Survivorship After Lateral Meniscal Allograft Transplantation Plus Concurrent Cartilage Procedure in Patients With Poor Cartilage Status

A Comparative Study

Jongjin Lee,* MD, Seong-Il Bin,*† MD, PhD, Jong-Min Kim,* MD, PhD, Bum-Sik Lee,* MD, PhD, Taehyeon Jeon,* MD, Kinam Bae,* MD, and Donghyok Kim,* MD
Investigation performed at Asan Medical Center, Seoul, Republic of Korea

Background: The effect of a concurrent cartilage procedure in lateral meniscal allograft transplantation (MAT) in patients with bipolar cartilage lesions (high-grade lesions on both the femoral and the tibial side) is not well studied. An objective evaluation of graft status after MAT and a concurrent cartilage procedure has not been reported.

Purpose: To investigate the effect of concurrent cartilage procedures and lateral MAT on objective and clinical outcomes, including survival, in patients with bipolar cartilage lesions.

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

Methods: A total of 149 patients with high-grade (International Cartilage Regeneration & Joint Preservation Society grade 3 or 4) cartilage lesions were enrolled and assigned to 1 of 3 groups based on the cartilage procedure and cartilage status at the time of MAT. Femoral cartilage procedures (microfracture, n = 18; osteochondral autograft transfer, n = 13) and lateral MAT were performed in 31 patients with bipolar cartilage lesions (cartilage procedure group). Another 70 patients with bipolar lesions underwent only lateral MAT without cartilage procedure (bipolar lesion group). The remaining 48 patients, who had high-grade lesions only on the tibial side and underwent lateral MAT without a cartilage procedure, were selected as a control group (unipolar lesion group). Anatomic survival was objectively assessed by follow-up magnetic resonance imaging and second-look arthroscopy. Clinical survivorship was determined with a Lysholm score <65 or need for additional surgery, such as revision MAT.

Results: The mean Lysholm score improved from 67.2 ± 15.9 preoperatively to 86.7 ± 11.1 with a mean follow-up of 78.0 ± 51.2 months ($P < .001$). The postoperative scores were not significantly different between the 3 groups. The estimated 5-year anatomic survival rate in the cartilage procedure group (86.7%) was higher than that in the bipolar lesion group (65.0%; $P = .043$) but comparable with that in the unipolar lesion group (90.2%; $P = .572$). The estimated 5-year clinical survival rates were not significantly different between the groups ($P = .187$).

Conclusion: A concurrent femoral cartilage procedure improved the anatomic survival rate in patients with bipolar chondral lesions who underwent lateral MAT. This finding suggests that the cartilage procedure is an effective treatment choice and may improve the status of an allograft after lateral MAT for patients with bipolar cartilage lesions.

Keywords: meniscal allograft transplantation; cartilage procedure; survival rate

Meniscal allograft transplantation (MAT) is an effective treatment choice in patients with postmeniscectomy syndrome.[1,10,11,14] Unfortunately, a considerable number of cartilage lesions are observed preoperatively in approximately 30% to 50% of patients and are closely associated with survival after MAT.[6,8,12] A previous study showed that patients with bipolar cartilage lesions, high-grade lesions on both the femoral and the tibial sides, had a lower graft survival rate than patients with intact cartilage or those with high-grade lesions on only 1 side.[9]

Various cartilage procedures, including osteochondral allograft and microfracture, are typically performed on femoral cartilage lesions to improve the outcomes after

The American Journal of Sports Medicine
2023;51(8):2120–2126
DOI: 10.1177/03635465231173692

MAT.[3,13,15,16] However, previous studies have not considered the presence of bipolar cartilage lesions in patients undergoing these procedures, despite its effect on outcomes after MAT. To our knowledge, no studies have been conducted on the effects of femoral cartilage procedures with MAT for patients with bipolar cartilage lesions.

Stone et al[19] reported that a combined cartilage procedure and MAT significantly improved pain, activity, and function at various follow-up periods. Saltzman et al[16] reported that patients who underwent concurrent cartilage procedures on chondral defects and those who underwent only MAT had similar clinical outcomes and complications. However, previous studies focused only on clinical outcomes and did not objectively evaluate allografts by follow-up magnetic resonance imaging (MRI) or second-look arthroscopy.

We evaluated whether the femoral cartilage procedure would improve objective and clinical outcomes, including survivorship, in patients with bipolar cartilage lesions who underwent lateral MAT. We hypothesized that the cartilage procedure would improve MAT survival rates to a level comparable with that in patients with unipolar cartilage lesions only on the tibial side.

METHODS

Patient Selection and Study Design

The study was approved by our institutional review board. The records of 442 consecutive patients who underwent lateral MAT between March 1998 and March 2020 were retrospectively reviewed. Physically active patients with persistent localized knee pain or discomfort in the lateral compartment after subtotal or total lateral meniscectomy were eligible to undergo lateral MAT. A minimum preserved joint space of 2 mm was confirmed on posteroanterior weightbearing radiographs under 45° of flexion. Valgus malalignment >5° was corrected by a varization femoral osteotomy, and ligament insufficiency was stabilized by ligament reconstruction before or during lateral MAT. Diffuse degenerative arthritis that was International Cartilage Regeneration & Joint Preservation Society (ICRS) grade 3 or 4 was a contraindication for MAT. However, localized grade 3 or 4 articular cartilage lesions confined to the area covered by the meniscal transplant were allowed. Osteochondral autograft transfer (OAT) or microfracture was performed as a concurrent cartilage procedure depending on the size, location, and depth of the cartilage lesions. However, only femoral lesions on weightbearing portions were repaired, because tibial cartilage lesions were difficult to approach anatomically and were

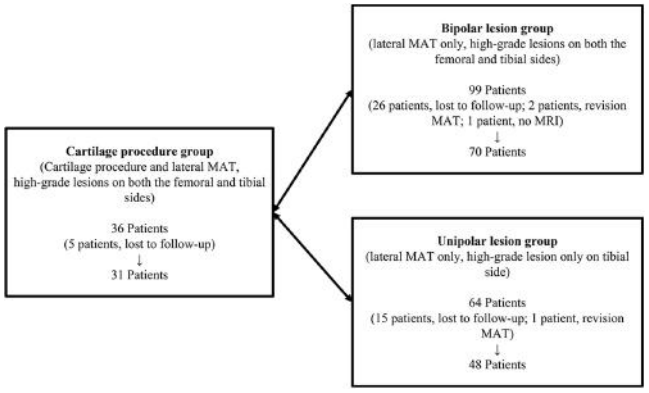

Figure 1. Patient groups according to the presence of a cartilage procedure and cartilage status. MAT, meniscal allograft transplantantion; MRI, magnetic resonance imaging.

associated with unfavorable outcomes.[7] Cartilage procedures were considered for 1- to 4-cm^2 lesions. OAT was used when the subchondral bone was involved based on preoperative MRI scans or when the previous cartilage procedure had failed.[2] Microfracture was considered when OAT could not be performed, for reasons such as the difficulty of the approach.[2,4] The mean ± SD size of femoral chondral lesions in the cartilage procedure group was 1.84 ± 0.84 cm^2. The mean size of cartilage lesions for OAT and microfracture was 1.76 ± 0.64 cm^2 and 2.12 ± 0.99 cm^2, respectively.

The inclusion criteria were as follows: (1) primary lateral MAT with a minimum 2-year follow-up including early failure and (2) presence of high-grade (ICRS grade 3 or 4) cartilage lesions at the time of MAT. The exclusion criteria were as follows: (1) revision MAT, (2) no MRI after MAT, and (3) low-grade cartilage lesions on the tibial side. A total of 149 patients were enrolled in this study and assigned to 1 of 3 groups based on the presence of a cartilage procedure and cartilage status (Figure 1). Concurrent femoral cartilage procedures (microfracture, n = 18; OAT, n = 13) and lateral MAT were performed in 31 patients with bipolar cartilage lesions (cartilage procedure group) (Figure 2, A and B). Another 70 patients with bipolar lesions underwent only lateral MAT without a cartilage procedure (bipolar lesion group) (Figure 2, C and D). The remaining 48 patients, who had high-grade lesions only on the tibial side and underwent lateral MAT without a cartilage procedure, were selected as an additional control group in order to compare the outcomes of patients with unipolar lesion versus those in the cartilage procedure group (unipolar lesion group) (Figure 2, E and F). There were no strict

†Address correspondence to Seong-Il Bin, MD, PhD, Department of Orthopedic Surgery, College of Medicine, University of Ulsan, Asan Medical Center, 88 Olympic-ro 43-gil, Songpa-gu, Seoul 05505, Republic of Korea (email: sibin99@naver.com).
*Department of Orthopedic Surgery, College of Medicine, University of Ulsan, Asan Medical Center, Seoul, Republic of Korea.
Submitted September 5, 2022; accepted March 3, 2023.
The authors declared that they have 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.

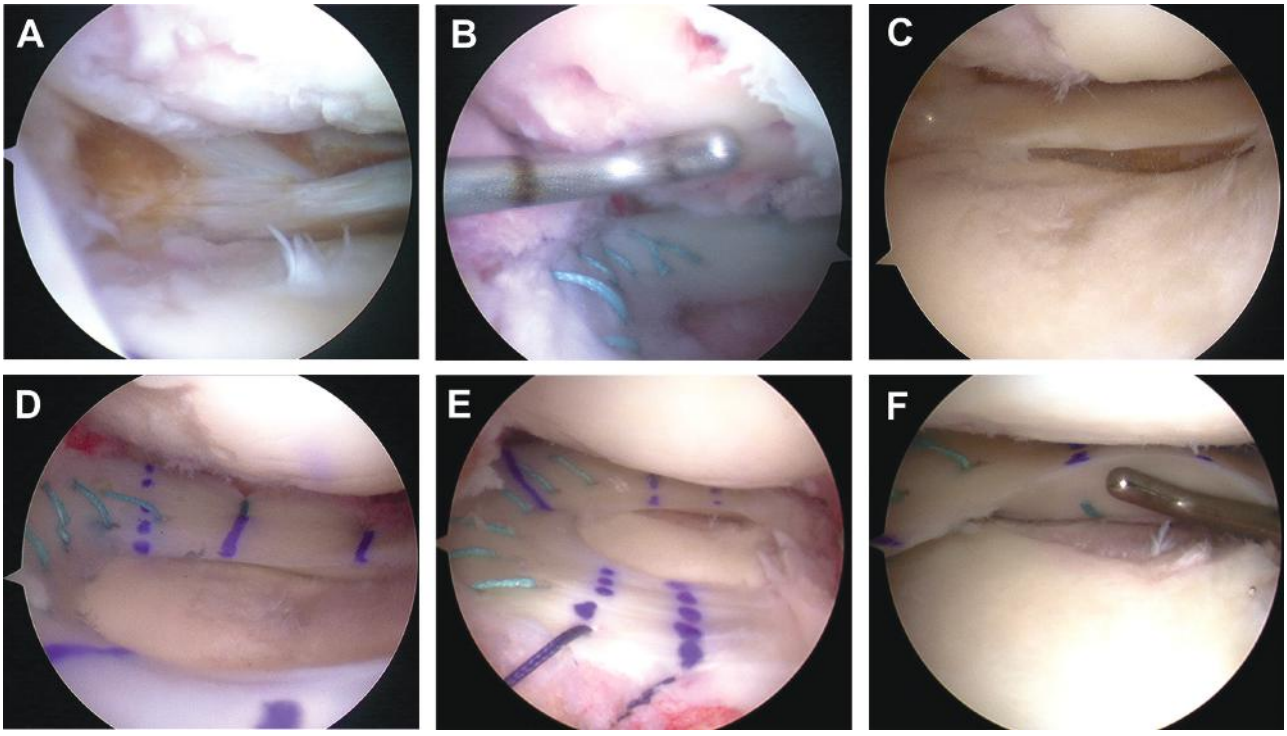

Figure 2. Typical arthroscopic photographs in each group. (A and B) Intraoperative photograph of a 46-year-old woman in the cartilage procedure group reveal high-grade chondral lesions on the lateral femoral condyle and tibial plateau and meniscal deficiency. Lateral meniscal allograft transplantation (MAT) and a concurrent femoral cartilage procedure were performed. (C and D) A 40-year-old man in the bipolar lesion group had high-grade lesions on both sides and underwent only lateral MAT without a cartilage procedure. (E and F) A 39-year-old man in the unipolar lesion group had high-grade cartilage lesion only on the lateral tibial plateau; this lesion was covered by a meniscal allograft.

criteria on whether to perform a femoral cartilage procedure in patients with bipolar lesions. Objective and clinical outcomes, including survival rates, were compared between the groups.

Surgical Technique and Rehabilitation

All lateral MATs were performed with size-matched, fresh-frozen allograft by a single senior surgeon (S.-I.B.) using the keyhole technique. The status of the cartilage, ligaments, and meniscus was evaluated through an arthroscopic examination, after which all remaining host meniscus was resected. After tunnel preparation for the bone bridge, the allograft was introduced through anterior mini-arthrotomy. After confirming the optimal allograft position, the surgeon performed a traditional inside-out meniscal repair. Postoperatively, a 90° range of flexion was gradually achieved within 4 weeks and 120° of flexion by 6 to 8 weeks. Toe-touch weightbearing was allowed during the first 2 weeks, and full weightbearing was allowed at 6 to 8 weeks postoperatively. Patients were advised to participate only in low-impact sports activities and light labor in order to avoid the deterioration of the meniscal allograft.

Postoperative Objective Evaluation and Clinical Outcomes

Postoperative allograft status was evaluated through follow-up MRI scans (Achieva 3T; Philips Healthcare) during the first year and every 2 years with the patient's agreement. Second-look arthroscopic surgery was considered if a patient had persistent postoperative knee pain and positive MRI findings for allograft tears or indications such as debridement, adhesiolysis, and revision ligament reconstruction. Depending on the pattern of the tear, it was treated by arthroscopic trimming, partial meniscectomy, or total meniscectomy. The clinical outcomes were estimated using a modified Lysholm knee score immediately after surgery and every 1 or 2 years postoperatively at follow-up visits.

Definition of MAT Failure

Failure was defined by objective and clinical evaluations. Anatomic failure was determined objectively by the graft status on follow-up MRI and second-look arthroscopy. Anatomic failure was defined as an allograft tear involving >50% of the graft on follow-up MRI or an unstable

TABLE 1
MRI and Clinical Follow-up Rates of All Patients Included in the Study[a]

Follow-up Point, y	MRI Follow-up	Clinical Follow-up
1	149 (100)	149 (100)
2	136 (91.3)	149 (100)
3	131 (87.9)	139 (93.3)
4	111 (74.5)	119 (79.8)
5	98 (65.8)	101 (67.8)

[a]Data are expressed as n (%). MRI, magnetic resonance imaging.

peripheral rim confirmed through second-look arthroscopy. Clinical failure was defined as a Lysholm score <65 or the requirement for additional surgery such as revision MAT, realignment osteotomy, arthroplasty, or meniscectomy for >50% of the allograft.[17] Two orthopaedic surgeons (J.L. and K.B.) who did not perform the surgeries independently evaluated anatomic failure in a double-blind manner. Any disagreements in the evaluation were resolved through discussion.

Statistical Analysis

The senior author (S.-I.B.) evaluated the status of articular cartilage with the ICRS grading system immediately after surgery. The degeneration was considered low grade if cartilage lesions were ICRS grade 1 or 2 and high grade if ICRS grade 3 or 4.

SPSS statistical software (Version 23.0; IBM) was used for statistical analyses. A P value of <.05 was considered statistically significant. The Student t test was applied to verify differences in clinical outcomes. One-way analysis of variance was performed between the groups using the post hoc Tukey test to compare continuous variables, and the chi-square test was used for categorical variables. Kaplan-Meier survival analysis was performed using the log-rank test to compare the anatomic and clinical survival rates among the 3 groups. Patients with <2 years of follow-up MRI scans were excluded from anatomic survival analysis.

RESULTS

Patient Characteristics

The MRI and clinical follow-up rates of all patients included in the study are presented in Table 1. In total, 31 of 31 patients in the cartilage procedure group, 63 of 70 patients in the bipolar lesion group, and 42 of 48 patients in the unipolar lesion group had a minimum 2-year follow-up MRI scans, and an anatomic survival analysis was performed on these patients.

The patients' characteristics are presented in Table 2. For all patients, the mean ± SD Lysholm score significantly improved from 67.2 ± 15.9 preoperatively to 86.7 ± 11.1 at the last follow-up (P < .001), at a mean of 78.0 ± 51.2 months (range, 6-270 months). The mean Lysholm scores at the last follow-up were not significantly different between the 3 groups (85.9 ± 11.1 for the cartilage procedure group, 86.6 ± 12.0 for the bipolar lesion group, and 87.5 ± 9.8 for the unipolar lesion group; P = .700).

Survivorship Analysis

The disparity between anatomic and clinical survivorship is presented in Table 3. Eight patients (25.8%) underwent anatomic failure in the cartilage procedure group. Among the 8 patients, 6 patients had an allograft tear covering >50% of the graft on MRI evaluation, and the other patients had an unstable peripheral rim on additional arthroscopic examination. In the cartilage procedure group, 4 patients had clinical failure. One patient had a Lysholm score <65, and 3 patients underwent additional surgery. Two patients underwent subtotal meniscectomy because of an unstable peripheral rim, and 1 patient underwent realignment osteotomy.

In the bipolar lesion group, 25 patients (39.7%) experienced anatomic failure. Of the 25 patients, 15 patients had an allograft tear covering >50% of the graft on MRI evaluation, and the other 10 patients had an unstable peripheral rim on additional arthroscopic examination. Eleven patients experienced clinical failure, 1 of whom had a Lysholm score of <65, and 10 patients underwent subtotal meniscectomy because of an unstable peripheral rim.

In the unipolar lesion group, 7 patients (16.7%) had anatomic failure. Among the 7 patients, 4 patients had an allograft tear covering >50% of the graft on MRI evaluation, and the other 3 patients had an unstable peripheral rim that was revealed on the additional arthroscopic examination. Four patients in the unipolar lesion group had clinical failure. One patient had a Lysholm score of <65, and 3 patients underwent subtotal meniscectomy because of an unstable peripheral rim.

The estimated 5-year anatomic survival rate was significantly higher in the cartilage procedure group (86.7%) than in the bipolar lesion group (65.0%; P = .043) but was not significantly different than that in the unipolar lesion group (90.2%; P = .572) (Figure 3).

The estimated 5-year clinical survival rates were not significantly different between the groups (cartilage procedure group, 89.8%; bipolar lesion group, 85.7%; unipolar lesion group, 95.8%; P = .187) (Figure 4).

DISCUSSION

In the present study, postoperative scores and clinical survival rates were not significantly different between the groups. However, a significant difference was found in the anatomic survival rates upon meniscal allograft evaluation through postoperative MRI or second-look arthroscopy. Although patients in the cartilage procedure group also had high-grade cartilage lesions on both the tibia

TABLE 2
Patient Characteristics and Clinical Outcomes in the 3 Study Groups[a]

Variable	Overall	Cartilage Procedure Group	Bipolar Lesion Group	Unipolar Lesion Group	*P*
No. of patients	149	31	70	48	
Age, y	35.4 ± 10.0	36.6 ± 8.5	36.8 ± 10.1	32.7 ± 10.5	.073
Sex, male:female, n	102:47	19:12	54:16	29:19	.099
Body mass index	24.6 ± 3.3	24.7 ± 3.3	24.6 ± 3.1	24.5 ± 3.6	.983
Alignment, degree	0.6 ± 2.6	0.3 ± 2.5	0.5 ± 2.4	0.9 ± 2.7	.476
Time from meniscectomy, mo	75.0 ± 81.2	69.2 ± 89.1	95.2 ± 85.8	49 ± 59.5	.009
Cartilage status, ICRS grade					
Femur, grade 1:2:3:4, n	7:41:35:66	0:0:5:26	0:0:30:40	7:41:0:0	**<.001**
Tibia, grade 1:2:3:4, n	0:0:86:63	0:0:12:19	0:0:31:39	0:0:43:5	**<.001**
Femoral cartilage lesion, cm^2	1.54 ± 0.91	1.84 ± 0.84	1.41 ± 0.92		.028
Tibial cartilage lesion, cm^2	1.68 ± 1.00	2.07 ± 0.87	1.69 ±1.09	1.41 ± 0.86	.016 (.173[b], .011[c])
Follow-up period, mo	78.0 ± 51.2	83.4 ± 55.2	77.7 ± 51.6	75.0 ± 48.7	.779
Preoperative Lysholm score	67.2 ± 15.9	66.6 ± 14.3	66.3 ± 17.2	69.4 ± 15.2	.488
Last follow-up Lysholm score	86.7 ± 11.1	85.9 ± 11.1	86.6 ± 12.0	87.5 ± 9.8	.700

[a]Data are expressed as mean ± SD unless otherwise noted. Boldface indicates statistical significance. ICRS, International Cartilage Repair Society.
[b]Determined with post hoc analysis between the cartilage procedure group and bipolar lesion group.
[c]Determined with post hoc analysis between the cartilage procedure group and unipolar lesion group.

TABLE 3
Objective and Clinical Evaluations of Survivorship in the 3 Study Groups

	Objective Evaluation			Clinical Evaluation		
	No. of Patients	Anatomic Failure, n (%)	Estimated Cumulative 5-Year Anatomic Survival Rate, % (95% CI)	No. of Patients	Clinical Failure, n (%)	Estimated Cumulative 5-Year Clinical Survival Rate, % (95% CI)
Cartilage procedure group	31	8 (25.8)	86.7 (74.5-98.9)	31	4 (12.9)	89.8 (78.8-100)
Microfracture	18	4 (22.2)	87.7 (71.6-100)	18	3 (16.7)	88.5 (73.6-100)
Osteochondral autograft transfer	13	4 (30.8)	84.6 (65.0-100)	13	1 (7.7)	92.3 (77.8-100)
Bipolar lesion group	63	25 (39.7)	65.0 (52.3-77.7)	70	11 (15.7)	85.7 (77.5-93.9)
Unipolar lesion group	42	7 (16.7)	90.2 (81.0-99.4)	48	4 (8.3)	95.8 (90.1-100)
Overall	136	40 (29.4)	78.2 (70.9-85.5)	149	19 (12.8)	89.8 (84.9-94.7)

and the femur, their 5-year anatomic survival rate was significantly higher than that of patients in the bipolar lesion group, who underwent lateral MAT only.

It may be important to improve graft survival after MAT in patients with bipolar chondral lesions, which are associated with inferior postoperative graft survival rates. Lee et al[9] reported that the outcomes after MAT were similar between patients with intact cartilage and those with unipolar lesions; however, patients with bipolar cartilage lesions had a lower graft survival rate. Therefore, a concurrent cartilage procedure might be an important treatment choice for these patients in order to improve their outcomes after MAT. Nonetheless, to our knowledge, the effect of a concurrent cartilage procedure in patients with bipolar chondral lesions has not been reported.

Favorable clinical outcomes have been reported for concurrent cartilage procedure and MAT.[5,16,19] Harris et al[5] performed a systematic review of 6 studies to compare the outcomes of combined cartilage procedure and MAT with isolated MAT. Those investigators reported that clinical outcomes after combined MAT and cartilage procedure were comparable with those after isolated MAT. However, objective outcomes, which reflect the actual status of an allograft, were not evaluated. Therefore, to the best of our knowledge, the present study is the first to report both objective and clinical outcomes after concurrent cartilage procedure and MAT.

We performed concurrent cartilage procedures and lateral MAT in patients with bipolar cartilage lesions and compared their objective and clinical outcomes with those of patients who underwent lateral MAT only. The anatomic and clinical survival rates in patients with bipolar lesions who underwent lateral MAT only were congruent with a previous study.[9] The 5-year anatomic survival rate in the cartilage procedure group was significantly higher than that in the bipolar lesion group, despite the presence

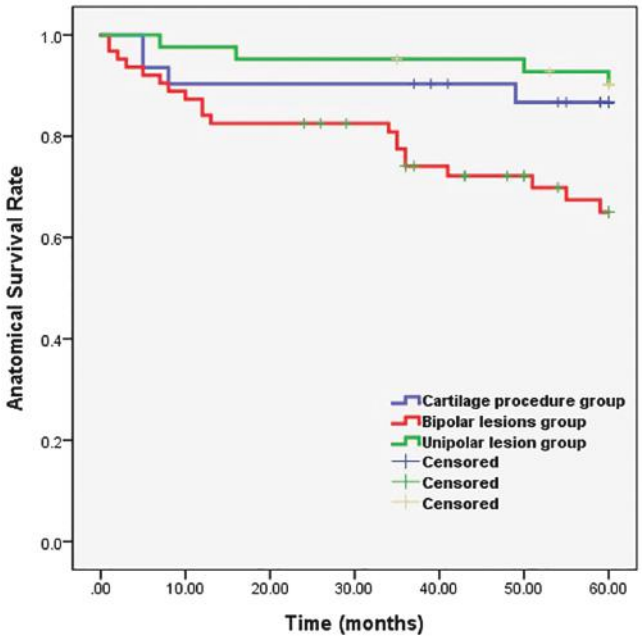

Figure 3. Anatomic survival rates in the 3 groups.

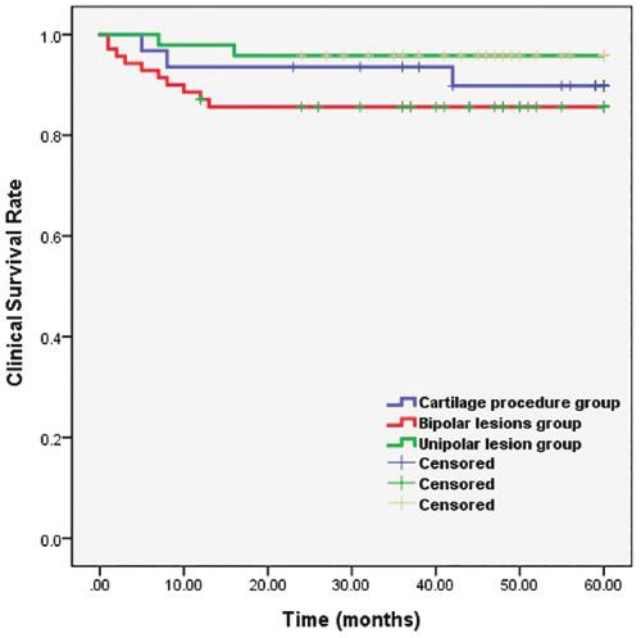

Figure 4. Clinical survival rates in the 3 groups.

of high-grade femoral and tibial cartilage lesions in both groups. Saltzman et al[16] performed cartilage procedures in 69 patients with full-thickness chondral defects and compared their clinical outcomes with those of patients without chondral defects, reporting no significant difference between the groups. Similar to Saltzman et al, we found no significant difference in clinical outcomes and clinical survival rates between groups in the current study. However, anatomic survival rates, which reflect the actual status of the allograft, were significantly different between the cartilage procedure group and the bipolar lesion group. This result suggests that concurrent cartilage procedures might improve the postoperative graft status of patients with bipolar cartilage lesions.

Because of the demographic heterogeneity between the cartilage procedure group and the bipolar lesion group, an additional comparison was performed with patients who had unipolar cartilage lesions. Femoral cartilage procedures were performed on patients with bipolar lesions to achieve outcomes comparable with those of the unipolar lesion group. The results showed that anatomic and clinical survival rates were not different between the cartilage procedure group and the unipolar lesion group at midterm follow-up, indicating that the femoral cartilage procedures were effective.

In our study, although the anatomic survival rate was significantly higher in the cartilage procedure group compared with the bipolar lesion group, we found no significant difference in clinical outcomes. The mismatch between clinical outcomes and anatomic survival rates has been reported in previous studies.[4,9,18,20] It could be explained by the fact that the remaining tissue of a failed allograft could partly perform normal meniscal functions to release pain in a meniscus-deficient knee. The present study focused on only the midterm results for 5 years, considering the follow-up period. Therefore, it would be necessary to evaluate whether the clinical outcomes are maintained in patients with anatomic failure, even in long-term results for 10 years and $\geq$15 years.

This study had several limitations. First, its retrospective nature may lead to selection bias. In addition, random allocation was not performed prospectively between the cartilage procedure group and the bipolar lesion group, and there were no strict criteria for whether to perform the cartilage procedure. This might lead to a possibility of selection bias between the cartilage procedure group and the bipolar lesion group. Second, the number of patients who underwent a cartilage procedure was small. Third, the effect of cartilage procedures in medial MAT was not investigated; given the differences in surgical method and the functions of the medial and lateral menisci, this study included only patients undergoing lateral MAT. Fourth, we used only the Lysholm score for the clinical outcome analysis. However, this is the most commonly used outcome measure for evaluation and has a high level of compliance, making it easy to obtain data over a long period.[17]

CONCLUSION

Patients with bipolar cartilage lesions had a better anatomic survival rate after concurrent femoral cartilage procedures and lateral MAT. The results of the current study suggest that a concurrent cartilage procedure was an effective treatment choice and may improve the status of an allograft after lateral MAT in patients with bipolar cartilage lesions. Therefore, we recommend performing

a concurrent femoral cartilage procedure when performing lateral MAT for better outcomes in patients with bipolar chondral lesions.

ORCID iDs

Seong-Il Bin https://orcid.org/0000-0003-1787-1139
Bum-Sik Lee https://orcid.org/0000-0002-7269-0915

REFERENCES

1. Dangelmajer S, Familiari F, Simonetta R, Kaymakoglu M, Huri G. Meniscal transplants and scaffolds: a systematic review of the literature. *Knee Surg Relat Res*. 2017;29(1):3-10.
2. Dekker TJ, Aman ZS, DePhillipo NN, Dickens JF, Anz AW, LaPrade RF. Chondral lesions of the knee: an evidence-based approach. *J Bone Joint Surg Am*. 2021;103(7):629-645.
3. Farr J, Rawal A, Marberry KM. Concomitant meniscal allograft transplantation and autologous chondrocyte implantation: minimum 2-year follow-up. *Am J Sports Med*. 2007;35(9):1459-1466.
4. Figueroa F, Figueroa D, Calvo R, Vaisman A, Espregueira-Mendes J. Meniscus allograft transplantation: indications, techniques and outcomes. *EFORT Open Rev*. 2019;4(4):115-120.
5. Harris JD, Cavo M, Brophy R, Siston R, Flanigan D. Biological knee reconstruction: a systematic review of combined meniscal allograft transplantation and cartilage repair or restoration. *Arthroscopy*. 2011;27(3):409-418.
6. Kempshall PJ, Parkinson B, Thomas M, et al. Outcome of meniscal allograft transplantation related to articular cartilage status: advanced chondral damage should not be a contraindication. *Knee Surg Sports Traumatol Arthrosc*. 2015;23(1):280-289.
7. Kreuz PC, Steinwachs MR, Erggelet C, et al. Results after microfracture of full-thickness chondral defects in different compartments in the knee. *Osteoarthritis Cartilage*. 2006;14(11):1119-1125.
8. Lee BS, Bin SI, Kim JM, Kim JH, Han GW. Proper cartilage status for meniscal allograft transplantation cannot be accurately determined by patient symptoms. *Am J Sports Med*. 2016;44(3):646-651.
9. Lee BS, Bin SI, Kim JM, Kim WK, Choi JW. Survivorship after meniscal allograft transplantation according to articular cartilage status. *Am J Sports Med*. 2017;45(5):1095-1101.
10. Lee BS, Kim JM, Sohn DW, Bin SI. Review of meniscal allograft transplantation focusing on long-term results and evaluation methods. *Knee Surg Relat Res*. 2013;25(1):1-6.
11. Lee SR, Kim JG, Nam SW. The tips and pitfalls of meniscus allograft transplantation. *Knee Surg Relat Res*. 2012;24(3):137-145.
12. Mahmoud A, Young J, Bullock-Saxton J, Myers P. Meniscal allograft transplantation: the effect of cartilage status on survivorship and clinical outcome. *Arthroscopy*. 2018;34(6):1871-1876.e1871.
13. Noyes FR, Barber-Westin SD, Rankin M. Meniscal transplantation in symptomatic patients less than fifty years old. *J Bone Joint Surg Am*. 2005;87(suppl 1, pt 2):149-165.
14. Rosso F, Bisicchia S, Bonasia DE, Amendola A. Meniscal allograft transplantation: a systematic review. *Am J Sports Med*. 2015;43(4):998-1007.
15. Rue JP, Yanke AB, Busam ML, McNickle AG, Cole BJ. Prospective evaluation of concurrent meniscus transplantation and articular cartilage repair: minimum 2-year follow-up. *Am J Sports Med*. 2008;36(9):1770-1778.
16. Saltzman BM, Meyer MA, Leroux TS, et al. The influence of full-thickness chondral defects on outcomes following meniscal allograft transplantation: a comparative study. *Arthroscopy*. 2018;34(2):519-529.
17. Smith NA, MacKay N, Costa M, Spalding T. Meniscal allograft transplantation in a symptomatic meniscal deficient knee: a systematic review. *Knee Surg Sports Traumatol Arthrosc*. 2015;23(1):270-279.
18. Song JH, Bin SI, Kim JM, Lee BS. Meniscal allograft transplantation shows a mismatch between anatomic and clinical failures. *Knee Surg Sports Traumatol Arthrosc*. 2022;30(5):1700-1705.
19. Stone KR, Adelson WS, Pelsis JR, Walgenbach AW, Turek TJ. Long-term survival of concurrent meniscus allograft transplantation and repair of the articular cartilage: a prospective two- to 12-year follow-up report. *J Bone Joint Surg Br*. 2010;92(7):941-948.
20. Verdonk PC, Verstraete KL, Almqvist KF, et al. Meniscal allograft transplantation: long-term clinical results with radiological and magnetic resonance imaging correlations. *Knee Surg Sports Traumatol Arthrosc*. 2006;14(8):694-706.