Factors Associated With the Clinical Outcomes of the Osteochondral Autograft Transfer System in Osteochondral Lesions of the Talus : Second-Look Arthroscopic Evaluation

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Am J Sports Med 2012 40: 2709 originally published online October 24, 2012
DOI: 10.1177/0363546512461132

Factors Associated With the Clinical Outcomes of the Osteochondral Autograft Transfer System in Osteochondral Lesions of the Talus

Second-Look Arthroscopic Evaluation

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Background: Identifying factors associated with the clinical outcomes of the osteochondral autograft transfer system would be helpful for treating patients with an osteochondral lesion of the talus.

Purpose: To investigate the clinical and second-look arthroscopic results of the osteochondral autograft transfer system and to identify the prognostic factors associated with this procedure.

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

Methods: The authors retrospectively evaluated 52 ankles that underwent osteochondral autograft transfer for a medial osteochondral lesion of the talus. Second-look arthroscopies were performed at a mean of 13.1 months postoperatively. Clinical outcomes were evaluated according to a visual analog scale (VAS) for pain, American Orthopaedic Foot and Ankle Society (AOFAS) score, and the Tegner activity scale. Statistical analyses were performed to identify various prognostic factors associated with the clinical outcomes.

Results: The mean VAS, AOFAS, and Tegner activity scale scores were all significantly improved from 6.9 ± 0.9 to 3.3 ± 1.4 (VAS), from 67.4 ± 4.9 to 82.6 ± 7.8 (AOFAS), and from 3.0 ± 0.8 to 3.9 ± 0.9 (Tegner; $P < .05$). Regarding overall patient satisfaction with the operation, 49 (95%) patients reported good to excellent results. Prognostic factors including the patient's age, sex, body mass index, duration of symptoms, defect size and depth, location of osteochondral lesion of the talus, and the existence of a subchondral cyst did not significantly influence clinical outcomes ($P > .05$), except for body mass index on the Tegner activity scale score ($P = .021$). Significant differences were observed among clinical outcomes for second-look arthroscopy according to the presence of soft tissue impingement and uncovered areas around the graft ($P < .05$). The VAS and AOFAS score at the last follow-up were significantly worse when the articular surface of the tibial plafond at the malleolar osteotomy site was uneven ($P = .031$ and .012, respectively).

Conclusion: This study showed that the articular surface of the tibial plafond at the malleolar osteotomy site, soft tissue impingement, and uncovered areas around the graft were important factors affecting the clinical outcomes, as observed through second-look arthroscopy. Therefore, surgeons should restore the articular surface accurately after the osteotomy, and more caution should be taken to avoid soft tissue impingement and uncovered areas around the graft when performing osteochondral autograft transfer.

Keywords: osteochondral autograft transfer system; osteochondral lesions; talus; second-look arthroscopy

Osteochondral lesion of the talus (OLT) can be treated with various operative methods, including marrow-inducing reparative procedures, such as abrasion chondroplasty, curettage, subchondral drilling, and debridement with microfracture, as well as restorative procedures, such as osteochondral grafting and chondrocyte transplantation.[12,14,15,17,18] There are conflicting opinions as to which of the various operative treatments are the better methods. Marrow-inducing reparative procedures provide acceptable clinical results over midterm follow-up periods but often fail in the long-term because of biomechanical

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The authors declared that they have no conflicts of interest in the authorship and publication of this contribution.

The American Journal of Sports Medicine, Vol. 40, No. 12
DOI: 10.1177/0363546512461132

insufficiency of regenerative fibrocartilage and scar tissue that result from these methods.[3,24] Subsequently, osteochondral lesions may not respond to these marrow-inducing reparative procedures, and articular surfaces may continue to deteriorate, leading to osteoarthritis. The osteochondral autograft transfer system has been used to replace articular defects with hyaline cartilage attached to its subchondral plate to allow for bony integration of the graft within the lesion bed.[33] Hence, biopsy samples obtained during second-look arthroscopy may provide histological evidence for confirming the survival of chondrocytes within the transplanted hyaline cartilage.[3,20]

A number of studies assessing the effectiveness of osteochondral autografts to treat OLT have been performed.[1,3,20,28,41]Among the literature, several studies have reported on the results of osteochondral autografts using specialized MRI sequences.[2,25,47] However, the efficacy of magnetic resonance imaging (MRI) in terms of assessing grafted cartilage quality has not been established, and it has been suggested that arthroscopy may better predict the quality of grafted cartilage.[4,38] Nevertheless, studies on the osteochondral autograft transfer system for treatment of OLT using second-look arthroscopy have rarely been published.

The aims of this study were (1) to investigate the clinical and second-look arthroscopic results of the osteochondral autograft transfer system in treatment of OLT and (2) to identify the prognostic factors associated with the osteochondral autograft transfer system.

MATERIALS AND METHODS

Between July 2007 and January 2010, 62 consecutive patients (69 ankles) with OLT were treated with the osteochondral autograft transfer system. Indications for the osteochondral autograft transfer system technique include symptomatic osteochondral defects and focal osteonecrosis combined with a limited cartilage defect. All patients had a localized osteochondral lesion of the talus with symptoms of ankle joint pain or functional limitations, despite a minimum of 3 months of nonoperative management. Patients with arthritic change of their ankle joint or deformity of the axis of the ankle on plain radiographs were excluded.

The preoperative range of motion of the ankle joints was not restricted in all cases. Among these cases, 60 lesions were located on the medial side and 9 were located on the lateral side of the talus. Second-look arthroscopies were performed at a mean of 13.1 months postoperatively (range, 10-17 months) in 52 of the 60 medial talar dome lesions. These 52 ankles (48 patients) were included in this study. Medial talar dome lesions were approached using a medial malleolar osteotomy, and all second-look arthroscopies were performed when the screws, which fixed the medial malleolus, were removed. We explained the purpose of the second-look arthroscopy (the evaluation of the grafted site and the need of additional arthroscopic procedures such as debridement, synovectomy, and adhesiolysis) to all patients before surgery and received written consent. This study was approved by the institutional review board of our hospital. The average age of the patients was 48.2 years (range, 21-67 years), and the mean follow-up period was 34.1 months (range, 24-48 months). There were 34 men and 18 women. The average preoperative body mass index (BMI) was 25.7 (range, 19.9-30.4), and the average duration of symptoms was 20.4 weeks (range, 16-34 weeks). Among the patients, there were no professional athletes, but all patients tended to enjoy sports activities and experienced traumatic events to their ankles during such activities before visiting our hospital.

All patients were evaluated clinically and radiographically before surgery and as part of the follow-up. As a clinical evaluation, a visual analog scale (VAS) for pain and the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot scale were used. The Tegner activity scale[45] was used to determine sporting and activity levels. Although the Tegner activity scale was originally used for the knee, it was designed to facilitate outcomes research in sports medicine. Furthermore, patients rated their overall satisfaction with the operation as excellent, good, fair, or poor and were asked whether they would undergo the procedure again.

At preoperative and follow-up examinations, we investigated the osteotomy sites through plain radiographs. We performed MRI to measure the size and location of lesions and to evaluate any associated lesions (eg, subchondral cyst) before surgery. To avoid potential bias, an independent observer, who was a trained musculoskeletal radiologist uninvolved in the care of the patients and who was blinded to the intention of this study, evaluated the MRI films. The width and length of the defect area were measured with coronal, sagittal, and axial MRI scans, and the largest dimension was selected. We reconfirmed the defect size with a ruler intraoperatively, and the defect size was calculated by the ellipse formula (Figure 1C). We compared the size measurements (width, length, and size) based on MRI with those determined intraoperatively, and a good correlation was found by linear regression analysis ($r = 0.85$, $P < .001$).

Surgical Technique

The patient was placed in the supine position under spinal anesthesia. A thigh tourniquet was used for hemostasis. Diagnostic arthroscopy was performed to investigate the sizes and shapes of the medial talar lesions, and medial malleolar osteotomy was performed as described below. A 10-cm linear medial incision was made overlying the center of the medial malleolus, parallel to the axis of tibia. The oblique osteotomy was performed using a microsagittal saw after exposing the medial malleolus. The apex and direction of the osteotomy were determined according to the size of the osteochondral lesion of the talus (Figure 2, A-D). The osteotomized medial malleolus was then reflected plantarward on the deltoid ligament to expose the medial aspect of the talar dome.

After identifying the lesion, we trimmed the peripheral rim of the lesion and measured its size (Figure 1). For the osteochondral autograft transfer, the Osteochondral Autograft Transfer System instrumentation set (Arthrex Inc,

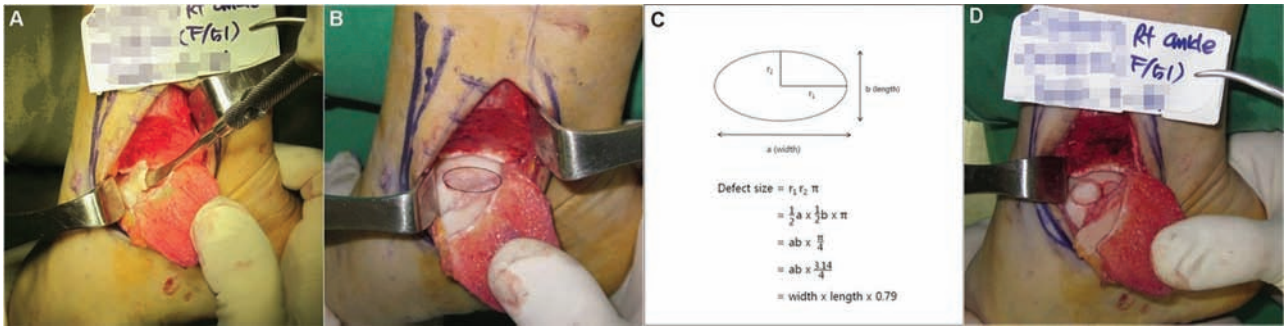

Figure 1. (A) Identification of the margin of osteochondral lesion was performed. (B, C) After the peripheral rim of the osteochondral lesion was trimmed, the size of lesion was calculated by ellipse formula. (D) Appropriate grafts were inserted after calculating the size.

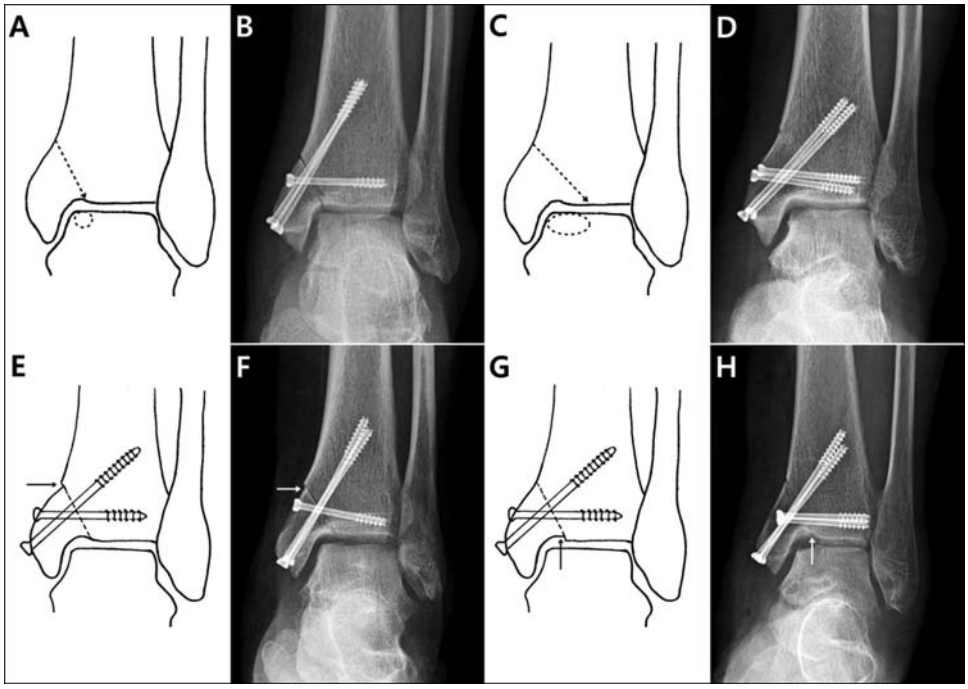

Figure 2. (A, C) Schematic drawings of the oblique medial malleolar osteotomy. (B, D) Postoperative anteroposterior radiographs of the ankle. The apex and direction of the osteotomy were determined according to the size of osteochondral lesion of the talus. (E, G) Schematic drawings of the oblique medial malleolar osteotomy. (F, H) Postoperative anteroposterior radiographs of the ankle. (E, F) If the articular surface of the tibial plafond at the malleolar osteotomy site was even, the apex of the osteotomy site tended to be uneven (horizontal arrows). (G, H) If the apex of the osteotomy site was even, the articular surface of the tibial plafond at the malleolar osteotomy site tended to be uneven (vertical arrows).

Naples, Florida) was used for the recipient site preparation as well as for osteochondral plug harvest and transplantation. The diameters of the plug and recipient socket were determined by measuring the size of the cartilage defect with sizer/tamps. Under direct visualization through a mini-arthrotomy, placed just lateral to the patellar tendon, an osteochondral plug was cored out from the lateral edge of the lateral trochlea using a donor tube harvester. A donor graft, slightly larger than the osteochondral lesion, was obtained to ensure that the lesion was completely resected. The donor plug was delivered to the recipient site and impacted flush with the surrounding articular cartilage of the talus. In 22 cases, 2 donor plugs were transplanted because of the large size of the osteochondral lesions. Subchondral drilling was performed at the uncovered site between the 2 impacted plugs (Figure 3A). Subsequently, the malleolus was returned to its original position and fixed with compression using three or four 4.0 cannulated screws (Figure 2B).

After the operation, a short leg splint was applied for 2 weeks, and after sutures were removed, a short leg nonweightbearing cast was applied for 4 weeks. Patients

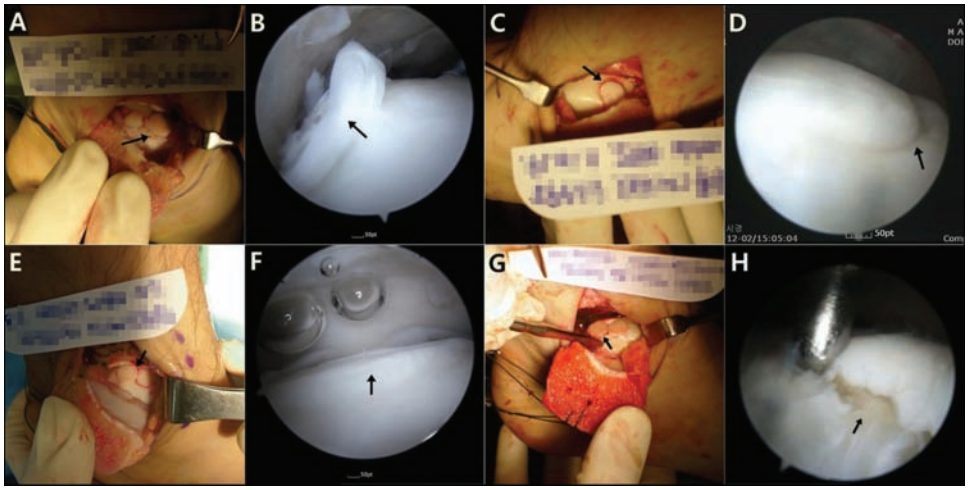

Figure 3. (A) Two osteochondral plugs were impacted, and the subchondral drilling (arrow) was performed at the uncovered area between the 2 impacted plugs. (B) On second-look arthroscopy, the uncovered area was filled with unstable fibrous cartilage. (C, D) The congruent margin of graft (arrow) was noticed. (E) Two osteochondral plugs were impacted, and the uneven surface (arrow) between the 2 impacted plugs was observed. (F) The incongruent margin of graft was noticed on second-look arthroscopy. (G) Two osteochondral plugs were impacted, and the uncovered area (arrow) between the 2 impacted plugs was observed. (H) The uncovered area (arrow) was still noticed on second-look arthroscopy.

began range of motion exercises of both active and passive exercises to the ankle joint at 6 weeks after the operation. Sports or high-impact activities were limited for at least 3 months. The cannulated screws were removed after radiological and clinical confirmation of union of the osteotomy site routinely after 12 months postoperatively. Second-look arthroscopy was performed at that time, before removal of the screws. Additional arthroscopic procedures were performed if pathologic lesions in the ankle joint were found during the second-look arthroscopy.

Statistical Analysis

Statistical analysis was performed using SPSS software version 12.0.1 (SPSS Inc, Chicago, Illinois), with significance defined as $P < .05$. Descriptive statistics were calculated as mean ± standard deviation. The principal dependent variables of clinical outcomes were VAS, AOFAS score, and the Tegner activity scale at the last follow-up. The paired t test was conducted for evaluation of changes in preoperative and last follow-up values, and the Wilcoxon signed rank test was conducted for evaluation of changes in clinical outcomes at the second-look arthroscopy and the last follow-up. We analyzed the association of factors—patient characteristics, variables of OLT (defect size and depth, location of OLT, and existence of subchondral cyst), and variables of surgical procedures— with clinical outcomes. Median values were used as standard values for dividing patients according to age, BMI, duration of symptoms, and defect size and depth of OLT. Differences between groups were analyzed using the Mann-Whitney U test or the Kruskal-Wallis test for multiple comparisons.

RESULTS

Outcomes at Follow-up

Before the operation, the mean VAS score was 6.9 ± 0.9, the mean AOFAS score was 67.4 ± 4.9, and the mean Tegner activity scale score was 3.0 ± 0.8. At the last follow-up, the mean VAS, AOFAS, and Tegner activity scale scores were all significantly improved to 3.3 ± 1.4, 82.6 ± 7.8, and 3.9 ± 0.9 ($P < .05$). Regarding overall patient satisfaction with the operation, 32 patients reported their satisfaction as excellent (62%), 17 good (33%), and 3 fair (5%). None of the patients reported poor satisfaction with the operation. All 48 patients stated that they would be willing to undergo the same operation for their 52 ankles again.

Associations Between Patient Characteristics and Outcomes

We used the Mann-Whitney U test to assess the independent effects of patient age, sex, BMI, and duration of symptoms on clinical outcomes (Table 1). Median values were used as a standard for dividing patients according to age (<48 or ≥48 years), BMI (<26.0 or ≥26.0), and duration of symptoms (<20 or ≥20 weeks). All prognostic factors including the patient's age, sex, BMI, and duration of symptoms did not exhibit significant influences on clinical outcomes ($P > .05$), except for BMI on the Tegner activity scale. There was a statistically significant association between BMI less than 26.0 and higher Tegner activity scale ($P = .021$).

TABLE 1
Associations Between Patient Characteristics and Outcomes[a]

		Final Follow-up					
		VAS		AOFAS		Tegner	
Factor	n	Mean ± SD	*P*	Mean ± SD	*P*	Mean ± SD	*P*
Age, y[b]			.088		.153		.621
<48	19	3.0 ± 1.6		85.4 ± 5.9		3.8 ± 1.9	
≥48	33	3.4 ± 1.3		81.3 ± 6.8		3.9 ± 1.8	
Sex			.414		.512		.720
Male	34	3.3 ± 1.9		81.9 ± 7.5		3.7 ± 1.4	
Female	18	3.5 ± 1.5		82.2 ± 7.6		3.6 ± 1.2	
BMI[b]			.392		.598		.021[c]
<26.0	30	3.3 ± 1.6		82.5 ± 8.5		4.0 ± 0.7	
≥26.0	22	3.4 ± 1.5		83.2 ± 6.8		3.4 ± 0.8	
Duration of symptoms, wk[b]			.823		.780		.650
<20	28	3.4 ± 1.5		81.5 ± 7.4		3.8 ± 0.7	
≥20	24	3.3 ± 1.2		81.7 ± 7.2		3.6 ± 0.9	

[a]VAS, visual analog scale; AOFAS, American Orthopaedic Foot and Ankle Society ankle-hindfoot scale; Tegner, Tegner activity scale; SD, standard deviation; BMI, body mass index.
[b]Median values are used as standard values for dividing the groups.
[c]Statistically significantly difference, $P < .05$.

Associations Between Variables of Osteochondral Lesions of the Talus and Outcomes

The mean defect size of OLT was 150.4 ± 56.7 mm^2 (range, 51.7-294.2 mm^2), and the mean depth was 9.0 ± 3.1 mm (range, 4.2-17.6 mm). To analyze the association of the size, depth, and location of the OLT with clinical outcomes, we divided the patients according to defect size into large (≥150 mm^2) and small (<150 mm^2) size groups and deep (≥9 mm) and shallow (<9 mm) depth groups. Median values were used as standard values for dividing the groups. For locating the OLT, we divided the medial talar dome into 3 parts horizontally and demarcated anteromedial, centromedial, and posteromedial areas. Regarding location of the OLTs, 8 ankles had OLTs in the anteromedial area, 15 ankles in the centromedial area, and 29 ankles in the posteromedial area. Subchondral cysts, investigated through MRI, existed in 30 ankles. According to the Mann-Whitney *U* test, all variable factors including defect size, depth, location of OLT, and the existence of a subchondral cyst did not significantly influence clinical outcomes ($P > .05$; Table 2).

Associations Between Variables of Surgical Procedures and Outcomes

We retrospectively reviewed postoperative plain radiographs and found that the articular surface of the tibial plafond and the apex of the osteotomy site did not tend to be even at the same time. That is to say, if the articular surface of the tibial plafond at the malleolar osteotomy site was even, the apex of the osteotomy site tended to be uneven, and, contrary to this, if the apex of the osteotomy site was even, the articular surface of the tibial plafond at the malleolar osteotomy site tended to be uneven, in most cases (Figure 2, E-H). We considered that this phenomenon might have occurred because of compressive force delivered to the malleolus in the process of fixation with screws. The articular surfaces of the tibial plafond at the malleolar osteotomy site were even in 39 ankles and uneven in 13 ankles. The second-look arthroscopic findings at these sites are shown in Figure 4, A-D. The VAS and the AOFAS scores at the last follow-up were significantly worse when the articular surface of the tibial plafond at the malleolar osteotomy site was uneven ($P = .031$, $P = .012$, respectively; Table 3). For osteochondral autograft transfer, the grafted plugs were inserted as follows: solitary 8-mm diameter plugs in 6 ankles, double 8-mm diameter plugs in 11 ankles, 8- and 10-mm-diameter plugs in 2 ankles, solitary 10-mm diameter plugs in 24 ankles, and double 10-mm diameter plugs in 9 ankles. No associations were found between grafted plugs and clinical outcomes (Table 3). In 10 cases, patients were treated with arthroscopic microfracture for OLT as a first operation and then subsequently treated with osteochondral autograft transfer because of persistent pain and unsatisfactory clinical outcomes. In 14 cases, patients with chronic ankle instability received a modified Broström operation along with the surgery for OLT. There were no statistical differences observed regarding whether previous arthroscopic microfracture or an accompanied modified Broström operation was performed or not (Table 3).

Second-Look Arthroscopic Findings

With the second-look arthroscopy, the original grafted plugs were preserved very well in all cases. However, some pathologic lesions such as fibrous adhesion, synovitis, incongruence of grafts, and uncovered area formed between plugs were observed. Fibrous adhesion causing soft tissue

TABLE 2
Associations Between Variables of Osteochondral Lesion of Talus and Outcomes[a]

		Final Follow-up					
		VAS		AOFAS		Tegner	
Factor	n	Mean ± SD	*P*	Mean ± SD	*P*	Mean ± SD	*P*
Defect size,[b] mm^2			.690		.781		.590
<150	30	3.5 ± 1.2		81.7 ± 6.4		3.5 ± 1.2	
≥150	22	3.4 ± 1.3		81.6 ± 6.8		3.6 ± 1.7	
Depth,[b] mm			.635		.640		.510
<9.0	29	3.3 ± 1.5		82.1 ± 7.3		3.8 ± 0.9	
≥9.0	33	3.5 ± 1.4		80.6 ± 7.9		3.7 ± 1.0	
Location			.745		.416		.256
AM	8	3.2 ± 1.6		85.3 ± 6.8		4.1 ± 0.9	
CM	15	3.3 ± 1.5		81.7 ± 7.4		3.8 ± 0.7	
PM	29	3.5 ± 1.7		81.1 ± 7.5		3.6 ± 0.8	
Subchondral cyst			.450		.275		.720
Existence	30	3.3 ± 1.5		82.7 ± 7.7		3.8 ± 0.9	
Nonexistence	22	3.5 ± 1.1		80.4 ± 7.8		3.7 ± 0.8	

[a]VAS, visual analog scale; AOFAS, American Orthopaedic Foot and Ankle Society ankle-hindfoot scale; Tegner, Tegner activity scale; SD, standard deviation; AM, anteromedial; CM, centromedial; PM, posteromedial.
[b]Median values are used as standard values for dividing the groups.

TABLE 3
Associations Between Variables of Surgical Procedures and Outcomes[a]

		Final Follow-up					
		VAS		AOFAS		Tegner	
Factor	n	Mean ± SD	*P*	Mean ± SD	*P*	Mean ± SD	*P*
ASTP			.031[b]		.012[b]		.245
Even	39	3.2 ± 1.2		83.7 ± 1.37		3.9 ± 0.6	
Uneven	13	4.4 ± 1.3		79.8 ± 1.2		3.7 ± 0.7	
Graft type			.350		.271		.528
Solitary 8-mm	6	2.2 ± 1.1		86.5 ± 8.9		4.1 ± 1.0	
Double 8-mm	11	3.2 ± 1.6		82.5 ± 9.3		3.5 ± 0.8	
8-mm, 10-mm	2	3.1 ± 1.4		81.5 ± 9.4		4.2 ± 0.8	
Solitary 10-mm	24	3.6 ± 1.5		80.7 ± 7.2		3.8 ± 0.9	
Double 10-mm	9	3.5 ± 1.4		81.8 ± 7.4		3.9 ± 1.0	
Previous microfracture			.425		.441		.582
Performed	10	3.5 ± 1.4		81.2 ± 8.3		3.7 ± 0.7	
Not performed	42	3.3 ± 1.6		83.5 ± 7.6		3.5 ± 0.6	
Accompanied MBO			.680		.883		.760
Performed	14	3.5 ± 1.5		81.9 ± 7.5		3.3 ± 0.8	
Not performed	38	3.6 ± 1.4		82.1 ± 7.6		3.5 ± 0.6	

[a]VAS, visual analog scale; AOFAS, American Orthopaedic Foot and Ankle Society ankle-hindfoot scale; Tegner, Tegner activity scale; SD, standard deviation; ASTP, articular surface of tibial plafond at malleolar osteotomy site; MBO, modified Broström operation.
[b]Statistically significantly difference, $P < .05$.

impingement in the anterior recess was observed in 15 ankles, and arthroscopic adhesiolysis and debridement of the impinged soft tissue were performed during the second-look arthroscopy (Figure 4, E and F). Significant differences were observed for clinical outcomes at the second-look arthroscopy according to the presence of soft tissue impingement ($P = .025$, $P = .005$, $P = .034$, for the VAS, AOFAS, and Tegner activity scale, respectively). After the arthroscopic procedures, there were no significant differences in clinical outcomes at the last follow-up ($P > .05$; Table 4). Severe synovitis was observed in 16 ankles, and arthroscopic synovectomy was performed during the second-look arthroscopy (Figure 4G). The mean VAS, AOFAS score, and Tegner activity scale score were improved after the synovectomy during the second-look arthroscopy, but there were no significant differences in clinical outcomes at the

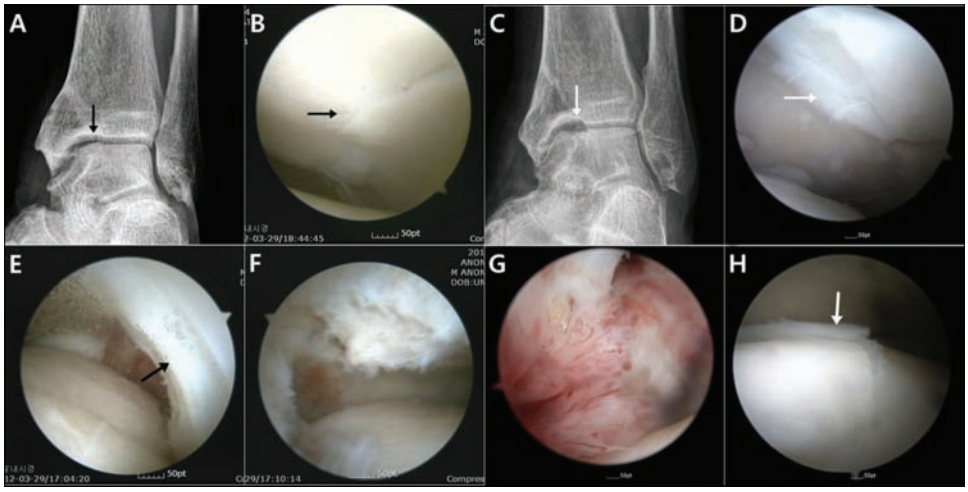

Figure 4. (A) The articular surface of tibial plafond at the malleolar osteotomy site was even (vertical black arrow). (B) Second-look arthroscopy revealed a well-healed surface of the osteotomy site (horizontal black arrow). (C) The articular surface of the tibial plafond at the malleolar osteotomy site was uneven (vertical white arrow). (D) The articular surface of the osteotomy site was filled with fibrous tissue (horizontal white arrow). (E) A fibrous adhesion causing the impingement in anterior recess (black arrow) was noticed. (F) Adhesiolysis and debridement of impinged tissue were performed. (G) Severe synovitis was noticed. (H) Fibrous cartilage (white arrow) was observed at the margin of the graft.

second-look arthroscopy and the last follow-up ($P > .05$; Table 4). The margins of the grafts were congruent in 42 ankles (Figure 3, C and D) and incongruent in 10 ankles. In those 10 ankles, the incongruity of the margin originated from an uneven surface between 2 impacted plugs (Figure 3, E and F). There were no significant differences in clinical outcomes at the second-look arthroscopy and the last follow-up regarding whether the margin of the graft was congruent or not ($P > .05$, respectively; Table 4). If an uncovered area formed between plugs when 2 osteochondral plugs were used to carry out the osteochondral autograft transfer, multiple subchondral drilling was performed additionally in that area (Figure 3A). Through the second-look arthroscopy, we observed that these uncovered areas were filled with fibrous cartilage (Figure 4H) or unstable fibrous cartilage (Figure 3B), or they still remained as a defect area (Figure 3, G and H). There was a significant difference in clinical outcomes at the second-look arthroscopy regarding whether an uncovered area was present or not (Table 4). In these cases, debridement and trimming of unstable fibrous cartilage as well as additional microfractures were performed during the second-look arthroscopy. However, there was still a significant difference in clinical outcomes at the last follow-up according to the presence of an uncovered area after the second-look arthroscopic procedures (Table 4).

DISCUSSION

A number of retrospective studies assessing the effectiveness of osteochondral autograft transfer to treat OLT have been performed.[§] In these studies, various factors involved with osteochondral autograft transfer, including the amount of incorporated grafts; the dead space between the cylindrical grafts, which became filled with fibrocartilage; the integration of donor and recipient hyaline cartilage; the size and depth of the defect; the size of the grafts; age; activity level; and reliability of the patient, were reported.[14,30,32] We retrospectively reviewed 48 consecutive patients (52 ankles) with medial OLT who underwent osteochondral autograft transfer and identified prognostic factors associated with the osteochondral autograft transfer system using second-look arthroscopy. To our knowledge, this is the first study to perform second-look arthroscopy to evaluate osteochondral autograft transfer for OLT.

The overall clinical outcomes of osteochondral autograft transfer for the treatment of OLT have been reported as good in the literature.[2,28,48] Assenmacher et al[2] reported that the mean VAS score was significantly improved from 7.7 to 3.1 ($P < .001$) after arthroscopically assisted autologous osteochondral transplantations, and the postoperative average AOFAS score was 80.2. Kreuz et al[28] had slightly better results after 4 years of follow-up in 35 patients, with AOFAS scores ranging from 87 to 94 in their 4 different groups. Valderrabano et al[48] reported that the mean VAS score significantly improved from 5.9 to 3.9 ($P = .02$), and the mean AOFAS score significantly increased from 45.9 to 80.2 ($P < .0001$) after knee-to-ankle mosaicplasty. Imhoff et al[25] reported significant increases in AOFAS score (from 50 to 78; $P < .01$) and Tegner score (from 3.1 to 3.7; $P < .05$) as well as a significant decrease in the VAS (from 7.8 to 1.5; $P < .01$) from preoperative to postoperative. In our study, similar postoperative clinical results were found. The mean VAS score significantly improved from 6.9 to 3.3, the mean AOFAS score

[§]References 1, 3, 14, 18, 20, 25, 28, 48.

TABLE 4
Associations Between Arthroscopic Findings and Outcomes at Second-Look Arthroscopy and Final Follow-up[a]

		Second-Look Arthroscopy						Final Follow-up					
		VAS		AOFAS		Tegner		VAS		AOFAS		Tegner	
Factor	n	Mean ± SD	*P*	Mean ± SD	*P*	Mean ± SD	*P*	Mean ± SD	*P*	Mean ± SD	*P*	Mean ± SD	*P*
Adhesion			.025[b]		.005[b]		.034[b]		.531		.570		.380
Present[c]	15	4.5 ± 0.8		78.4 ± 6.1		3.2 ± 1.0		3.4 ± 1.4		82.7 ± 5.8		3.6 ± 0.6	
Absent	37	3.6 ± 1.5		81.4 ± 8.3		3.9 ± 1.0		3.3 ± 1.7		80.9 ± 6.1		3.9 ± 0.9	
Synovitis			.839		.143		.196		.670		.154		.160
Present	16	3.9 ± 1.5		76.9 ± 1.0		3.4 ± 1.0		3.5 ± 1.6		78.7 ± 7.8		3.5 ± 0.6	
Absent	36	3.8 ± 1.4		80.6 ± 7.5		3.9 ± 1.0		3.3 ± 1.4		82.9 ± 5.4		3.9 ± 0.7	
Surface of graft			.071		.133		.300		.120		.159		.620
Congruent	42	3.1 ± 1.4		80.2 ± 8.0		3.8 ± 1.0		2.5 ± 1.2		82.5 ± 7.4		3.8 ± 0.8	
Incongruent	10	4.0 ± 1.3		76.0 ± 9.9		3.4 ± 1.1		3.3 ± 1.4		78.0 ± 9.5		3.6 ± 0.6	
Uncovered area			.002[b]		.001[b]		.010[b]		.045[b]		.031[b]		.026[b]
Present	14	4.8 ± 1.6		72.1 ± 8.0		3.1 ± 0.9		4.2 ± 1.6		77.5 ± 8.2		3.3 ± 0.8	
Absent	38	3.5 ± 1.1		82.1 ± 6.9		4.0 ± 1.0		3.1 ± 1.3		83.9 ± 6.8		4.0 ± 0.7	

[a]VAS, visual analog scale; AOFAS, American Orthopaedic Foot and Ankle Society ankle-hindfoot scale; Tegner, Tegner activity scale; SD, standard deviation.
[b]Statistically significant difference, $P < .05$ (Mann-Whitney *U* test).
[c]Results of the Wilcoxon signed-rank test show statistically significant difference in VAS, AOFAS, and Tegner scale scores, $P = .005$, .001, .023, respectively.

significantly increased from 67.4 to 82.6, and the mean Tegner activity scale significantly increased from 3.0 to 3.9 ($P < .05$, respectively).

Several recent studies have indicated that older patients seem to do well with arthroscopic treatment for OLT,[9,12,22] while several authors have reported less favorable outcomes of marrow-inducing reparative procedures for the treatment of OLT in older patients.[10,17,27] Most of these studies used an arbitrary age limit as a cutoff to define "older" patients. However, Choi et al[8] reported that older age was not an independent predictor of clinical failure after arthroscopic treatment for OLT after controlling for other prognostic factors. Regarding osteochondral autograft transfer for the treatment of OLT, Gautier et al[14] reported that there was a statistically significant association between age less than 45 years and higher outcome scores ($P = .0001$). However, in our study, patient age (<48 or ≥48 years) did not significantly influence clinical outcomes ($P > .05$). We considered that long-term evaluations including multivariate analyses are required to investigate the association between a patient's age and the clinical outcomes of the osteochondral autograft transfer system.

In our study, we found that all prognostic factors including the patient's age, sex, BMI, and duration of symptoms did not significantly influence clinical outcomes ($P > .05$), except for BMI on Tegner activity scale score (Table 1). There was a statistically significant association between BMI less than 26.0 and higher Tegner activity scale ($P = .021$). We considered that confounding factors, such as patient's lifestyle—refraining from sports activity—or donor site morbidity, might influence clinical outcomes in obese patients.

A review of the literature revealed significant correlations between defect size and clinical outcomes of arthroscopic treatment of OLT. Several authors suggested arthroscopic treatment for osteochondral lesions smaller than 150 mm^2.[9,10,17] However, there are no data available for limits on the size of an OLT suitable for osteochondral autograft transfer or for the maximal size in which fibrocartilaginous filling will give relief from pain and prevent progression of the disease.[14] Hangody et al[19] reported that the minimum size of OLT suitable for mosaicplasty is 10 mm in diameter. In a case reported by Chang and Lenczner,[7] the size of the talar defect was 9 mm in diameter. Gautier et al[14] reported a size of OLT from 70 mm^2 to 420 mm^2 in their study. In our study, the mean defect size of OLT was 150.4 ± 56.7 mm^2 (range, 51.7-294.2 mm^2), and there was no significant association between defect size of OLT and clinical outcomes when we divided patients according to defect size into large (≥150 mm^2) and small (<150 mm^2) size groups ($P > .05$; Table 2).

The results of grafting based on the location of the lesion have not been extensively investigated. Only 1 study reported improved outcomes for medial compared with lateral lesions.[1] In our study, we divided the medial talar dome into 3 parts horizontally (anteromedial, centromedial, and posteromedial areas) and found no significant association between location of OLT and clinical outcomes ($P > .05$; Table 2).

OLTs associated with subchondral cysts have been treated with a variety of procedures. Some authors have advised against the use of marrow stimulation alone in the treatment of cystic lesions, based on the results of their studies.[12,42,43] Second-look arthroscopy after talar osteochondral drilling has also shown irregular chondral surfaces.[16,26] Therefore, replacement of articular cartilage and subchondral bone would provide normal hyaline cartilage and strengthen the subchondral bone.[21] However, there is insufficient evidence in the literature to support the

use of osteochondral autografts in the treatment of cystic lesions. Scranton et al[44] evaluated the use of osteochondral autografts to treat cystic lesions and reported good results. In our study, subchondral cysts existed in 30 ankles, and the existence of subchondral cysts did not demonstrate significant influences on the clinical outcomes ($P > .05$; Table 2).

Access to the defect to permit insertion of the autograft perpendicular to the articular surface often requires an arthrotomy combined with a periarticularosteotomy.[13,34,46] Although most of the articular surface can be exposed using an appropriate osteotomy, 15% of the talus, comprising the central portion of the dome, cannot be accessed perpendicularly with any osteotomy.[34] In our study, an oblique medial malleolar osteotomy was performed to expose the medial talar dome, and the apex and direction of the osteotomy were determined according to the size of the OLT (Figure 2, A-D). When performing an oblique osteotomy, care must be taken not to inflict damage at the articular surface of the tibial plafond because damage to the weightbearing surface may influence clinical outcomes. O'Loughlin et al[35] reported that critical to the osteotomy is precise reduction and fixation to avoid fibrous nonunion or malunion. Accurate reduction of the malleolus is also important to reduce damage at the articular surface of the tibial plafond (Figure 4, A-D). In our study, VAS and AOFAS score at the last follow-up were significantly worse when the articular surface of the tibial plafond at the malleolar osteotomy site was uneven ($P = .031$, $P = .012$, respectively; Table 3). As a technical point, reduction of the articular surface of the tibial plafond at the malleolar osteotomy site should be performed evenly, although the apex of the osteotomy site is uneven (Figure 2, E-H). Predrilling in the medial malleolus before reflecting it plantarward on the deltoid ligament may be helpful to reduce the medial malleolus more accurately and easily at the end of the procedure.[46] At the last follow-up, we found that an uneven apex at the osteotomy site became even as the bony union progressed, but uneven articular surfaces of the tibial plafond remained uneven (Figure 4, A-D).

Imhoff et al[25] reported that patients who had prior drilling of their OLT and received osteochondral autograft transfer thereafter had significantly worse clinical scores (the VAS, the AOFAS score, and the Tegner activity scale) than patients who underwent osteochondral autograft transfer as a first-line treatment ($P = .001$, .008, and .005, respectively). They hypothesized that during drilling of the OLT, thermal damage might occur and consequently impair the incorporation of a second-line osteochondral autograft transfer treatment. In our study, 10 patients who had been treated with arthroscopic microfracture for OLT as a first operation were subsequently treated with osteochondral autograft transfer, and there were no statistical differences observed in clinical outcomes (the VAS, the AOFAS score, and the Tegner activity scale) regarding whether previous arthroscopic microfracture was performed or not ($P = .419$, .381, and .682, respectively; Table 3). Therefore, the osteochondral autograft transfer system may be a useful treatment option as a secondary salvaging procedure after a failed arthroscopic microfracture.

Persisting pain after an ankle surgery is often caused by the development of intra-articular fibrous scars or adhesion causing soft tissue impingement of the ankle joint. Plain radiograph is valuable for the diagnosis of bony impingement but not for soft tissue impingement. MRI is helpful for identifying soft tissue impingement; however, its use in diagnosing soft tissue impingement lesions remains controversial.[11,31,40] Nevertheless, arthroscopy is an effective method for diagnosing and treating soft tissue impingement of the ankle joint.[6] In the second-look arthroscopy of our study, a fibrous adhesion causing soft tissue impingement in the anterior recess was observed in 15 ankles, and arthroscopic adhesiolysis and debridement of impinged soft tissue were performed during the second-look arthroscopy (Figure 4, E and F). The VAS, AOFAS score, and Tegner activity scale score were improved after performing the arthroscopic procedures. Before the second-look arthroscopy, significant differences were observed in clinical outcomes according to the presence of soft tissue impingement ($P = .025$, .005, and .034 for the VAS, AOFAS score, and Tegner activity scale, respectively), and after performing the arthroscopic procedures, there were no significant differences in clinical outcomes at the last follow-up ($P > .05$; Table 4). We discerned that second-look arthroscopy would be useful in providing valuable prognostic information as well as treating such pathologic conditions.

An interesting finding was observed on the second-look arthroscopy. The incongruity of the margin originating from an uneven surface between 2 impacted plugs was observed in 10 ankles (Figure 3, E and F). However, there were no significant differences in clinical outcomes at the second-look arthroscopy and the last follow-up regarding whether the margin of graft was congruent or not ($P > .05$; Table 4).

Several authors have reported that up to one third of the total area of an osteochondral autograft will degenerate into reparative fibrocartilage because of damaged cartilage at the periphery of the graft, filling of gaps at the interface of the graft and the walls of the defect, and chondrocyte death due to mechanical trauma of graft insertion.[5,23,36] In our study, we observed through the second-look arthroscopy that uncovered areas were filled with fibrous cartilage (Figure 4H), filled with unstable fibrous cartilage (Figure 3B), or still remained as a defect area (Figure 3, G and H). There was a significant difference in clinical outcomes at the second-look arthroscopy with regard to whether uncovered areas were present or not (Table 4). This result highlights the critical importance of careful matching of the size and shape of the autograft to the defect to minimize the amount of fibrocartilage that forms around the autograft.[33]

There were no complications in our study, including nerve injury, infection, or delayed wound healing. Nonunion and delayed union of the osteotomy may occur at a rate reported between 0% and 2%.[1,3,14,19,28,46] Baltzer and Arnold[3] and Lee et al[29] recommended that the fixation be removed between 9 and 18 months after the osteotomy regardless of pain or evidence of hardware failure. In our study, cannulated screws were removed after radiologic and clinical confirmation of union of the osteotomy site routinely after 12 months postoperatively, and there was

no nonunion or delayed union of the osteotomy site. In 13 ankles, the articular surface of the tibial plafond at the malleolar osteotomy site was uneven, and the clinical outcomes were significantly worse in those ankles at the last follow-up. Therefore, surgeons should restore the articular surface accurately after the osteotomy to avoid mismatching of the articular surface. Potential donor-site morbidity at the knee after harvesting an osteochondral graft for the talus has been discussed in the literature.[37,39,48] However, there was no donor-site morbidity in our study. In the current study, postoperative symptoms—such as persistent pain, pain on heavy exertion, patellar instability, giving way, and difficulty kneeling or squatting—were observed in obese patients. Paul et al[37] reported poorer results in patients with an increased BMI. These results were also observed in our study: there was a statistically significant association between BMI less than 26.0 and higher Tegner activity scale ($P = .021$; Table 1).

We investigated the clinical and second-look arthroscopic results of the osteochondral autograft transfer system in treatment of OLT and identified the prognostic factors associated with the osteochondral autograft transfer system through this study. However, there are a number of limitations. First, there was a small number of cases and a relatively short duration of follow-up period. For more accurate evaluation of the osteochondral autograft transfer system for OLT, a prospective study and a larger series of cases with a longer follow-up period are required. Second, we limited the subjects of this study to patients with medial OLT. Therefore, further evaluation including lateral OLT is needed to support the results of this study. Third, we used the VAS, AOFAS score, and the Tegner activity scale to evaluate clinical outcomes. A new scoring system for second-look arthroscopy correlated with clinical outcomes, and power analysis is necessary to identify the prognostic factors more precisely. Lastly, the second-look arthroscopy was performed at 1 year postoperatively. It is unknown how the grafted cartilage will behave over time, and changes of influencing factors after the first year cannot be predicted.

In conclusion, this study showed that the articular surface of the tibial plafond at the malleolar osteotomy site, soft tissue impingement, and uncovered areas around the graft were important factors affecting the clinical outcomes, as observed through second-look arthroscopy. Therefore, surgeons should restore the articular surface accurately following the osteotomy, and more caution should be taken to avoid soft tissue impingement and uncovered areas around the graft when performing osteochondral autograft transfer.

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