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Effects of Early Weightbearing on Microfracture Treatment of Osteochondral Lesions of Talus with Subchondral Bone Defects

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Summary: When subchondral bone defects are present in osteochondral lesions of the talus (OCLT), it is inconclusive whether to allow early weightbearing after microfracture treatment because of the lack of effective support of the newly-formed fibrocartilage. After performing arthroscopic debridement and microfracture treatment on OCLT patients with subchondral bone defects, we allowed patients to have an early postoperative weightbearing exercise to observe their clinical outcome. Forty-two OCLT patients with subchondral bone defects were analyzed. Patients were randomly divided into two groups with 21 patients in each group. After arthroscopic debridement and microfracture treatment, group A was allowed to have early partial weightbearing while weightbearing was delayed in group B. Visual analogue scale (VAS) was used to evaluate joint pain before and after surgery. American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score was used to evaluate joint function. Tegner activity scale was used to assess patient's exercise level. The AOFAS ankle-hindfoot score in group A increased from 54.4 to 87.6, and that in group B increased from 54.9 to 87.3. The VAS score in group A decreased from 6.5 to 2.2, and that in group B decreased from 6.4 to 2.3. The Tegner activity scale increased from 2.6 to 4.4 in group A, and that in group B increased from 2.6 to 3.9. There was significant difference in the Tegner activity scale between group A and group B ($P<0.05$). It was suggested that when performing microfracture treatment on OCLT patients with subchondral bone defects, early postoperative weightbearing may achieve similar clinical outcomes as delayed weightbearing, and patients may be better able to return to sports.
Key words: osteochondral lesions of the talus; subchondral bone; arthroscopic microfracture; weightbearing time

Osteochondral lesions of the talus (OCLT) are injuries involving the articular cartilage of the talus and its subchondral bone[1] and are common in ankle sprain. When the talus is twisted at the ankle, the articular cartilage on the surface of the talus may be subjected to vertical compression or horizontal shear, resulting in bruising, softening and fissures, and subchondral bone below it may also be damaged. Due to the poor healing ability of articular cartilage, satisfactory outcomes were difficult to achieve with conservative treatment[2].

There are a variety of surgical methods that can be used to treat OCLT, including drilling, microfracture and osteochondral transplantation[3]. Among them, arthroscopic microfracture is the preferred method to treat OCLT because of its ease and reliability[4]. The basic principle of microfracture is to penetrate the subchondral bone to induce the repair reaction, forming fibrocartilage covering the wound. The location and size of articular cartilage damage, subchondral bone defects and postoperative exercise will all affect the efficacy of microfracture treatment[5]. After the initial formation of fibrocartilage, it needs to be stabilized to reach certain mechanical strength. Thus, it is generally believed that after microfracture treatment weightbearing should be delayed[6]. However, more and more recent studies have shown that early weightbearing does not have a negative effect on the efficacy of microfracture treatment[7]. For OCLT with subchondral bone defects, it is still inconclusive whether after microfracture treatment newly formed fibrocartilages without effective bone support can tolerate early weighbearing.

We treated OCLT patients with subchondral bone defects with arthroscopic debridement and microfracture, allowing patients to have early post-operative weightbearing exercises to observe their clinical outcomes.

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1 MATERIALS AND METHODS

1.1 Patients Characteristics and Grouping

We collected OCLT patients with subchondral bone defects from January 2011 to December 2014. This study protocol was approved by the hospital ethics committee and all patients signed informed consent. Inclusion criteria were as follows: (1) a single osteochondral lesion in the talus; (2) defects in the corresponding subchondral bone. Exclusion criteria were as follows: (1) the size of talus cartilage injury was greater than 200 mm^2 or less than 36 mm^2; (2) the depth of subchondral bone defect was greater than 6 mm; (3) extensive talus cartilage degeneration or the presence of tibial osteochondral injury; (4) bilateral ankle joint lesions; (5) patients were younger than 18 years old or older than 60 years old; (6) patients had serious medical conditions, including diabetes, high blood pressure, etc.

A total of 42 patients were included in this study. Their gender, age, symptom duration, location and size of cartilage injury, and depth of subchondral bone injury were recorded. There were 29 males and 13 females, with age of 44.1±9.0 years (26 to 58 years). Symptom duration was 2.6±1.4 years (1 to 7 years). All patients had ankle pain and swelling. Thirty-six cases had lesions at medial side of the talus and 6 cases were at the lateral side of the talus. Articular cartilage injury size was 97.7±24.8 mm^2 (48–144 mm^2), and subchondral bone defect depth was 4.9±0.9 mm (3–6 mm).

These patients were randomly divided into two groups with 21 patients in each group. In group A, early partial weightbearing was allowed after operation and full weight was achieved at 4th week after operation. In group B, weightbearing started at the 5th week after operation and full weight was achieved at 8th week after operation.

There were 15 males and 6 females in group A, aged 44.0±8.7 years (28 to 58 years). Symptom duration was 2.6±1.5 years (1 to 7 years). In 20 cases, lesions were located at the medial side of the talus and 1 case at the lateral side. Articular cartilage injury size was 98.7±26.0 mm^2 (48–144 mm^2) and subchondral bone defect depth was 4.9±0.9 mm (3–6 mm).

There were 14 males and 7 females in group B, aged 44.1±9.6 years (26 to 58 years). Symptom duration was 2.6±1.4 years (1 to 7 years). In 16 cases, lesions were located at the medial side of the talus and those at the lateral side in 5 cases. Articular cartilage injury size was 96.7±24.1 mm^2 (48–144 mm^2) and subchondral bone defect depth was 5.0±0.8 mm (3–6 mm).

In addition to the location of injury, these two groups were comparable in terms of gender, age, symptom duration, size of talar osteochondral injury, and the depth of subchondral bone defects (table 1, P>0.05).

Ankle anteroposterior and lateral radiograph was taken preoperatively and 1 year after surgery and the talar osteochondral injury was assessed using Berndt and Harty classification[8]. Ankle magnetic resonance imaging (MRI) was taken preoperatively and 1 year after surgery and Mintz classification[9] was used to evaluate the injury and the healing of talus cartilage. Arthroscopic examination was performed and Ferkel and Cheng classification[10] was used to assess the OCLT. Joint pain was evaluated by visual analogue scale (VAS) before and 6 months, 1 year and 2 years after surgery. AOFAS ankle-hindfoot score[11] was used to evaluate joint function and Tegner activity scale[12] was used to assess patient's activity level. There was no significant difference in VAS score, AOFAS ankle-hindfoot score and Tegner activity scale between two groups before operation (table 1, P> 0.05).

1.2 Surgical Technique

After general anesthesia, patient was in a supine position and routine disinfection was performed. Arthroscopy (2.7 mm, 30 degrees, Smith & Nephew) was performed through anterior medial and anterior lateral portals of ankle. If there was no enough joint space, non-invasive traction can be used to help pull the joint apart. The probe was used to determine the location of cartilage injury and debride damaged articular cartilage (fig. 1A). The subchondral bone defects were located and the loose surface of the bone was removed. The bone edge was carefully maintained to limit the lesion. The curettage with different angle was used to debride the internal lesions of the talus (fig. 1B). The cartilage injury area was measured by

Table 1 Comparison of general data between group A and group B

Variables	Group A	Group B	P value
Gender (M/F)	15/6	14/7	0.136
Age (years)	44.0±8.7	44.1±9.6	0.987
Symptom duration (years)	2.6±1.5	2.6±1.4	0.915
Injury site (Medial/Lateral)	20/1	16/5	0.005
Cartilage injury area (mm^2)	98.7±26.0	96.7±24.1	0.797
Depth of injury (mm)	4.9±0.9	5.0±0.8	0.861
Preoperative VAS score	6.5±1.7	6.4±1.7	0.931
Preoperative AOFAS score	54.4±16.4	54.9±14.3	0.961
Preoperative Tegner activity scale	2.6±0.7	2.6±0.7	0.821

the graduated probe (fig. 1C). The hardened zone was penetrated through the microfrature (fig. 1D). The interval between the holes was 3–4 mm. After closing the arthroscopic perfusion and confirming wound bleed was normal (fig. 1E), the incision was sutured.

1.3 Rehabilitation Program

Postoperative brace was used for 12 weeks. On the first day after the operation, passive ankle flexion and extension exercises were performed 60 times per day and increased to 600 times per day after 4 weeks until the 12th week after operation.

Patients in group A started partial weightbearing on the first day after operation. When weightbearing, patient's ankle was maintained in static neutral position with a weightbearing time of 10 min every day and an initial weight of 1/4 body weight. Every week after the surgery, weight and duration increased by interval of 1/4 body weight and 10 min respectively. At the 4th week after surgery, full body weight was achieved. Afterwards, patients practiced walking with the protection of walking braces and the walking time gradually increased. Three months after surgery, patients returned to normal life. Six months after the surgery, simple physical activity resumed.

Patients in group B didn't carry weight within 4 weeks after operation. Weightbearing started at the 5th week after operation. When weightbearing, patient's ankle was maintained in static neutral position with a weightbearing time of 10 min every day and an initial weight of 1/4 body weight. Every week after surgery, weight and duration increased by interval of 1/4 body weight and 10 min respectively. At the 8th week after surgery, full body weight was achieved. Afterwards, patients practiced walking with the protection of walking braces and the walking time gradually increased. Three months after surgery, patients returned to normal life. Six months after the surgery, simple physical activity resumed.

1.4 Statistical Processing

Collected data were analyzed by SPSS19.0 software. *T* test was used for count data and χ^2 test was used for frequency data. Mann-Whitney *U* rank test was used for classification data. Difference was statistically significant at $P<0.05$.

2 RESULTS

All patients were followed up for 24 to 60 months. The anteroposterior and lateral radiographs of the ankle were taken and Berndt and Harty classification was used to evaluate the injury of subchondral bone. There was no significant difference between these two groups before and after surgery (table 2, $P>0.05$). Ankle MRI was performed and Mintz grading was used to evaluate the damage and healing of the talar cartilage (fig. 2A–2D). There was no significant difference between two groups before and after surgery (table 3, $P>0.05$). For the arthroscopic examination, the grading method reported by Ferkel and Cheng was used to assess talar osteochondral lesions. There was no significant difference between the two groups (table 4, $P>0.05$).

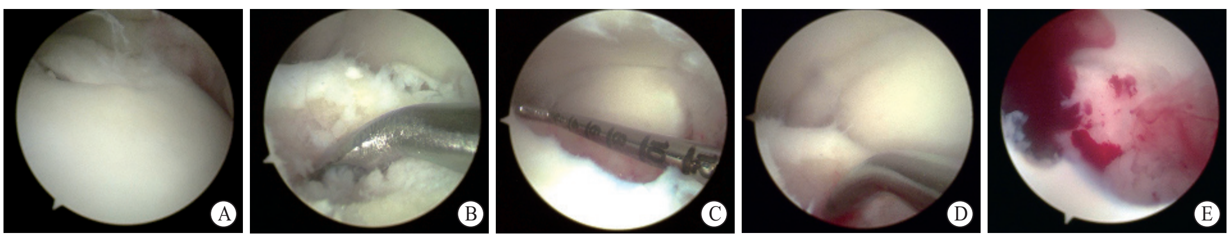

Fig. 1 Surgical technique of debridement and microfracture
A: debriding damaged articular cartilage; B: using the curettage with different angle to debride the internal lesions of the talus; C: measuring the cartilage injury area with the graduated probe; D: penetrating the hardened zone through the microfrature; E: closing the arthroscopic perfusion and confirming wound bleed was normal

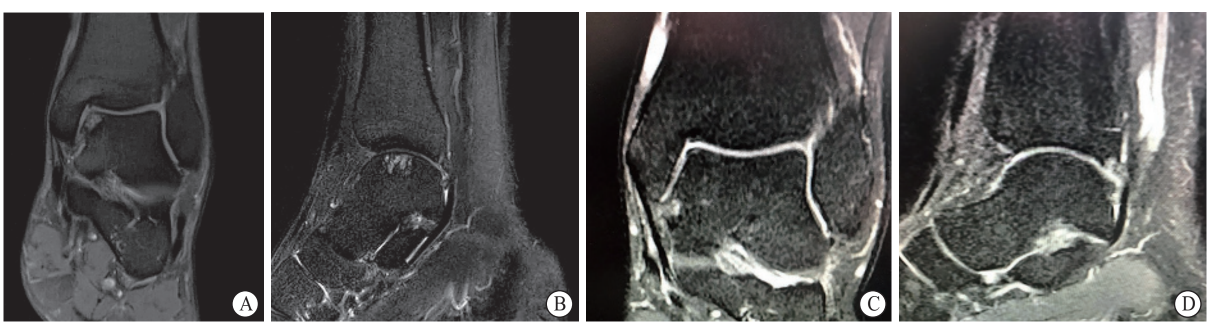

Fig. 2 Evaluation of the damage and healing of the talar cartilage by ankle MRI
A and B: OCLT and marrow edema in the subchondral bone in the preoperative ankle MRI; C and D: healing of OCLT and disappearance of marrow edema in the subchondral bone in the ankle MRI 1 year after operation

Table 2 Comparison of Berndt and Harty classification between early and delayed weightbearing groups

Groups	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4
A					
Preoperation	0	2	5	7	7
Postoperation	8	8	5	0	0
B					
Preoperation	0	2	6	7	6
Postoperation	8	7	6	0	0

The mann-Whitney *U* rank sum test: $P<0.001$ in both groups before and after operation; $P=0.732$ between groups A and B before operation; $P=0.862$ between groups A and B after operation

Table 3 Comparison of Mintz grading between early and delayed weightbearing groups

Groups	Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
A						
Preoperation	0	0	3	8	8	2
Postoperation	2	13	6	0	0	0
B						
Preoperation	0	0	3	7	8	3
Postoperation	2	12	7	0	0	0

The mann-Whitney *U* rank sum test: $P<0.001$ in groups A and B before and after operation; $P=0.730$ between groups A and B before operation; $P=0.784$ between groups A and B after operation

Table 4 Comparison of Ferkel and Cheng grading between early and delayed weightbearing groups

Groups	Phase A	Phase B	Phase C	Phase D	Phase E	Phase F
A	0	0	1	10	8	2
B	0	0	2	9	7	3

Themann-Whitney *U* rank sum test: $P=0.989$ between groups A and B

There was no significant difference in AOFAS ankle-hindfoot scores in the two groups before and after surgery (table 5, $P>0.05$). Postoperative scores were significantly higher than preoperative scores (table 5, $P<0.05$). There was no significant difference in preoperative and postoperative VAS scores between the two groups (table 6, $P>0.05$). Postoperative scores of each group were significantly lower than preoperative scores (table 6, $P<0.05$). There was no significant difference in the preoperative Tegner activity scale between the two groups (table 7, $P>0.05$). Tegner activity scale at 6th, 12th and 24th month after surgery in group A was significantly higher than that in group B (table 7, $P<0.05$). Postoperative scores of each group were significantly higher than preoperative scores (table 7, $P<0.05$).

Table 5 Comparison of AOFAS ankle and hindfoot scores between early and delayed weightbearing patients

Groups	Preoperation	Postoperation (months)		
		6	12	24
A	54.4±16.4	84.3±6.5	86.9±6.9	87.6±6.8
B	54.9±14.3	83.1±6.3	86.3±6.5	87.3±7.3
P value	0.961	0.565	0.781	0.896

Table 6 Comparison of VAS scores between early and delayed weightbearing patients

Groups	Preoperation	Postoperation (months)		
		6	12	24
A	6.5±1.7	2.7±0.6	2.4±0.8	2.2±0.5
B	6.4±1.7	2.8±0.7	2.5±0.7	2.3±0.7
P value	0.931	0.661	0.821	0.633

Table 7 Comparison of Tegner activity scale between early and delayed weightbearing patients

Groups	Preoperation	Postoperation (months)		
		6	12	24
A	2.6±0.7	4.0±0.7	4.4±1.0	4.4±1.0
B	2.6±0.7	2.6±0.7	3.7±0.7	3.9±0.6
P value	0.821	0.000	0.007	0.026

3 DISCUSSION

Ankle joints are one of the most vulnerable body parts during exercise. Osteochondral injury occurs in 50% of ankle sprains and fractures[13]. Due to the prevalence of ankle varus injury and the characteristics of surface structure of talar cartilage, injury tends to locate in the medial talus. Most of lesions in our study are also located in the medial talus. After osteochondral injury occurs, synovial fluid enters talar subchondral bone via cartilage fissure, resulting in subchondral bone softening with pressure from body weight[14]. In our study, patients had symptoms for more than 1 year, which proved that the formation of subchondral bone defects is a slow process.

Articular cartilage has low regeneration ability and repair can only be induced by penetrating the subchondral bone[15, 16]. Microfracture is by far the most commonly used repair technique and it can be operated under arthroscopic monitoring and is easy to perform. Fibrocartilage formed after serum factor is induced through penetration of subchondral bone[17]. As the biomechanical properties of fibrocartilage are inferior to hyaline cartilage, the outcome of this technique on large OCLTs is not ideal. The size of lesion suitable for microfracture technique is still debatable clinically[15, 18], and it is generally believed to be between 100 and 200 mm^2. In the literature, although its efficacy is still controversial, microfracture is an effective method to relieve clinical symptoms through subchondral decompression and the formation of fibrocartilage covering the wound[19].

The traditional view is that it takes time to form and stabilize fibrocartilage, so it is not advisable to make patient bear weight too early. The recommended weightbearing time is usually 6 to 8 weeks after microfracture surgery[20, 21]. However, delayed weightbearing can also bring a series of side effects, such as degeneration of articular cartilage and osteoporosis around the joint which can eventually affect the recovery of patients' motor function. To avoid these side effects, some researchers begun to try early weightbearing[22]. Lee *et al*[23] compared the clinical outcomes of early weightbearing and delayed weightbearing after microfracture surgery and found no difference in AOFAS score, VAS score and AAS score.

The main concern of early weightbearing is the stability of newly-formed fibrocartilage. We required patients to take a static weightbearing stand. Weightbearing ankle only withstands longitudinal pressure, thus avoiding the occurrence of this situation. If newly-formed fibrocartilage does not fall off, early weightbearing may provide additional benefits, including avoiding degeneration of articular cartilage and surrounding osteoporosis. As patients may be able to move sooner they will have more confidence resuming sports. Our study also confirmed that early weightbearing group had higher Tegner activity scale than the delayed weightbearing group.

For cases with subchondral bone defects, osteochondral transplantation is usually not considered when bone defects are not serious[24]. Early stress stimulation contributes to the formation of subchondral bone. But at the beginning of bone formation there is a lack of effective support on the surface of newly-formed fibrocartilage, and it is not clear whether weightbearing will cause adverse effects. By using a weightbearing approach that gradually increases weight and time, we did our best to protect the newly-formed subchondral bone. In our study, there was no difference in the AOFAS and VAS scores between the two groups, demonstrating that the newly-formed subchondral bone can withstand progressive gravitational stimulation and protected early weightbearing won't lead to any adverse effects.

The number of cases in this study was not very large and follow-up was not long, which could affect the outcomes. In the case of grouping, injury sites were not matched completely, which may also affect the results. When we selected cases, although the predefined criteria of the cartilage damage size were less than 200 mm^2, the average area of cartilage damage was less than 100 mm^2. It is possible that peripheral cartilage degeneration or tibial cartilage damage tended to occur with extensive cartilage damage, which led to exclusion of these cases. Finally, this study didn't have a method to evaluate the histology of newly-formed cartilage.

In conclusion, for OCLT patients with subchondral bone defects, similar clinical outcomes can be obtained either with early weightbearing or delayed weightbearing after microfracture surgery. However, early weightbearing patients were able to regain movement and return sports sooner.

Conflict of Interest Statement

The authors declare that they have no conflicts of interest or financial disclosures to report.

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