Article

AMERICAN ORTHOPAEDIC FOOT & ANKLE SOCIETY

Foot & Ankle Orthopaedics
2020, Vol. 5(2) 1-6
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DOI: 10.1177/2473011420916139
journals.sagepub.com/home/fao

Retrograde Drilling for Osteochondral Lesion of the Talus in Juvenile Patients

Yasunari Ikuta, MD, PhD[1], Tomoyuki Nakasa, MD, PhD[1], Yuki Ota, MD[1], Munekazu Kanemitsu, MD[1], Junichi Sumii, MD[1], Akinori Nekomoto, MD[1], and Nobuo Adachi, MD, PhD[1]

Abstract

Background: Retrograde drilling (RD) is generally used for treating osteochondral lesion of the talus (OLT) with a stable osteochondral fragment and nearly normal articular cartilage surface. Previous studies that included participants of various ages have reported good clinical results. This study aimed to clarify the clinical outcomes of RD for OLT in juvenile patients whose bone-forming ability and physical activity might affect the healing process.

Methods: This retrospective study included 8 juvenile patients who underwent RD for OLT (5 boys and 3 girls, mean age 14.9 years, mean follow-up 2 years, 7 medial and 1 central lesion). American Orthopaedic Foot & Ankle Society (AOFAS) ankle-hindfoot score and ankle activity score were evaluated, and arthroscopic findings were graded according to the International Cartilage Research Society (ICRS) classification system. The condition of the underlying bone was assessed on preoperative computed tomographic images. The stability, incorporation, and subsidence of the osteochondral fragment, articular surface congruity, and the area of the bone marrow lesion (BML) were evaluated using magnetic resonance imaging (MRI).

Results: AOFAS ankle-hindfoot score and ankle activity score significantly improved postoperatively. Arthroscopically, the lesions were classified as ICRS grade 0 or 1. Bone sclerosis or multiple small cysts of the underlying bone were observed in all patients. MRI demonstrated no signs of osteochondral fragment instability or subsidence, good or fair fragment incorporation, good articular surface congruity, or slight irregularity. The postoperative BML was reduced; however, these BMLs were still detectable at 1 year after surgery.

Conclusion: Our data suggested that RD is an option for treating juvenile patients with OLT refractory to nonoperative treatment at short-term follow-up. Although bone sclerosis or multiple small cysts were identified in the underlying bone preoperatively and the BML under the osteochondral fragment remained postoperatively, clinical status such as pain and physical activity level were improved by RD.

Level of Evidence: Level IV, retrospective case series.

Keywords: osteochondral lesion of the talus, retrograde drilling, bone marrow lesion, bone sclerosis, juvenile

Introduction

Osteochondral lesion of the talus (OLT) is a relatively common injury that causes pain in the ankle in recreational and professional athletes. Some acute ankle sprains and fractures lead to chondral/osteochondral injury.[22] Cartilage repair techniques have been shown to provide long-term symptomatic relief and return to sports and activities of daily living.[22] In general, operative treatment is indicated for OLT that has been refractory to 3-6 months of nonoperative treatment.[8] Several operative options have been available to treat OLT, such as excision of the lesion, curettage, microfracture, autogenous cancellous bone grafting, transmalleolar drilling, retrograde drilling, fixation of the osteochondral fragment, osteochondral transplantation, and autologous chondrocyte implantation.[3,22] Arthroscopic transmalleolar or retrograde drilling has been described as a good

[1] Department of Orthopaedic Surgery, Graduate School of Biomedical and Health Sciences, Hiroshima University, Hiroshima, Japan

Corresponding Author:
Yasunari Ikuta, MD, PhD, Department of Orthopaedic Surgery, Graduate School of Biomedical and Health Sciences, Hiroshima University, Kasumi 1-2-3, Minami-ku, Hiroshima, 734-8551 Japan.
Email: yikuta@hiroshima-u.ac.jp

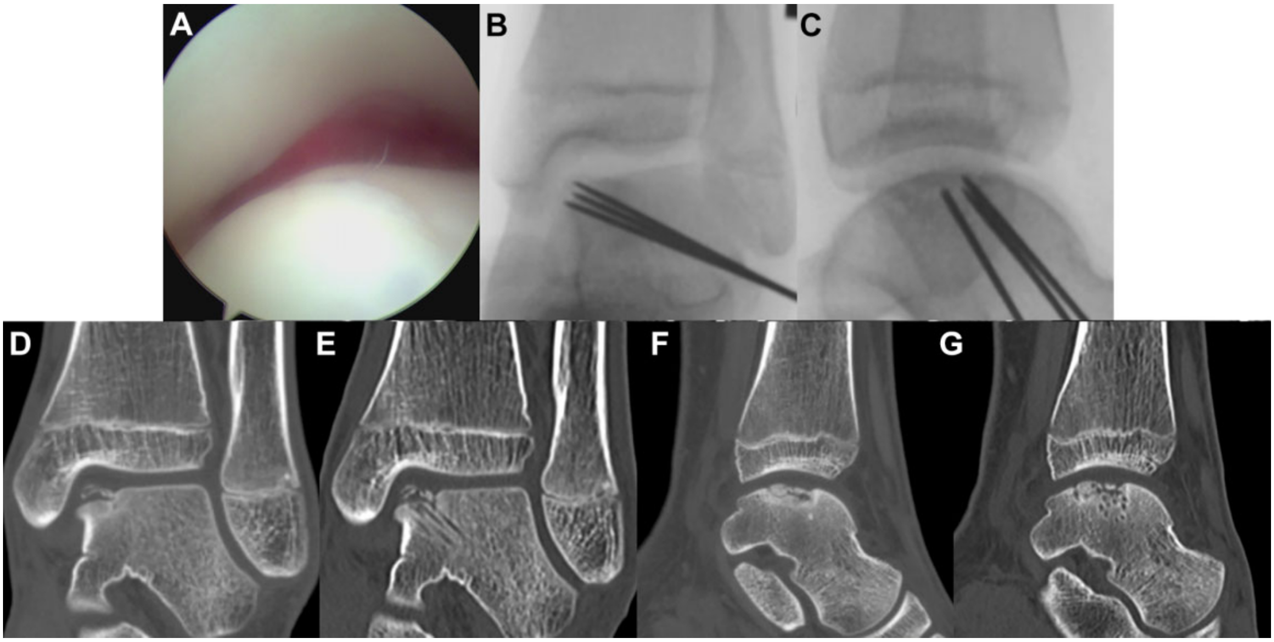

Figure 1. Representative images of osteochondral lesion of the talus. (A) Arthroscopic finding showing the lesion was classified as ICRS grade 1. (B, C) Retrograde drilling procedure was performed under intraoperative image intensifier. (D-G) Coronal and sagittal computed tomographic images. (D, F) Preoperative image showing osteochondral fragment at the medial talar dome. (E, G) The track of wires after retrograde drilling.

minimally invasive technique for treating OLT. Kumai et al demonstrated the clinical outcomes of percutaneous transmalleolar drilling for 18 ankles of patients with a mean age of 28 years (range, 10-78). The procedure was effective and useful in young patients, especially those who had an open epiphyseal plate.[18] Retrograde drilling is a nontransarticular procedure that has an advantage in preventing iatrogenic articular cartilage injury.[6,20] This technique is generally employed for a stable osteochondral fragment with intact or nearly normal articular cartilage surface[3,20] and expected to result in revascularization of the subchondral bone and induce new bone formation.[6] Although previous studies have reported good clinical results of retrograde drilling for OLT, such studies included participants of various ages, between 9 and 58 years old.[8,10,17,19] In this study, we focused on juvenile patients because their skeletal development, bone-forming ability, and physical activity level might have affected the healing process of the OLT. Thus, the study aimed to clarify the clinical outcomes of retrograde drilling for OLT in juvenile patients.

Methods

This study was approved by the ethics committee of our university. A retrograde drilling procedure was employed for treating symptomatic stable OLT. This retrospective analysis included 8 patients who underwent retrograde drilling for OLT, in 5 boys and 3 girls with a mean age of 14.9 ± 2.7 years (range, 11-19). All 8 patients had with a mean follow-up period of 2 years (range, 1-5). The mean duration from the appearance of symptoms to surgery was 7.4 months (range, 2-12) and from the first visit to our clinic to surgery was 3.6 months (range, 1.5-8). All patients had received nonoperative treatment in a previous clinic for several months, and they had played regular sports activity before developing ankle pain.

Range of motion (ROM), American Orthopaedic Foot & Ankle Society (AOFAS) ankle-hindfoot score, and ankle activity score[12] were evaluated as clinical outcomes. Arthroscopic findings of the OLTs were graded (grade 0 to grade 4) according to the International Cartilage Research Society (ICRS) classification system for the cartilage surface of the osteochondral fragment.[4]

Operative Technique

All retrograde drilling procedures were performed by 2 experienced surgeons (T.N., N.A.) with >10 years of experience. Arthroscopic examination for evaluating the condition of the articular cartilage, intra-articular ligament, and synovium was performed through conventional anteromedial and anterolateral portals (Figure 1A). Then, a Kirschner wire was inserted from the lateral aspect of the talar neck to the center of the lesion under image intensifier. An additional 2 or 3 wires were inserted carefully to prevent articular cartilage damage along the reference wire, and the sclerotic subchondral bone of the OLTs were penetrated repeatedly

Table 1. Demographic and Clinical Data of Patients.

Patient	Age, y	Sex	BMI	Location	AOFAS Scale		Activity Score	
					Preop.	Postop.	Preop.	Postop.
1	13	M	20.6	Medial	57	100	3	5
2	13	M	17.2	Medial	74	100	2	5
3	16	F	23.9	Medial	57	100	1	5
4	14	M	18.9	Medial	77	90	2	8
5	11	M	17.4	Medial	72	100	2	8
6	18	F	20.9	Medial	75	97	2	7
7	19	F	20.1	Center	55	90	2	7
8	15	M	20.9	Medial	87	100	2	8
Mean	14.9		20.0		69.3	97.1	2	6.6

Abbreviations: AOFAS, American Orthopaedic Foot & Ankle Society ankle-hindfoot score; BMI, body mass index; F, female; M, male; Postop, postoperation; Preop, preoperation.

(Figure 1B-G). The diameter of the wires ranged from 1.0 to 1.2 mm depending on the patient size.

Postoperative Management

A cast or splint was not applied postoperatively. ROM exercise was started under nonweightbearing condition at the first day after surgery. Partial weight bearing was permitted at 3 weeks after surgery. Mild physical activity, like jogging, was allowed at 3 months, and all patients returned to sports activity completely at 6 months after surgery.

Image-Based Assessment

OLTs were classified into each stage according to the Anderson classification,[1] and distal tibial growth plates were evaluated on preoperative plain radiographs. For the Anderson classification, 3 and 5 patients were graded 2 and 3, respectively. Radiographically, the growth plate remained open in 4 of 8 patients. The location of the lesions was classified as medial, central, and lateral; the size (anteroposterior, mediolateral, height) of OLTs was measured on coronal and sagittal computed tomographic (CT) images. OLTs were located on the posteromedial aspect in 7 patients and centrally in 1 patient. The mean length, width, and height of the osteochondral fragments were 9.8 mm (range, 7.2-12.4), 6.8 mm (range, 5.1-8.4), and 3.5 mm (range, 2.4-4.7), respectively.

The underlying bone of the osteochondral fragment was also evaluated for bone sclerosis and absorption using preoperative CT images. Pre- and postoperative magnetic resonance (MR) imaging was undertaken in all patients using a 1.5- or 3.0-tesla MR system according to a scanning protocol. Postoperative MR examinations were performed at 1 year after surgery. The stability, subsidence, and incorporation of the osteochondral fragment and articular surface congruity were assessed by commonly used criteria.[7,9] The area of the bone marrow lesion (BML) of the talus under the osteochondral fragment was measured on coronal and sagittal fat-suppressed T2-weighted images according to a previous report.[23]

Statistical Analysis

All data are presented as mean, standard deviation, and 95% confidence intervals. Pre- and postoperative ROM, AOFAS ankle-hindfoot score, ankle activity score, and BML area were compared using Wilcoxon signed-rank test. Statistical analysis was performed in SPSS statistics for Windows, version 22.0 (IBM Corporation, Armonk, NY), with P <.05 considered significant.

Results

No patient had a postoperative complication or revision surgery. The mean total ROM was 65.6 (95% confidence interval, 58.4, 72.8) degrees preoperatively and 67.5 (64.3, 70.7) degrees postoperatively (P = .55). AOFAS ankle-hindfoot score significantly improved from 69.3 (59.6, 78.9) to 97.1 (93.3, 100.9) postoperatively (P = .012). The ankle activity score also improved from 2.0 (1.6, 2.5) to 6.6 (5.5, 7.8) postoperatively (P = .011). All patients returned to sport activity at their presymptomatic level of performance at 6 months after surgery, and their activity level remained unchanged at the last follow-up (Table 1). OLT lesions of ICRS grade 0 and grade 1 were identified arthroscopically in 3 and 5 patients, respectively. With regard to the underlying bone condition, bone sclerosis and multiple small cysts were observed in 6 and 2 patients, respectively. Postoperative MR images demonstrated no signs of osteochondral fragment instability nor subsidence in any patient. Fragment incorporation was good in 6 patients and fair in 2 patients. In terms of the irregularity of the articular cartilage, good congruity was observed in 5 patients, and slight irregularity with intact cartilage was found in 3 patients. BML areas were reduced postoperatively on coronal and sagittal T2 fat-suppressed images; however, they were still detectable at 1 year after surgery (Table 2, Figure 2).

Table 2. The BML Area in the Talus on Fat-Suppressed T2-Weighted MRIs.

	Preoperative BML, mm^2, Mean (95% CI)	Postoperative BML, mm^2, Mean (95% CI)	*P* Value
Sagittal images	418.8 (213.5, 624.1)	216.0 (62.2, 369.8)	.017
Coronal images	222.0 (119.5, 324.5)	148.5 (53.6, 243.5)	.12

Abbreviations: BML, bone marrow lesion; CI, confidence interval; MRIs, magnetic resonance images.

Discussion

This study revealed that retrograde drilling improved the clinical status in juvenile OLT patients. Although the BML of the talus under the osteochondral fragment remained postoperatively, pain, physical activity level, and AOFAS score was improved.

Transmalleolar drilling has the downside of penetrating the intact tibial cartilage for accessing the OLT.[3] Kono et al reported the clinical outcomes of both retrograde drilling (11 feet; mean age, 25; range, 9-47) and transmalleolar drilling (19 feet; mean age, 29; range, 14-49) for OLTs. Arthroscopic examination revealed that the cartilage condition was improved in 3 patients and unchanged in 8 patients at 1 year after retrograde drilling. They concluded that retrograde drilling improved the arthroscopic appearance of OLT compared with transmalleolar drilling.[17] Another report showed good clinical results of retrograde drilling for OLT.[19]

The natural history of OLT patients who received nonoperative treatment has been described. In total, 48 patients with a mean age of 48 (range, 13-78) years were reviewed retrospectively. Most patients were pain-free or reported less pain using the visual analog scale (VAS), the lesion size decreased, and MRI stages remained unchanged after a mean follow-up of 52 months. However, limitations of activities of daily living and recreational or sports activities were observed in 11 (22.9%) and 28 patients (58.3%), respectively.[16] This study included young, adolescent, and adult patients together. Although subjective pain was decreased at the final follow-up, activity limitation remained in most patients. By contrast, our data suggest that retrograde drilling is very helpful for juvenile OLT patients who have Anderson grade 2 or 3 lesions with ICRS grade 0 or 1 articular cartilage. This minimally invasive procedure requires only 2 conventional portals and the insertion points of the Kirschner wires; better clinical outcomes including sports activity level were promising in these juvenile patients. Thus, the retrograde drilling procedure is an acceptable option for treating juvenile OLT patients refractory to nonoperative treatment.

A previous report showed that arthritic change of the ankle and multiple cyst formation of the talus were observed in a 53-year-old man with OLT and subchondral cyst 5 years after retrograde drilling.[15] Retrograde drilling induces subchondral bone revascularization and subsequently stimulates bone formation without disrupting the articular cartilage.[19,28] Hayashi et al have reported the repair process of the cartilage defect after microfracture, and endochondral ossification plays a main role in the process. Early-phase histologic changes were initially evoked by the activation of osteoclasts around the microfracture holes; subsequently, subchondral bone repair advanced with subchondral bone remodeling.[13] These findings lead to the possibility that the retrograde drilling procedure for patients with OLT who had cyst enlargement may have been caused by osteoclast activity and deficient subchondral bone. Thus, we believe that retrograde drilling should be employed for Anderson grade 2 or 3 lesions, not for a grade 2a lesion, cystic lesion.

In this study, large BMLs under the osteochondral fragment were observed in the preoperative MR images, and BML areas were reduced postoperatively on both coronal and sagittal T2 fat-suppressed images. Nakasa et al have demonstrated that a large BML area exhibited low degeneration of cartilage of the osteochondral fragment, whereas a small BML area indicated sclerosis of the subchondral bone with severe degeneration of cartilage.[23] In this study, arthroscopic findings revealed that all patients had normal or nearly normal articular cartilage and a large BML area of the talus on preoperative MR images. On MRI, the extent of BML would predict the cartilage condition. Common causes of BML in the foot and ankle include high turnover in children, stress, contusions, and osteoarthritis.[25] Additionally, some predisposing factors of BML have been described, including vitamin D deficiency, osteoporosis, and microtrauma.[11] Horas et al have described a high rate of hypovitaminosis D and vitamin D deficiency among patients presenting with BML of the foot and ankle. Vitamin D deficiency is associated with high bone turnover, which might increase the susceptibility of the bone to develop BML.[14] A high rate of vitamin D deficiency or hypovitaminosis D was also identified in patients with OLT and juvenile osteochondritis dissecans.[21,27] Vitamin D deficiency is potentially an important cofactor in the multifactorial development of osteochondritis dissecans.[27] Adolescent participants often have vitamin D insufficiency, and serum vitamin D levels below 20 ng/mL were observed in 64.8% of adolescent girls and 52.1% of adolescent boys.[2] Although serum vitamin D level was not measured in this study, they might have had vitamin D insufficiency because the subjects were juvenile OLT patients. One could argue that postoperative persistent BML was induced by a high bone turnover rate that was associated with vitamin D insufficiency.

Active bone formation is a primary factor in the spontaneous regression of BML.[24] However, how the development and resolution of edema correlate with its intensity and extent of involvement within the talus, particularly after the operative procedure, is still unclear.[5] Although BMLs of the

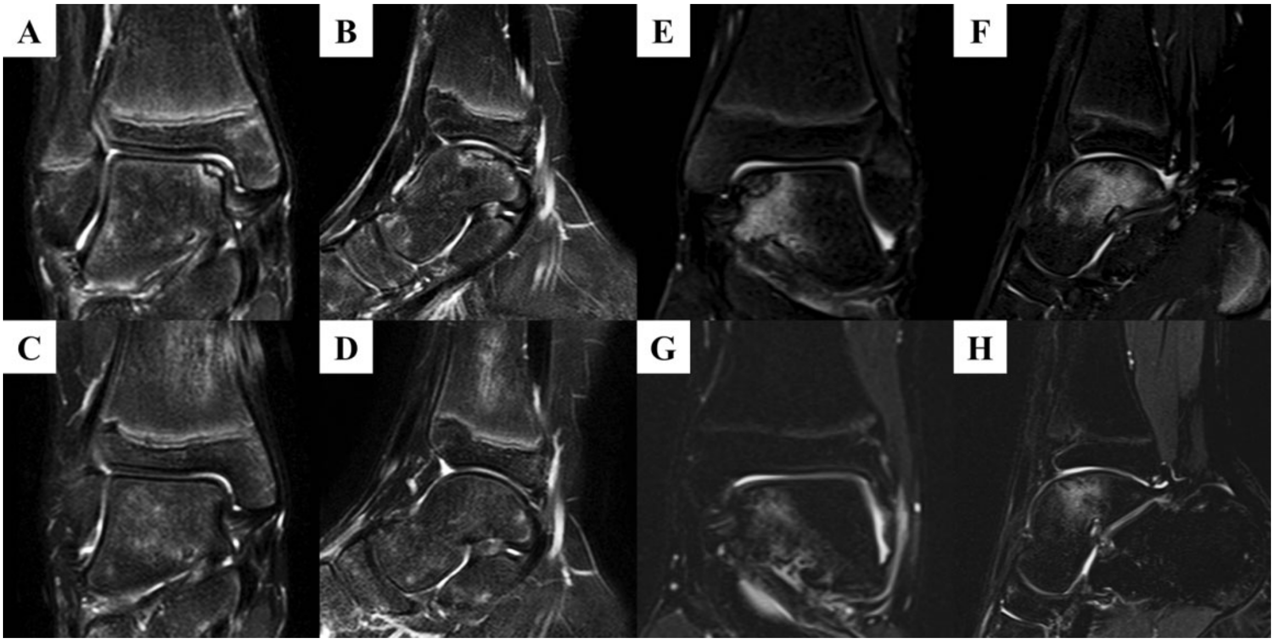

Figure 2. Representative fat-suppressed T2-weighted images. (A-D) Case 1: Preoperative magnetic resonance images showing osteochondral lesion at the medial talar dome and bone marrow lesion under the osteochondral fragment. (A, B) Subchondral bone healing and disappearance of the bone marrow lesion under the osteochondral fragment. (C, D) High-signal T2 changes of the bone marrow is observed in the talar neck, tibia, and navicular. (E-H) Case 2: Osteochondral lesion at the medial talar dome and large bone marrow lesion under the osteochondral fragment. (E, F) The area of bone marrow lesion reduced postoperatively. (G, H) High-signal T2 line of the talus is observed along the path of Kirschner wires.

foot and ankle were commonly found on MRI in clinical practice, the origin of the discomfort cannot be exactly related with this condition.[11] D'Ambrosi et al reported the clinical outcomes of arthroscopic talus autologous matrix-induced chondrogenesis for OLT with BML in 13 patients. AOFAS score and VAS score significantly improved; however, 23% of patients still had BML at 2 years after surgery.[5] Our results exhibited similar findings, which included good clinical outcomes and persistent small BML areas. Interestingly, Shabshin et al have described that high-signal T2 changes of the bone marrow are prevalent before the age of 15 years, particularly in the talus and calcaneus, and can easily be confused with traumatic or stress injuries. This pattern might be caused by focal regions of residual red marrow or physiological stress, possibly related to weight-bearing or altered biomechanics related to normal skeletal growth.[26]

Natural subchondral bone healing is difficult to induce in treating OLTs with sclerotic underlying bone. The penetration of the sclerotic bone by retrograde drilling can evoke normal subchondral bone remodeling process and subsequent healing of the osteochondral fragment. In particular, juvenile patients present higher bone-forming ability than adults, which facilitates repair of osteochondral lesions with sclerotic underlying bone by retrograde drilling. In this study, poor condition of the underlying bone such as bone sclerosis or multiple small cysts was identified; however, retrograde drilling provided good clinical results regardless. Multiple drilling is warranted to attain adequate penetration of the sclerotic bone, and the procedure induced unavoidable BML along the track of the wires postoperatively. Thus, persistent BML should be observed without anxiety because good clinical results are expected in juvenile patients postoperatively.

Major limitations of this study are the small number of patients and the lack of a control group with short follow-up periods. This study included only 8 patients with some variation of patient age distribution and indication of retrograde drilling. We focused on juvenile patients who account for a small part of the OLT patient population. In addition, retrograde drilling was performed for OLTs with nearly normal articular cartilage. Another technique, such as fixation of the fragment or osteochondral autologous transplantation, was used for lesions with damaged articular cartilage. For this reason, this single-center study did not address large numbers of juvenile OLT patients.

In conclusion, our data suggest that retrograde drilling is an acceptable option for treating juvenile OLT patients refractory to nonoperative treatment. Although bone sclerosis or multiple small cysts were identified in the underlying bone preoperatively and the BML under the osteochondral fragment remained postoperatively, pain, AOFAS score, and physical activity level were improved by retrograde drilling.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. ICMJE forms for all authors are available online.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

Yasunari Ikuta, MD, PhD, https://orcid.org/0000-0002-8419-9154
Tomoyuki Nakasa, MD, PhD, https://orcid.org/0000-0002-6267-3556
Munekazu Kanemitsu, MD, https://orcid.org/0000-0001-8989-9013

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