at the midbody of the allograft. In the isolated MAT group, 1 patient had a peripheral tear at the midbody, but there was no tear of the allograft in the other patients.

Conclusion: LCS did not decrease extrusion of lateral meniscal transplantation, but it can lead to increased risk for graft or capsule tear.

Keywords: lateral meniscal allograft transplantation; extrusion; lateral capsule stabilization

Allograft extrusion is commonly observed after meniscal transplantation.[7,15] Extrusion of the meniscus is biomechanically harmful and can be associated with cartilage volume loss, decrease in cartilage thickness, and increase in denuded bone in the lateral compartment of the knee.[11] A recent long-term follow-up after meniscal allograft transplantation (MAT) demonstrated a greater decrease in joint space in the extrusion group than in the nonextrusion group.[8]

Several strategies have been proposed to decrease the degree of meniscal allograft extrusion.[9] Anatomic placement of the lateral meniscal allograft is important in decreasing extrusion.[1,7] Redundant lateral capsule is suggested as a cause of postoperative extrusion. If the midbody of the allograft is sutured to redundant lateral capsule located away from the lateral tibial plateau, postoperative extrusion is anticipated. Several authors have proposed stabilizing the lateral capsule to the tibial plateau in an

‡Address correspondence to ‡Nam-Hong Choi, MD, Department of Orthopaedic Surgery, Eulji Medical Center, 280-1 Hagye-1-dong, Nowon-gu, Seoul 01830, Republic of Korea (email: cnh2406@yahoo.com).

*Department of Orthopedic Surgery, Hallym University Dongtan Sacred Heart Hospital, Hwaseong, Republic of Korea.

†Department of Orthopaedic Surgery, Eulji Medical Center, Seoul, Republic of Korea.

§Department of Orthopedic Surgery, Case Western Reserve University, Cleveland, Ohio, USA.

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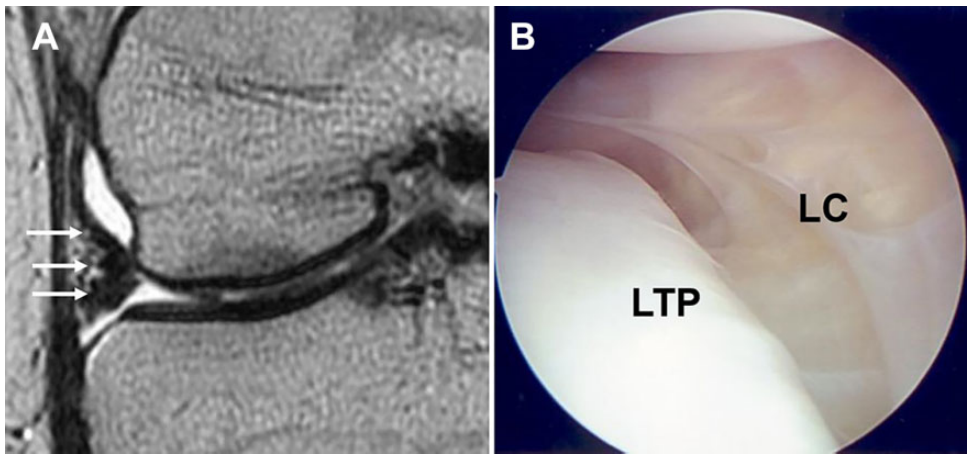

Figure 1. (A) Preoperative coronal T2-weighted magnetic resonance imaging scan of a right knee. The midbody of the lateral meniscus was removed during a previous surgery. The lateral capsule (LC) (arrows) was displaced from the lateral tibial plateau (LTP). (B) Arthroscopic view of a knee. The midbody and posterior horn of the lateral meniscus were completely removed during previous surgery. The LC was displaced from the LTP.

attempt to decrease midbody extrusion.[2,5,9] To fix the lateral capsule at the rim of the lateral tibial plateau, Jung et al[2] and Koga et al[5] used suture anchors, and Masferrer-Pino et al[9] used transosseous sutures. Masferrer-Pino et al[9] reported that the capsulodesis technique resulted in less meniscal extrusion compared with the bone-bridge fixation technique. However, these methods may limit the normal mobility of the meniscus during knee motion, resulting in a potential tear of the allograft or the stabilized capsule.

There is a paucity of literature on postoperative magnetic resonance imaging (MRI) findings after lateral capsular stabilization (LCS) at the time of lateral MAT. Therefore, the purpose of this retrospective study was to describe the MRI findings after LCS and compare postoperative extrusion between isolated lateral MAT and lateral MAT with LCS. We hypothesized that allograft extrusion would be reduced after MAT with LCS but that the stabilized capsule would increase the risk of tears to the capsule or allograft.

METHODS

Patients

We retrospectively enrolled patients who underwent lateral MAT and completed an MRI of the knee at 6 months postoperatively between February 2005 and November 2012. MAT with or without LCS was performed in a single center by a single surgeon (N-H.C.) who has >20 years of experience in performing arthroscopic surgeries. Excluded were patients who did not have follow-up MRI scans or were lost to follow-up after lateral MAT. Indications of the lateral meniscal transplantation were as follows: (1) pain on the lateral compartment >6 months after subtotal or total meniscectomy, (2) chondromalacia on the lateral compartment classified as Outerbridge grade <3, (3) malalignment <5°, and (4) no cruciate ligamentous deficiency. LCS was performed for patients with redundant lateral capsule displaced from the lateral tibial plateau on the coronal view of MRI scans or via arthroscopic examination (MAT+LCS group) (Figure 1). Isolated MAT was performed for patients who did not have a redundant lateral capsule (isolated MAT group). The study protocol was reviewed and approved by an institutional review board, and all patients signed an informed consent form.

Surgical Procedures

The lateral meniscal allograft was prepared with a bony bridge. The recipient meniscus was debrided using a motorized shaver to expose the meniscocapsular junction of the posterior horn and midbody. A mini-arthrotomy was performed, and the anterior horn of the recipient meniscus was excised. A bony trough was made just lateral to the anterior cruciate ligament insertion on the tibia along the line between the anterior and posterior horns of the lateral meniscus. The bony bridge of the allograft was inserted into the bony trough. The allograft was positioned precisely on the lateral tibial plateau, and arthroscopy was used to confirm the correct position of the meniscal allograft. Open meniscal repair using No. 2.0 absorbable sutures (Ethicon) 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 done via the arthroscopic inside-out technique using multiple No. 1 absorbable sutures (Ethicon).

In patients who underwent LCS, an area was determined where the lateral capsule was most displaced from the rim of the lateral tibial plateau while viewing from the anteromedial portal. The determined area was abraded gently using a motorized bur to remove cartilage from the rim of the lateral tibial plateau. A small stab wound was made at the center of the abraded area, and a small pilot hole was created in the abraded area on the lateral edge of the lateral tibial plateau. A 2.8-mm anchor (Smith & Nephew

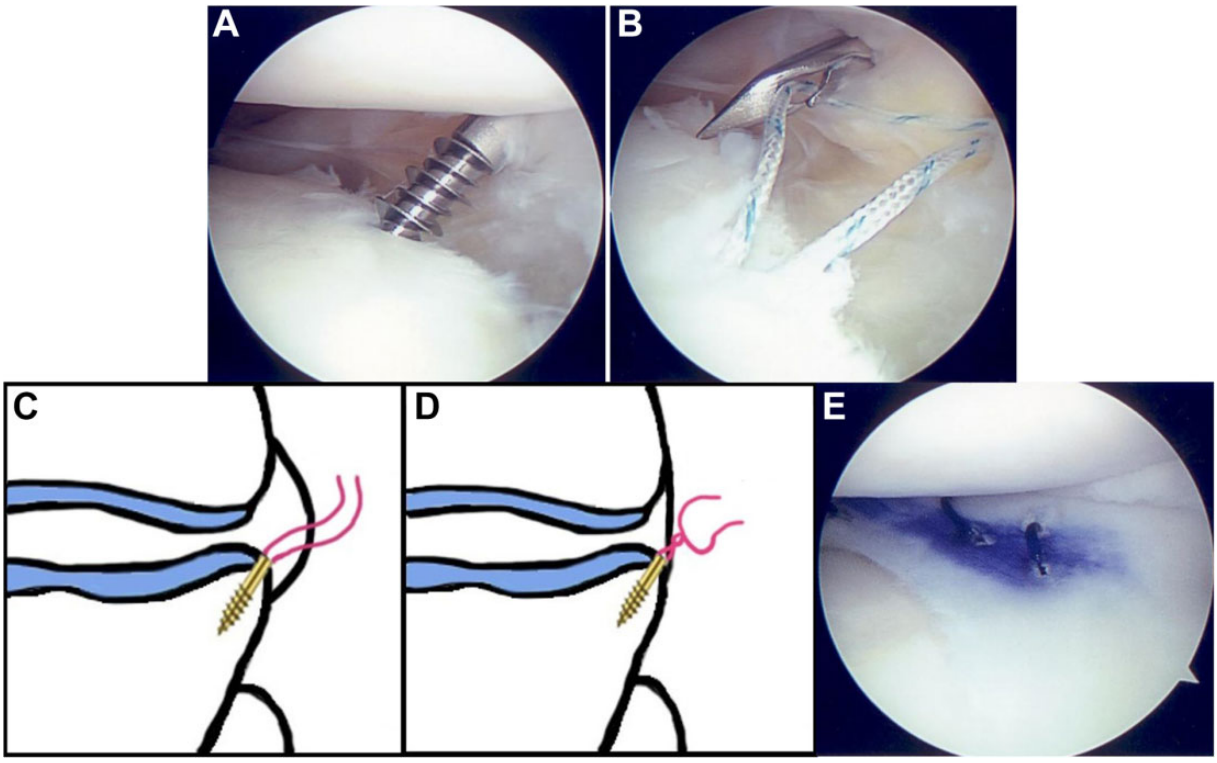

Figure 2. The arthroscope was inserted from the anteromedial portal in the left knee. (A) An anchor was inserted into the lateral edge of the lateral tibial plateau where the lateral capsule was most displaced. (B) The Arthro-Pierce (Smith & Nephew Endoscopy) was introduced through the anterior and posterior stab wounds to retrieve each strand. (C) Schematic drawing showing 2 limbs of anchor were retrieved out of the lateral capsule. (D) Schematic drawing showing a secure knot was made and the lateral capsule was stabilized on the lateral tibial plateau. (E) After the lateral capsule stabilization, the lateral meniscal allograft transplantation was performed.

Endoscopy) was inserted (Figure 2A). Another 2 stab wounds were made 1 cm anterior and posterior to the previous stab wound, respectively. The Arthro-Pierce (Smith & Nephew Endoscopy) was introduced through the anterior and posterior stab wounds to retrieve each strand (Figure 2, B and C). The 2 limbs of suture of the anchor were tied outside the joint capsule (Figure 2D). Stabilization of the lateral joint capsule onto the rim of the lateral tibial plateau was confirmed via arthroscopic evaluation. After the LCS, lateral MAT was performed (Figure 2E).

Postoperatively, the identical postoperative rehabilitation protocol was utilized for the MAT+LCS and isolated MAT groups. No postoperative brace was used. In the MAT+LCS group, the cross-leg position was not allowed for 3 months. Partial weightbearing was allowed immediately after surgery. Closed kinetic chain exercises and quadriceps setting exercises were started as early as possible. Full weightbearing was permitted 6 weeks after surgery. Jogging was started after 8 weeks. Return-to-sports activity was allowed after 10 months.

Postoperative Evaluation

Functional outcomes included the Lysholm score, Tegner activity score, and lateral joint space at 2 years postoperatively. The lateral joint space was measured by an orthopaedic fellow (J-S.H.) on a Picture Archiving and Communications System (GE Healthcare). In addition, patients underwent MRI (Magnetom Verio; Siemens Healthcare, Erlangen) at the 6-month follow-up, and maximum extrusion, rotation, and position of the allograft bridge were measured on MRI scans.

On coronal MRI scans, a view showing the maximum extrusion of the midbody was chosen, and extrusion was measured as the distance between the outer edge of the articular cartilage of the tibial plateau and the outer edge of the allograft (Figure 3). Rotation of the allograft bridge was measured using the obliquity angle (Figure 4A). On axial MRI scans, a view showing the bony bridge clearly was chosen, and a line perpendicular to the tangential line along both posterior edges of the medial and lateral tibial plateau was drawn. Another longitudinal line along the center of the bony bridge was drawn, and the obliquity angle was measured between these 2 lines (Figure 4A). To calculate the position of the bony bridge of the allograft on the tibial plateau, the center between the medial and lateral edges of the bony bridge was first identified. The position of the bony bridge was calculated as the distance between the outer edge of the lateral tibial plateau and the center of the bony bridge divided by the length of the entire

tibial plateau (Figure 4B). In the MAT+LCS group, the tear of the lateral capsule or allograft where the lateral capsule was stabilized to the tibial plateau was determined on coronal MRI scans. An orthopaedic fellow (J-S.H.) who was not involved in the MAT measured all parameters.

Statistical Analysis

For each study group, we compared the change in extrusion from pre- to postoperatively. In addition, extrusion, rotation, and position of the allograft bridge were compared between the MAT+LCS and isolated MAT groups. Regression analysis was performed to identify which measured parameters among the presence of LCS, rotation, and position of the allograft bridge were predictive of the degree of extrusion. Analysis was performed using SPSS for Windows release 12.0 (IBM Corp), and significance was assumed at $P < .05$.

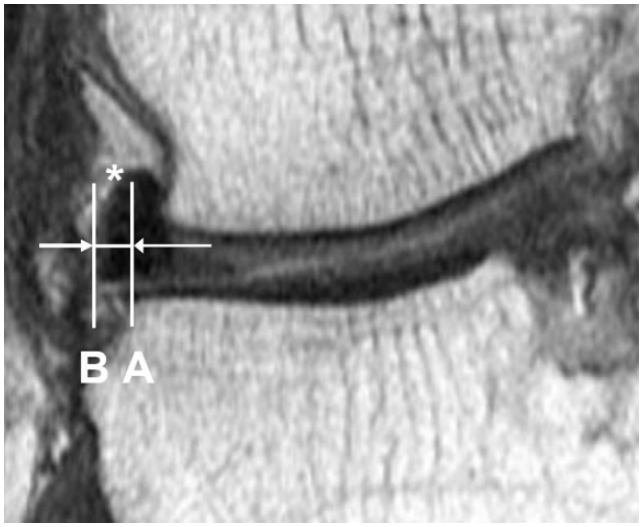

Figure 3. Extrusion (*) of the lateral meniscus was defined as the distance between the outer edge of the articular cartilage (line *A*) of the tibial plateau and the outer edge of the allograft (line *B*).

RESULTS

Twenty-six patients underwent lateral meniscal transplantation. Thirteen patients underwent LCS concomitantly with the MAT, and another 13 patients underwent isolated lateral MAT. Among the 13 patients who underwent LCS, 3 did not have follow-up MRI. Therefore, there were 10 patients in the MAT+LCS group and 13 in the isolated MAT group. The average age of the patients at the time of surgery was 29.9 years (range, 17-48 years). Fifteen patients were male, and 8 were female. There were no differences in preoperative patient characteristics between the 2 groups (Table 1).

The Lysholm score, Tegner score, and lateral joint space did not differ between the 2 groups (Table 2). The isolated MAT group showed that postoperative extrusion increased significantly compared with preoperative extrusion ($P = .026$). In the MAT+LCS group, postoperative extrusion decreased but was not statistically significant ($P = .186$) (Table 3). Postoperative extrusion, obliquity angle, and position of the bridge demonstrated no differences between the 2 groups (Table 4). Regression analysis demonstrated that postoperative extrusion was not related to the obliquity angle, position of the bridge, or presence of the LCS. In the MAT+LCS group, 1 patient showed a tear of the lateral capsule and a radial tear of the allograft (Figure 5A). Three patients had a meniscocapsular separation at the midbody of the allograft (Figure 5B). The other 6 patients had no tear of the lateral capsule or the allograft. In the isolated MAT group, 1 patient had a peripheral tear at the midbody, but there was no tear of the allograft in the other patients.

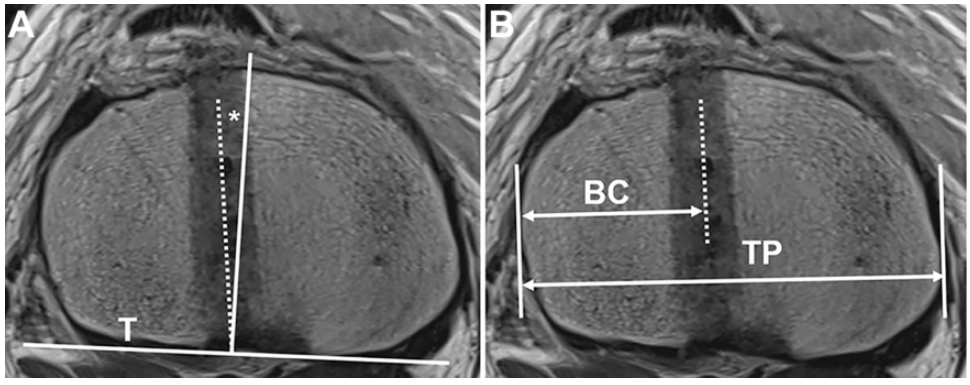

Figure 4. Postoperative axial proton density–weighted magnetic resonance imaging scans of the right knee. (A) For the obliquity angle (*), the line tangential to both posterior edges of the medial and lateral tibial plateau (line *T*) was determined, and then a line perpendicular to this was drawn. Another longitudinal line (dotted line) was drawn along the center of the bony bridge, and the obliquity angle was measured between these 2 lines. (B) To determine the position of the bony bridge of the allograft on the tibial plateau (dotted line), the center of the bony bridge was identified. The length of the entire tibial plateau (*TP*) and the distance between the outer edge of the lateral tibial plateau and the center of the bony bridge (*BC*) was measured, and *BC*/*TP* was regarded as the position of the bony bridge.

TABLE 1
Preoperative Patient Data of the 2 Groups[a]

	MAT+LCS (n = 10)	Isolated MAT (n = 13)	P
Ages, y	28.2 ± 8.9	31.0 ± 10.9	.504
Sex, male/female	6/4	9/4	.490
BMI	22.1 ± 1.7	23.9 ± 3.7	.343
Kellgren-Lawrence grade 1/ grade 2	6/4	8/5	.940
Outerbridge grade 1/grade 2	5/5	9/4	.417
Preoperative extrusion, mm	2.3 ± 1.1	1.3 ± 1.5	.113

[a]Data are reported as mean ± SD or n. BMI, body mass index; LCS, lateral capsule stabilization; MAT, meniscal allograft transplantation.

TABLE 2
Follow-up Clinical Scores and Radiologic Outcomes[a]

	MAT+LCS (n = 10)	Isolated MAT (n = 13)	P
Lysholm score	84.3 ± 17.1	84.9 ± 12.6	.912
Tegner score	4.8 ± 0.7	4.1 ± 1.4	.129
Lateral joint space, mm	4.6 ± 0.9	4.2 ± 1.4	.314

[a]Data are reported as mean ± SD. LCS, lateral capsule stabilization; MAT, meniscal allograft transplantation.

TABLE 3
Preoperative Versus Postoperative Extrusion of the Study Groups[a]

	MAT+LCS (n = 10)	Isolated MAT (n = 13)
Preoperative extrusion, mm	2.3 ± 1.1	1.3 ± 1.5
Postoperative extrusion, mm	1.2 ± 2.1	2.6 ± 1.3
P	.186	**.026**

[a]Data are reported as mean ± SD. Bolded P value indicates a statistically significant difference from pre- to postoperatively ($P < .05$). LCS, lateral capsule stabilization; MAT, meniscal allograft transplantation.

TABLE 4
Postoperative MRI Parameters Between Study Groups[a]

	MAT+LCS (n = 10)	Isolated MAT (n = 13)	P
Postoperative extrusion, mm	1.2 ± 2.1	2.6 ± 1.3	.083
Obliquity angle, deg	85.9 ± 10.3	92.5 ± 10.1	.137
Position of the bridge, %	44.2 ± 3.5	44.4 ± 2.6	.904

[a]Data are reported as mean ± SD. LCS, lateral capsule stabilization; MAT, meniscal allograft transplantation; MRI, magnetic resonance imaging.

DISCUSSION

The most important finding of this study was that 6-month follow-up MRI scans showed a capsular tear and meniscocapsular separations in 4 (40%) patients from the MAT+LCS group. However, LCS did not decrease postoperative extrusion of the allograft significantly, and there were no differences in the Lysholm, Tegner, and lateral joint space measurements between the 2 groups. Our hypotheses were partially confirmed.

MAT has been performed to prevent the development of arthritic changes due to meniscal deficiency. However, MAT did not delay or prevent arthritic progression of the tibiofemoral joint.[13] Van Der Straeten et al[13] reported clinical outcomes at a mean of 6.8 years after 329 MATs; 19.2% were converted to arthroplasty at a mean of 10.3 years. Cumulative allograft survivorship was 15.1% at 24.0 years. Although several origins for low allograft survivorship were discussed, nonanatomic placement of the allograft may be the most important cause. Nonanatomically inserted meniscal transplant results in degenerative cartilage changes and inferior biomechanical properties.[12,16] A clinical study demonstrated that nonanatomic horn position increases the risk of early graft failure after lateral MAT.[3]

Therefore, anatomic placement of the meniscal allograft is imperative to achieve satisfactory clinical outcomes. Laterally placed meniscal allografts can affect the degree of extrusion. Choi et al[1] reported that the amount of extrusion was correlated with the position of the bony bridge of the graft and the cutoff percentage above which extrusion did not occur was 42.1%. An externally rotated allograft can result in allograft extrusion. Lee et al[7] measured the axial trough angle between a tangential line along the posterior tibial condyle and a longitudinal line along the center of the bony trough of the allograft. They reported that 23 (47%) knees had extruded grafts. An increase in axial trough angle was found to be correlated with an increase in extrusion, and the cutoff value was 5.6°. Original meniscal subluxation may also result in postoperative subluxation after MAT.[6] In the MAT procedure, both anterior and posterior horns of the graft are fixed using bone plugs or a trough. However, the rest of the allograft is sutured to the capsule of the knee joint. In patients whose lateral capsule is redundant and located away from the lateral tibial plateau, the midbody of the allograft is sutured to redundant, lateral capsule, resulting in extrusion after surgery.

To tighten redundant or loose capsule, or reduce the extruded midbody of the lateral meniscus, 2 types of therapeutic options have been reported. Jung et al[2] described a novel technique to place displaced lateral joint capsule onto the rim of the lateral tibial plateau using a suture anchor. After stabilization of the lateral capsule, transplantation of the lateral meniscus was then performed. They reported that the midbody of the allograft was not extruded on follow-up MRI scans. Koga et al[5] described a similar technique to reduce extruded midbody of the lateral meniscus. The indication for their technique was extrusion of the midbody of the lateral meniscus confirmed preoperatively via

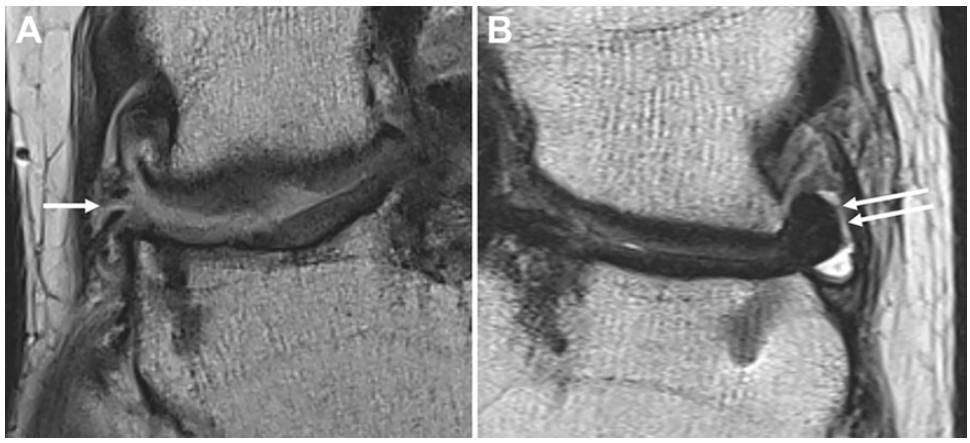

Figure 5. (A) Postoperative coronal proton density–weighted magnetic resonance imaging (MRI) scan of the right knee demonstrated a tear in the stabilized lateral capsule (arrow) and a full-thickness radial tear of the allograft. (B) Postoperative coronal T2-weighted MRI scan of the left knee showed extrusion of the midbody and a meniscocapsular separation (arrows) of the allograft.

an MRI coronal view. The capsule at the margin between the midbody of the lateral meniscus and the capsule was sutured to the lateral edge of the lateral tibial plateau using suture anchors. Follow-up MRI scans showed that the extrusion in 9 patients who had it preoperatively was significantly reduced from 5.0 mm (range, 3-9 mm) to 1.1 mm (range, 0-3 mm). One patient showed postoperative extrusion because of torn sutures.[4] Masferrer-Pino et al[9] compared the postoperative extrusion and the functional outcomes after lateral MAT between a bony fixation technique and a soft tissue fixation technique with capsulodesis. Although they allocated the patients randomly to either bony fixation or soft tissue fixation groups, they found redundant or loose lateral capsule in the soft tissue fixation with capsulodesis group. In the capsulodesis group, they made two 2.4-mm tunnels placed 10 mm apart and then drilled from the anteromedial tibial cortex in an oblique direction toward the edge of the lateral plateau where the capsule is redundant or loose. Two transtibial sutures that captured the lateral capsule and meniscal remnants were tied to each other on the medial tibial cortex. They compared the incidence of the numbers of patients between the minor (<3 mm) and major (>3 mm) extrusion groups. A lower percentage of extruded menisci was found in the MAT with capsulodesis group. Patient-reported outcomes were similar between the 2 groups.

LCS in this study did not decrease postoperative extrusion of the allograft significantly, contrary to results of the study by Koga et al.[4] Differences in inclusion criteria might be a cause. In this study, patients who underwent lateral MAT were included. In the study of Koga et al, [4] patients with discoid or nondiscoid meniscus were included. Comparison of postoperative extrusion between this study and that of Masferrer-Pino et al[9] is also difficult because postoperative extrusion can be affected by the position of the bony trough or keyhole of the graft, as well as addition of the LCS.

The aforementioned procedures have a risk of limiting the normal mobility of the meniscus during knee motion. Vedi et al[14] examined meniscal translation in healthy volunteers while weightbearing from full extension to 90° of flexion in vivo using open MRI and found that the anterior horn of the lateral meniscus translates posteriorly 9.5 mm, while the posterior horn translates 5.6 mm. Recently, McCulloch et al[10] measured normal posterior translation of the lateral meniscus from cadaveric knees using roentgen stereophotogrammetric analysis. They divided the lateral meniscus into 6 regions: anterior root, anteromedial, anterolateral, posterolateral, posteromedial, and posterior root. Among them, the anteromedial and anterolateral regions showed translations of 11.20 ± 4.81 and 11.13 ± 3.86 mm, respectively. However, postoperative MRI findings of the lateral capsule after either stabilizing or capsulodesis were not reported in the literature.

In this study, the MAT+LCS group demonstrated a capsular tear in 1 patient and meniscocapsular separations in 3 patients. The meniscocapsular separations were located in the area where the lateral capsule was fixed. It is possible that the large penetrator contributed to the capsular tear or meniscocapsular separation. However, 6 patients in the MAT+LCS group had no capsular tear or meniscocapsular separation. Although the exact reason is not known why 4 patients had complications and 6 did not, differences in activities of daily living might have affected the results. Limited excursion of the lateral meniscal allograft by LCS during squatting may increase the risk of tear of the capsule or the allograft. Beginning postoperative rehabilitation too soon may result in complications. However, the postoperative rehabilitation protocol was identical for both groups, and other researchers have reported similar postoperative rehabilitation.[4,9] The clinical implications of capsular tear or localized meniscocapsular separations in MAT are not clear. Although functional outcomes were not compared between the patients with and those without complications, functional outcomes between the MAT+LCS and isolated MAT groups showed no differences.

There were several limitations in this study. First, there were small numbers of patients in both groups. Indications of MAT are very narrow in our country. Moreover, the patients very rarely require LCS. Post hoc power analysis showed 0.6, which indicates the study was underpowered and a limitation of this study. Second, functional outcomes were evaluated at 2 years, and follow-up MRI was obtained at 6 months postoperatively. Follow-up MRI findings might be not correlated with functional outcomes. Third, follow-up MRI scans in this study were checked at 6 months postoperatively. We did not evaluate the meniscus at time zero. Furthermore, MRI scans at a longer follow-up period may show an increased incidence of tears of the capsule or allograft.

CONCLUSION

In this study, LCS did not decrease extrusion of lateral meniscal transplantation, but it can lead to an increased risk for graft or capsule tear.

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