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Comparison of clinical outcomes between arthroscopic subchondral drilling and microfracture for osteochondral lesions of the talus

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Abstract
Purpose The objectives of this study were to compare the clinical outcomes of the two common bone marrow stimulation techniques such as subchondral drilling and microfracture for symptomatic osteochondral lesions of the talus and to evaluate prognostic factors affecting the outcomes.
Methods Ninety patients (90 ankles) who underwent arthroscopic bone marrow stimulation for small- to mid-sized osteochondral lesions of the talus constituted the study cohort. The 90 ankles were divided into two groups: a drilling group (40 ankles) and a microfracture group (50 ankles). Each group was matched for age and gender, and both groups had characteristics similar to those obtained from pre-operative demographic data. The American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score and the ankle activity score (AAS) were used to compare clinical outcomes, during a mean follow-up period of 43 months.
Results The median AOFAS scores were 66.0 points (51–80) in drilling group and 66.5 points (45–81) in microfracture group pre-operatively, and these improved to 89.4 points (77–100) and 90.1 points (69–100) at the final follow-up, respectively. The median VAS scores improved at the final follow-up compared with the pre-operative condition. The median AAS for the drilling group improved from 4.5 (1–6) pre-operatively to 6.0 (1–8) at the final follow-up, while those for the microfracture group improved from 3.0 (2–8) to 6.0 (3–9). No significant differences were observed between the two groups in terms of the AOFAS scores, VAS, and AAS.
Conclusions The arthroscopic subchondral drilling and microfracture techniques that were used to stimulate bone marrow showed similar clinical outcomes. The results of this study suggest that both techniques are effective and reliable in treating small- to mid-sized osteochondral lesions of the talus, regardless of which of the two techniques is used.
Level of evidence Level III, retrospective comparative study.

Keywords Talus · Osteochondral lesion · Arthroscopy · Subchondral drilling · Microfracture

Introduction

Osteochondral lesions of the talus (OLT) are defects of the articular cartilage and subchondral bone of the talar dome [25]. OLT can cause serious problems reducing both quality of life and work capacity [7]. Therefore, the goals for treatment of cartilage defects include pain relief, improvement of joint function, and prevention of further osteoarthritic progression [4]. However, joint cartilage has poor reparative capacity, so the cartilaginous surface rarely heals spontaneously with normal hyaline cartilage [13, 35]. A systemic review of the literature concluded that non-surgical treatment provides successful results in only 45 % of the patients [34, 38]. Therefore, various operative techniques have been used to improve the outcomes of OLT [3, 6, 13, 28, 30, 34]. Operative procedures include debridement, curettage, abrasion, subchondral drilling, microfracture, osteochondral grafting, and chondrocyte transplantation [12, 14, 17, 23, 28, 30]. Arthroscopic bone marrow

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stimulation has been widely used as the primary treatment strategy among these surgical interventions, and the two methods commonly used to stimulate bone marrow are subchondral drilling and microfracture. Both techniques have advantages in that they have limited invasiveness, offer technical simplicity, and result in low post-operative morbidity [10, 25, 26].

However, the limitations of these bone marrow stimulation techniques include osteocyte damage due to heat caused by drilling, technical difficulties with drilling through the normal medial malleolus [15], and the inability to recanalize the subchondral cyst to the underlying marrow of the talus when using the microfracture technique. In addition, both techniques also have a disadvantage in that fibrocartilage is substituted for normal hyaline cartilage during recovery [27].

Regardless of these disadvantages and limitations, treatment of OLT via bone marrow stimulation has shown good-to-excellent clinical results [10, 25], particularly for small- to mid-sized cartilage lesions (<2.0 cm^2) [24, 35]. Although it is rather disputed whether or not bone marrow stimulation actually improves OLT [16], most studies have demonstrated that it provides symptomatic relief [4, 14, 34]. On the other hand, many surgeons assume that subchondral drilling will result in worse clinical outcomes than microfracture treatment since it is a relatively difficult technique to implement and may result in heat necrosis. However, to the best of our knowledge, no studies have compared clinical outcomes between subchondral drilling and microfracture for OLT.

Our hypothesis was that clinical outcomes for subchondral drilling would not be inferior to those of microfracture. Accordingly, the purpose of the present study was to compare clinical outcomes of the two operative methods for small- to mid-sized OLT and to evaluate prognostic factors that may affect such outcomes.

Materials and methods

A total of 146 patients (150 ankles) with symptomatic OLT underwent arthroscopic subchondral drilling or microfracture from October 2005 to June 2011. The inclusion criteria consisted of symptomatic OLT with a single focal lesion, lesion area <2.0 cm^2, age ≤60 years or ≥18 years, primary surgery, and failure of non-surgical treatment. Forty-two patients (46 ankles) with global (tibial and talar) lesions (10 ankles), lesions >2.0 cm^2 (7 ankles), aged >60 years or <18 years (15 ankles), previous ankle fractures (10 ankles), and bilateral lesions (4 ankles) were excluded. The remaining 104 patients (104 ankles) with isolated OLT were included in this study. After matching age and sex between groups, 90 patients (90 ankles) were enrolled in the study.

Table 1 Comparison of dermographical data between the drilling and microfracture groups

	Drilling ($n = 40$)	Microfracture ($n = 50$)	P value[a]
Gender (male/female)	28/12	40/10	n.s.
Age (*y*)	31.0 (18–60)	30.0 (18–60)	n.s.
Body mass index (kg/m^2)	24.0 (18.1–33.1)	23.7 (19.3–33.4)	n.s.
Symptom duration (mo)	17.5 (1–65)	18.2 (1–72)	n.s.
Lesion size (cm^2)	1.0 (0.6–1.8)	1.0 (0.6–1.9)	n.s.
Follow-up duration (mo)	38.1 (24–91)	38.5 (24–84)	n.s.

The values are expressed as median (range) unless otherwise indicated

[a] Independent *t* test. The *P* values shown are for intergroup comparisons. Significance was accepted for *P* values of <0.05

The 90 ankles were divided into two groups: a drilling group (40 ankles) and a microfracture group (50 ankles).

The drilling group consisted of 28 men and 12 women (median age 31 years; range 18–60) and a median follow-up duration of 38.1 months (range 24–91); the microfracture group consisted of 40 men and 10 women (median age 30 years; range 18–60) and a median follow-up duration of 38.5 months (range 24–84). The median lesion size in the drilling group was 1.0 cm^2 (range 0.6–1.8) and that in the microfracture group was 1.0 cm^2 (range 0.6–1.9). The drilling group exhibited a medial talar lesion in 32 (80 %) ankles and a lateral talar lesion in 8 (20 %) ankles, while the microfracture group exhibited a medial talar lesion in 38 (76 %) and a lateral talar lesion in 12 (24 %) ankles. The pre-operative demographic data did not show significant differences between the groups (Table 1).

The plain radiographic evaluations included anteroposterior and lateral views of the ankle in all patients. The radiological evaluations were performed pre-operatively and post-operatively at 3, 6, 12 months, and then annually thereafter. To avoid potential bias, plain radiographs and pre-operative magnetic resonance imaging (MRI) were evaluated by two independent observers who were not involved in the surgical treatment of the patients and who were blinded to the intention of this study. The OLT was assessed using the staging system proposed by Berndt and Harty [5].

In addition, MRI scans were obtained in order to confirm the lesions of the talus and to detect concurrent injuries before surgery. All lesions were classified using the MRI stages described by Anderson et al. [1] The arthroscopic findings were evaluated using the Ferkel and Cheng [11] classification system.

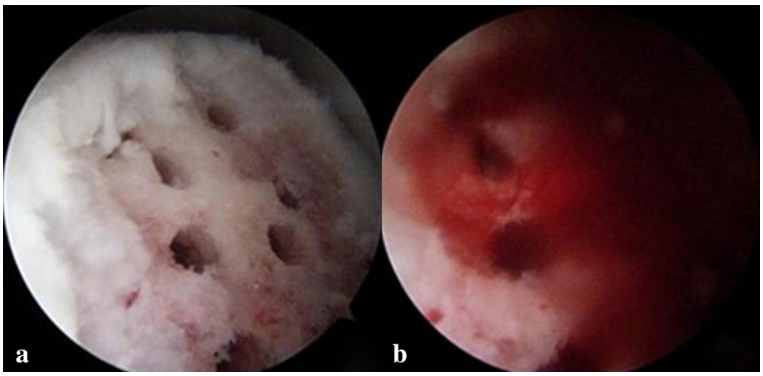

Fig. 1 Arthroscopic subchondral drilling **a** The arthroscopic photographs showing drill holes were placed about 3–4 mm apart on the lesion. **b** Adequate bleeding occurred from the drilled holes after tourniquet release

The American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score [21], the visual analogue scale (VAS) for pain, and the ankle activity score (AAS) were used to evaluate the clinical outcomes [16, 18]. The results were obtained pre-operatively using these instruments and at each follow-up visit at 3, 6, 12 months, and annually thereafter. To avoid examiner bias, clinical scoring was evaluated by two independent observers who were not involved in the surgical treatment of the patients.

The 100-point AOFAS scoring system combines subjective and objective data to evaluate the clinical parameters. Points are allocated for pain (40 points), function (50 points), and alignment (10 points). This system considers a score of $\geq$90 points as excellent, 80–89 as good, 70–79 as fair, and $\leq$69 as poor. A 10-point VAS was used to quantify patient assessed pain, and the 10-point AAS developed from the Tegner scoring system [33] was used to assess the activity levels.

Surgical techniques

Subchondral drilling

Arthroscopic drilling was performed under general anaesthesia with the use of a thigh tourniquet. The atraumatic distraction was performed by using a foot strap, and for all procedures, a 2.5-mm, 30° arthroscope (Linvatec, Largo, Florida, USA) was used through three portals (anteromedial, anterolateral, and posterolateral). A 1.6-mm Kirschner wire was inserted from about 3-cm proximal to the tip of the medial malleolus and was directed across the medial malleolus into the lesion with an ACL guide (Linvatec, Largo, Florida, USA). The Kirschner wire was withdrawn towards the articular surface at the distal end of the tibia under arthroscopy, and drilling was performed at several other sites after slightly changing the angle of the plantar flexion or dorsiflexion of the ankle joint. In the case of an anterior OLT, a drill guide was used to drill the lesion directly from the anterior aspect of the distal tibia, anteromedial, or anterolateral portals by plantar flexion of the ankle. Drilling continued until healthy bleeding from the bone marrow or leakage of fat droplets could be confirmed (Fig. 1).

Microfracture

The anaesthesia and arthroscopic settings were the same as those used for the drilling technique. All unstable cartilaginous and fibrous tissues were debrided after a limited synovectomy, and sharp perpendicular articular margins were created in order to attach suitable marrow clots. Microfracture awls (Arthrex, Karlsfeld, Germany) were used at different angles to place subchondral bone penetrations approximately 3–4 mm apart, 3–4 mm deep, peripheral to the centre of the lesion. After the microfracture treatment, the tourniquet was released, and adequate bone bleeding and marrow fat droplets were confirmed on the talar bed (Fig. 2).

Post-operative management

For the first week, a bulky compressive dressing and a posterior plaster splint were applied in the neutral position. During the first 2 weeks, tolerable weight bearing in a walking boot was allowed, followed by full weight bearing and active ankle range of motion and strengthening exercises. The walking boots were removed at 8 weeks, and sports activities such as running, climbing, and jumping were avoided for at least 4 months.

This study was approved by the Institutional Review Board of Chonnam National University Hospital (IRB No: CNUH-2013-025) and informed consent was obtained from all patients.

Statistical analysis

To determine the significances of intergroup differences, the independent *t* test was used for age, follow-up duration, AOFAS scores, VAS, and AAS. The paired *t* test was used to analyse intragroup clinical and radiographic differences

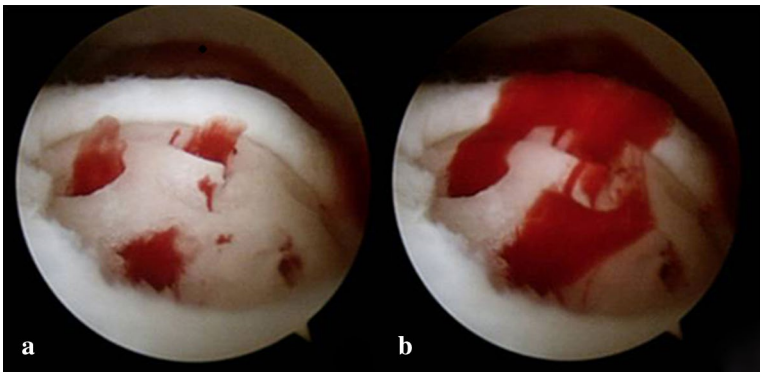

Fig. 2 Arthroscopic microfracture. **a** The microfracture holes were placed about 3–4 mm apart on the lesion. **b** Adequate bleeding occurred from the holes after tourniquet release

Table 2 Clinical outcomes of the drilling and microfracture groups

	Drilling ($n = 40$)	Microfracture ($n = 50$)	P value[a]
AOFAS[b] score			
Pre-operatively	66.0 (51–80)	66.5 (45–81)	n.s.
Final follow-up	89.4 (77–100)	90.1 (69–100)	n.s.
VAS[c] score			
Pre-operatively	7.0 (5–9)	8.0 (5–10)	n.s.
Final follow-up	2.0 (0–8)	2.0 (0–6)	n.s.
AAS[d] score			
Pre-operatively	4.5 (1–6)	3.0 (2–8)	n.s.
Final follow-up	6.0 (1–8)	6.0 (3–9)	n.s.

The values are expressed as median (range)

[a] Independent t test. The P values shown are for intergroup comparisons. Significance was accepted for P values of <0.05

[b] *AOFAS* American Orthopaedic Foot and Ankle Society ankle-hindfoot score

[c] *VAS* Visual Analogue Scale

[d] *AAS* Ankle Activity Score

before and after surgery. In addition, correlations between age, sex, body mass index (BMI), symptom duration, and lesion size were analysed using multivariate analysis. P values <0.05 were considered to be significant, and all analyses were independently reviewed by a statistician.

Results

As shown in Table 2, the median AOFAS scores in the drilling and microfracture groups improved to 89.4 points (range 77–100) and 90.1 points (range 69–100) at the final follow-up, respectively (independent t test, $P < 0.05$). According to the AOFAS scores, the overall results for the drilling group were excellent in 30 patients (75 %), good in 5 (12.5 %), and fair in 5 (12.5 %), while those for the microfracture group were excellent in 34 (68 %), good in 10 (20 %), and fair in 6 (12 %). Therefore, each group yielded excellent or good rates for 87.5 and 88 % of the cases, respectively. In addition, the median VAS and AAS scores showed significant improvement between the pre-operative and the final follow-up clinical outcomes in both groups (paired t test, $P < 0.05$). However, no significant differences were observed between the two groups in terms of the AOFAS scores, VAS, and AAS.

To identify prognostic factors affecting AOFAS scores post-operatively, patients were dichotomized with respect to age (<30 or ≥30 years), sex, BMI (<25 or ≥25 kg/m^2), symptom duration (<1 or ≥1 year), and lesion size (<1.0 or ≥1.0 cm^2). However, the multivariate analysis did not reveal any factor to be significantly correlated with the post-operative AOFAS scores in both groups (Table 3). No complications, including superficial peroneal nerve injury, superficial or deep infection, portal pain, post-operative ankle stiffness, or deep vein thrombosis, were encountered in both groups.

Radiological results

The results of the pre-operative Berndt and Harty [5] staging system using plain radiographs were as follows: stage I, 16 ankles (40 %); II, 12 ankles (30 %); III, 9 ankles (23 %); and IV, 3 ankles (7 %) in the drilling group; and stage I, 14 ankles (28 %); II, 18 ankles (36 %); III, 14 ankles (28 %); and IV, 4 ankles (8 %) in the microfracture group. At the final follow-up, the drilling group exhibited stage 0 (normal), 14 ankles (36 %); stage I, 13 ankles (32 %); and stage II, 13 ankles (32 %), while the microfracture group exhibited stage 0, 23 ankles (46 %); stage I, 20 ankles (40 %); and stage II, 7 ankles (14 %). In terms of the improvements in the Berndt and Harty [5] stage improvements, the drilling group showed no change in 16 ankles (40 %), a 1 grade improvement in 8 (20 %), 2 grades in 4 (10 %), 3 grades in 9 (22 %), and 4 grades in 3 (8 %), and the microfracture group showed no change in 9 (18 %), a 1 grade improvement in 9 (18 %), 2 grades in 14 (28 %), 3 grades in 14

Table 3 Prognostic factors and clinical outcomes of the drilling and microfracture groups

	Drilling ($n = 40$)		Microfracture ($n = 50$)	
	AOFAS[a] score	P value[b]	AOFAS[a] score	P value[b]
Age at operation		n.s.		n.s.
<30 years	91.1 ± 6.0		92.8 ± 6.9	
≥30 years	92.6 ± 8.0		89.2 ± 9.2	
Sex		n.s.		n.s.
Male	92.6 ± 7.2		91.4 ± 8.4	
Female	89.7 ± 6.9		90.4 ± 8.5	
Body mass index		n.s.		n.s.
<25 kg/m^2	91.8 ± 6.6		91.1 ± 8.4	
≥25 kg/m^2	92.1 ± 8.8		90.3 ± 8.5	
Symptom duration		n.s.		n.s.
<1 year	93.5 ± 7.2		88.4 ± 9.6	
≥1 year	89.5 ± 7.0		92.5 ± 7.1	
Lesion size		n.s.		n.s.
<1.0 cm^2	91.1 ± 7.4		90.1 ± 8.7	
≥1.0 cm^2	93.2 ± 6.8		90.9 ± 7.3	

The values are expressed as mean ± SD

[a] AOFAS American Orthopaedic Foot and Ankle Society ankle hindfoot score

[b] ANOVA multivariate analysis. Significance was accepted for P values of <0.05

(28 %), and 4 grades in 4 (8 %) (paired t test, $P < 0.05$). No significant differences in terms of the grade changes were observed between the two groups at the final follow-up (Table 4).

The pre-operative MRI classification system findings according to Anderson et al. [1] were as follows: stage I for 7 ankles (17 %), IIa for 10 (25 %), IIb for 12 (31 %), III for 7 (17 %), and IV for 4 (10 %) in the drilling group and stage I for 6 ankles (12 %), II for 19 (38 %), IIa for 8 (16 %), III for 14 (28 %), and IV for 3 (6 %) in the microfracture group.

Arthroscopic findings

The intraoperative arthroscopic findings according to the Ferkel and Cheng [11] staging system were as follows: stage A, 1 ankle (3 %); stage B, 7 ankles (17 %); stage C, 12 ankles (30 %); stage D, 14 ankles (33 %); stage E, 5 ankles (13 %); and stage F, 1 ankle (3 %) in the drilling group; and stage A, 1 ankle (2 %); stage B, 12 ankles (23 %); stage C, 12 ankles (25 %); stage D, 16 ankles (32 %); stage E, 8 ankles (16 %); and stage F, 1 ankle(2 %) in the microfracture group. No significant differences were observed between the two groups.

Discussion

The most important finding of the present study was that the arthroscopic subchondral drilling and microfracture techniques showed similar clinical outcomes, and both techniques were effective and reliable in treating small- to mid-sized OLT, regardless of which of the two techniques is used.

This is the first study that compares the clinical outcomes between subchondral drilling and microfracture as treatments for OLT, particularly by incorporating age- and sex-matched controls. About 87.5 % of the drilling group and 88 % of the microfracture group achieved excellent or good results, as determined according to the AOFAS scoring system.

The bone marrow stimulation procedures for OLT should promote blood flow and blood clot formation in the debrided cartilage lesions and should allow for an influx of cells from the bone marrow. This process recruits mesenchymal stem cells from the bone marrow and initiates the formation of fibrocartilaginous tissue [32]. Subchondral drilling and microfracture treatment are two common techniques that are used to stimulate bone marrow to treat OLT. Each method has several advantages and disadvantages.

Table 4 Pre-operative and post-operative radiographic stages in drilling and microfracture groups

Stage[a]	Drilling ($n = 40$)		Microfracture ($n = 50$)		
	Pre-operative	Post-operative	Pre-operative	Post-operative	P value[b]
Normal	–	14 (36 %)	–	23 (46 %)	n.s.
I	16 (40 %)	13 (32 %)	14 (28 %)	20 (40 %)	
II	12 (30 %)	13 (32 %)	18 (36 %)	7 (14 %)	
III	9 (23 %)	–	14 (28 %)	–	
IV	3 (7 %)	–	4 (8 %)	–	

[a] Stage determined by the Berndt and Harty classification system

[b] Chi-square test. The P values shown are for intergroup comparisons. Significance was accepted for P values of <0.05

Drilling has a greater healing potential than microfracture, since drilling can make deeper holes. The deep holes produce a larger subchondral haematoma with increased access to marrow stroma [36]. In addition, the transmalleolar approach to a difficult lesion, such as a shoulder lesion, can be achieved by drilling [29]. However, a drawback of the transmalleolar approach is that iatrogenic damage to the opposing tibial articular cartilages may occur. In addition, a significant thermal effect on bone during drilling can cause bone necrosis. Such a condition is also associated with persistent pain and oedema, and stress fractures may also appear [29]. In the present study, eventual necrosis that results from heat introduced during drilling was minimized by performing the procedure at a low speed with sufficient flushing. Kirschner wires were used instead of a drill bit to minimize cartilage injury since Kirschner wires with a small diameter have been successfully used during routine ankle arthroscopy [31, 37]. When compared to drilling, the Kirschner wires have the advantage of being more flexible and thus reducing the risk of breakage.

Microfracture has the advantages of avoiding the potential for heat necrosis, as in the case of drilling, and it can treat around corner lesions by using a microfracture awl [36, 38]. A disadvantage of this procedure is that it may create loose body particles and if these are not properly removed, they may cause locking and cartilage damage [36]. We carefully inspected the ankle joint at the end of the surgery to locate any remaining loose bodies or cartilage particles, and we did not detect any patient with locking or loose bodies on plain radiographs or with their accompanying clinical symptoms.

The healing process for the subchondral bone is also different between the two procedures. Chen et al. [9] reported on acute osteochondral characteristics following microfracture and compared the results to drilling in a rabbit model for cartilage repair. They demonstrated that drilling cleanly removed bone debris and left free access channels from the hole to the marrow, whereas microfracture with an awl induced acute fractures and compaction in the bone surrounding the holes, which potentially impedes repair. Although they only focused on acute events (first postoperative day), they revealed distinct differences between microfracture and drilling in the acute subchondral bone structure and osteocyte necrosis.

However, the bone marrow stimulation procedure has a fundamental disadvantage in that the articular cartilage is regenerated as a fibrous cartilage or as scar tissue instead of the original hyaline cartilage [32]. Fibrous cartilage is softer than normal hyaline cartilage and is easily damaged afterwards [4]. Lee et al. [26] reported that second-look arthroscopic findings at 12 months post-operatively after microfracture treatment for OLT revealed that 40 % of lesions were incompletely healed, but the majority of the patients achieved a good clinical outcome.

Lee et al. [25] reported that 35 patients (<50 years with lesions of <1.5 cm^2) who underwent microfracture yielded excellent or good results in 89 % of the cases, according to their AOFAS scores. Becher and Thermann [4] presented a prospective report of 30 patients treated with microfracture, and the results indicated that 83 % of the participants had excellent or good results according to the Hannover Scoring System. Angermann and Jensen [2] reported that 85 % of the patients (17 out of 20) achieved good clinical results after removal of bone fragments and subsequent drilling.

In our study, about 87.5 % of the drilling group and 88 % of the microfracture group achieved excellent or good results. Both the drilling and microfracture techniques provided good clinical results as well as similar outcomes in terms of their AOFAS score, VAS, and AAS. This may indicate that drilling is as effective as microfracture without deterioration of clinical outcomes in small- to mid-sized OLT.

Although several attempts have been made to provide an algorithm to assist in the choice of treatment, a lack of high-quality comparative studies prevents appropriate treatment strategies to be determined for each individual patient, based according to their specific characteristics, lesion type, or other prognostic factors [22]. Becher and Thermann [4] reported that when arthroscopic microfracture was performed for OLT, the clinical outcomes may be affected by several prognostic factors. Better outcomes were achieved after microfracture treatment in younger patients and also in those with a lower BMI. In contrast, Choi et al. [8] reported that an increased age was not an independent risk factor for poor clinical outcomes after arthroscopic treatment for OLT. Ferkel et al. [12] found no correlation between age, sex, symptom duration, or lesion location with clinical outcomes. Likewise, the present study showed that sex, age, BMI, and symptom duration had no influence on the clinical outcomes in both groups.

Several recent studies have attempted to overcome the disadvantages of bone marrow stimulation alone. Kerkhoffs et al. [19] introduced a new arthroscopic treatment method for OLT, which they referred to as LDFF (Lift, drill, fill, and fix). This method seems to be useful in OLT with large osteochondral lesions (diameter >10 mm), but not for chondral lesions in young patients.

On the other hand, Kim et al. [20] compared the clinical and MRI outcomes between bone marrow stimulation alone and injection of mesenchymal stem cells along with bone marrow stimulation in patients with OLT. Although the study follow-up period was short, they suggested that the stem cell group exhibited promising results when compared to the marrow stimulation only group, even when

poor prognostic factors were present, including old age, a large lesion size, or a subchondral cyst. Although stem cell treatment showed good clinical results in treating OLT, there is limited evidence on the direct clinical benefits of such treatment. Therefore, randomized control studies and long-term follow-up should be performed in the future.

The limitations of this study are that the study groups were relatively small, so further studies should involve more cases. Another limitation is that this study presented results only on clinical outcomes, suggesting that the healing status of the lesion was not directly assessed through MRI or arthroscopy. Although the location of the lesion may affect the technical difficulties of subchondral drilling or of microfracture, subsequently influencing the clinical outcomes, this issue was not covered in this study.

Many surgeons disagree as to which technique is the best for treating small- to mid-sized OLT. Some assume that subchondral drilling will have worse clinical outcomes relative to microfracture treatment due to heat necrosis and technical difficulties. However, this study showed that both methods present similar clinical outcomes. Our results suggest that the surgeon treating a small- to mid-sized OLT may choose between either method depending on their preferences and location of the lesion.

Conclusions

Arthroscopic subchondral drilling and microfracture techniques to treat OLT showed similar clinical outcomes when used to stimulate bone marrow. Accordingly, our results suggest that both techniques provide an effective and reliable means to treat small- to mid-sized OLT, regardless of different techniques.

Conflict of interest We have no conflict of interest.

References

1. Anderson IF, Crichton KJ, Grattan-Smith T, Cooper RA, Brazier D (1989) Osteochondral fractures of the dome of the talus. J Bone Joint Surg Am 71:1143–1152
2. Angermann P, Jensen P (1989) Osteochondritis dissecans of the talus long-term results of surgical treatment. Foot Ankle Int 10:161–163
3. Baums MH, Heidrich G, Schultz W, Steckel H, Kahl E, Klinger HM (2006) Autologous chondrocyte transplantation for treating cartilage defects of the talus. J Bone Joint Surg Am 88:303–308
4. Becher C, Thermann H (2005) Results of microfracture in the treatment of articular cartilage defects of the talus. Foot Ankle Int 26:583–585
5. Berndt AL, Harty M (1959) Transchondral fractures (osteochondritisdissecans) of the talus. J Bone Joint Surg Am 41:988–1020
6. Brittberg M, Tallheden T, Sjogren-Jansson B, Lindahl A, Peterson L (2001) Autologous chondrocytes used for articular cartilage repair: an update. Clin Orthop Relat Res 391(Suppl):S337–S348
7. Buckwalter JA, Mankin HJ (1998) Articular cartilage: degeneration and osteoarthritis, repair, regeneration, and transplantation. Instr Course Lect 47:487–504
8. Choi WJ, Kim BS, Lee JW (2012) Osteochondral lesion of the talus: could age be an indication for arthroscopic treatment? Am J Sports Med 40(2):419–424
9. Chen H, Sun J, Hoemann CD, Lascau-Coman V, Ouyang W, McKee MD, Shive MS, Buschmann MD (2009) Drilling and microfracture lead to different bone structure and necrosis during bone-marrow stimulation for cartilage repair. J Orthop Res 27(11):1432–1438
10. Chuckpaiwong B, Berkson EM, Theodore GH (2008) Microfracture for osteochondral lesions of the ankle: outcome analysis and outcome predictors of 105 cases. Arthroscopy 24:106–112
11. Ferkel RD, Cheng JC (1999) Ankle and subtalar arthroscopy. In: Kelikian A (ed) Operative Treatment of the Foot and Ankle, 1st edn. Appleton-Croft, New York, pp 321–350
12. Ferkel RD, Zanotti RM, Komenda GA, Sgaglione NA, Cheng MS, Applegate GR, Dopirak RM (2008) Arthroscopic treatment of chronic osteochondral lesions of the talus: long-term results. Am J Sports Med 36:1750–1762
13. Giannini S, Vannini F (2004) Operative treatment of osteochondral lesions of the talar dome: current concepts review. Foot Ankle Int 25:168–175
14. Gobbi A, Francisco RA, Lubowitz JH, Allegra F, Canata G (2006) Osteochondral lesions of the talus: randomized controlled trial comparing chondroplasty, microfracture, and osteochondral autograft transplantation. Arthroscopy 22:1085–1092
15. Gobbi A, Nunag P, Malinowski K (2005) Treatment of full thickness chondral lesions of the knee with microfracture in a group of athletes. Knee Surg Sports Traumatol Arthrosc 13:213–221
16. Halasi T, Kynsburg A, Tallay A, Berkes I (2004) Development of a new activity score for the evaluation of ankle instability. Am J Sports Med 32:899–908
17. Han SH, Lee JW, Lee DY, Kang ES (2006) Radiographic changes and clinical results of osteochondral defects of the talus with and without subchondral cysts. Foot Ankle Int 27:1109–1114
18. Hunt SA, Sherman O (2003) Arthroscopic treatment of osteochondral lesions of the talus with correlation of outcome scoring systems. Arthroscopy 19(4):360–367
19. Kerkhoffs GM, Reilingh ML, Gerards RM, de Leeuw PA (2014) Lift, drill, fill and fix (LDFF): a new arthroscopic treatment for talar osteochondral defects. Knee Surg Sports Traumatol Arthrosc May 20 [Epub ahead of print]
20. Kim YS, Lee HJ, Choi YJ, Kim YI, Koh YG (2014) Does an injection of a stromal vascular fraction containing adipose-derived mesenchymal stem cells influence the outcomes of marrow stimulation in osteochondral lesions of the talus? A clinical and magnetic resonance imaging study. Am J Sports Med 42(10):2424–2434
21. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M (1994) Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. Foot Ankle Int 15:349–353
22. Kok AC, Sd Dunnen, Tuijthof GJ, van Dijk CN, Kerkhoffs GM (2012) Is technique performance a prognostic factor in bone marrow stimulation of the talus? J Foot Ankle Surg 51:777–782
23. Kumai T, Takakura Y, Higashiyama I, Tamai S (1999) Arthroscopic drilling for the treatment of osteochondral lesions of the talus. J Bone Joint Surg Am 81:1229–1235
24. Lahm A, Erggelet C, Steinwachs M, Reichelt A (2006) Arthroscopic management of osteochondral lesion of the talus: results of drilling and usefulness of the magnetic resonance imaging before and after treatment. Arthroscopy 16:299–304
25. Lee KB, Bai LB, Chung JY, Seon JK (2010) Arthroscopic microfracture for osteochondral lesions of the talus. Knee Surg Sports Traumatol Arthrosc 18:247–253

26. Lee KB, Bai LB, Yoon TR, Jung ST, Seon JK (2009) Second-look arthroscopic findings and clinical outcomes after microfracture for osteochondral lesions of the talus. Am J Sports Med 37(Suppl 1):S63–S70
27. Nehrer S, Spector M, Minas T (1999) Histologic analysis of tissue after failed cartilage repair procedures. Clin Orthop Relat Res 365:149–162
28. Pritsch M, Horoshovski H, Farine I (1986) Arthroscopic treatment of osteochondral lesions of the talus. J Bone Joint Surg Am 68:862–865
29. Robinson DE, Winson IG, Harries WJ, Kelly AJ (2003) Arthroscopic treatment of osteochondral lesions of the talus. J Bone Joint Surg Br 85:989–993
30. Sammarco GJ, Makwana NK (2002) Treatment of talarosteochondral lesions using local osteochondral graft. Foot Ankle Int 23:693–698
31. Schuman L, Struijs PA, van Dijk CN (2002) Arthroscopic treatment for osteochondral defects of the talus. results at follow up at 2 to 11 years. J Bone Joint Surg Br 84:364–368
32. Steadman JR, Rodkey WG, Singleton SB, Briggs KK (1997) Microfracture technique for full-thickness chondral defects: technique and clinical results. Oper Tech Orthop 7:300–304
33. Tegner Y, Lysholm J (1985) Rating systems in the evaluation of knee ligament injuries. Clin Orthop Relat Res 198:43–49
34. Thermann H, Driessen A, Becher C (2008) Autologous chondrocyte transplantation in the treatment of articular cartilage lesions of the talus. Orthopade 37:232–239
35. Tol JL, Struijs PA, Bossuyt PM, Verhagen RA, van Dijk CN (2000) Treatment strategies in osteochondral defects of the talar dome: a systematic review. Foot Ankle Int 21:119–126
36. van Bergen CJ, de Leeuw PA, van Dijk CN (2009) Potential pitfall in the microfracturing technique during the arthroscopic treatment of an osteochondral lesion. Knee Surg Sports Traumatol Arthrosc 17:184–187
37. vanDijk CN, Scholte D (1997) Arthroscopy of the ankle joint. Arthroscopy 13:90–96
38. Verhagen RA, Struijs PA, Bossuyt PM, van Dijk CN (2003) Systematic review of treatment strategies for osteochondral defects of the talar dome. Foot Ankle Clin 8(233–242):391 Suppl: S233–S242