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Abstract

Background: The purpose of this study was to document outcomes following microfracture of articular cartilage lesions of the ankle. Our hypothesis was that patients who underwent ankle microfracture would have good to excellent outcomes.

Methods: This study was institutional review board approved. Patients older than 18 years who underwent ankle microfracture surgery for Outerbridge grade 3 or 4 articular cartilage lesions, by a single surgeon, were included. Detailed intraoperative findings were documented at surgery. Patients completed a questionnaire with Foot and Ankle Disability Index (FADI), Lysholm, Tegner, and patient satisfaction with outcome. All data were collected prospectively and stored in a data registry and retrospectively reviewed. Forty patients (21 males, 19 females, mean age = 42 years [range, 19-65 years]) were included in this study. Thirteen (33%) had previous ankle surgery. Follow-up was obtained for 94% of patients (n = 34). Mean follow-up time was 26 months (range, 12-48 months).

Results: Mean talar defect size was 70 mm² (range, 4-300 mm²). Mean tibia defect size was 31 mm² (range, 8-54 mm²). Four patients (10.5%) required subsequent surgery following microfracture surgery. Mean time to second surgery was 17 months (range, 4-32 months). Mean Lysholm score was 74 (range, 31-96). Mean FADI Activities of Daily Living (ADL) was 81 (range, 33-99), FADI Sport was 62 (range, 13-100), and FADI total score was 77 (range, 28-98). Median Tegner was 4 (range, 0-10). Median patient satisfaction was 8 (range, 3-10). Patients who had previous ankle surgery had significantly lower outcome scores versus patients who did not have previous ankle surgery for FADI ADL (70 vs 81, P = .029) and FADI Total (51 vs 77, P = .028). Days from injury to surgery were correlated with age at surgery (r = .323, P = .042) and negatively correlated with FADI ADL (r = -.431, P = .014), FADI Sport (r = -.490, P = .004), FADI Total (r = -.429, P = .014), and Tegner (r = -.402, P = .023).

Conclusion: Patients who underwent microfracture for grade 3 or 4 ankle articular cartilage lesions had high patient satisfaction. Patients who had previous ankle surgery had lower postoperative ankle function; however, patient satisfaction remained high. This study supports microfracture for treatment of grade 3 and 4 ankle articular cartilage lesions.

Level of Evidence: Level IV, case series

Keywords: ankle arthroscopy, microfracture, articular cartilage lesion, osteochondral, talus

Articular cartilage lesions of the ankle can be a common cause of pain and disability.⁴ These cartilage defects are usually the result of trauma, such as ankle sprains or fractures, which has been implicated in 70% of medial lesions and 98% of lateral lesions.¹² Up to 50% of acute ankle sprains and 73-80% of ankle fractures will result in some type of cartilage damage.^{16,22} An untreated articular cartilage defect is a significant risk factor for the development of ankle osteoarthritis (OA), with previous studies documenting the development of degenerative changes in up to 50% of cases.^{5,20}

Various treatment methods have been described for articular cartilage lesions of the ankle,^{6,11,20} which have also

been commonly referred to as osteochondral lesions (OCLs) or, more specifically, osteochondral lesions of the talus (OLTs) when occurring on the talus. Conservative treatment options include immobilization with casting, walking boots, or braces; nonsteroidal anti-inflammatory drug (NSAID) therapy; activity modification; corticosteroid injections; and, more recently, hyaluronate and platelet rich plasma

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injections.⁷ A large systematic review of 52 studies revealed only a 45% to 53% rate of good to excellent outcomes with nonoperative management, indicating that approximately half of patients with OLTs may require further intervention.²⁹ In the landmark study by Berndt and Harty, poor outcomes were documented in 75% of patients following nonoperative treatment for talar OCLs.³ Due to these poor results, various operative techniques have been developed.

Operative techniques include mosaicplasty, osteochondral autograft or allograft transplantation, autologous chondrocyte implantation (ACI), and marrow stimulation such as drilling or microfracture.^{7,28} Mosaicplasty, osteochondral autograft or allograft transplantation and ACI are generally performed as an open procedure, often requiring a malleolar osteotomy.^{10,17} These open procedures increase the risk of wound healing complications, as well as nonunion or malunion of the osteotomy.¹⁸ In addition, mosaicplasty and osteochondral autograft transplantation from the knee may lead to donor site pain and possible morbidity from disruption of normal knee cartilage due to autograft harvest.^{9,13} For osteochondral allograft transplantation, there is also the potential for infection transmission and host immune response.⁹ Downfalls of the ACI procedure include the need for 2 separate surgeries, including chondrocyte harvest and a subsequent implantation procedure, as well as a potential for cell dedifferentiation.²² In addition, these procedures can be very expensive, especially if 2 surgeries are required.^{15,22,29} Microfracture, however, has shown to be a relatively low-cost, low-risk procedure with good to excellent results in both the knee and the ankle.^{14,25}

The microfracture technique, popularized by Steadman et al²⁶ in the 1990s, relies on systematically creating small defects in the subchondral bone to allow primitive mesenchymal cells to infiltrate and repair the defect.^{1,2} This technique has advantages of being cost-effective and having low morbidity and complication rates, is minimally invasive, and is not technically complex.²⁵

Microfracture surgery of the knee has been well documented, reporting functional and symptomatic improvement in approximately 67% to 80% of patients.^{21,25,26} However, the microfracture technique in the ankle has been less thoroughly studied. In a randomized controlled trial comparing chondroplasty, microfracture, and osteochondral autologous transplantation, Gobbi and colleagues found no significant difference in postoperative outcomes scores at 12 and 24 months follow-up.¹⁴ A systematic review of outcomes following microfracture of the ankle reported approximately 80% of patients achieving good to excellent results, which is similar to the knee. Interestingly, the conclusion of the article was that further research needs to be completed to validate the results.⁸ The purpose of this study was to document outcomes following microfracture of articular cartilage lesions of the ankle joint. Our hypothesis was that patients who underwent ankle microfracture

Table 1. Mechanism of Injury for All Patients.

Mechanism of Injury	Percentage of Patients	n
Sport participation	60.0	24
Slip and fall	17.5	7
Chronic	17.5	7
Auto accident/plane crash	5.0	2

surgery for articular cartilage lesions of the ankle would have good to excellent outcomes.

Methods

This study was approved by an institutional review board. All patients 18 years or older, who underwent ankle microfracture surgery for the treatment of an Outerbridge grade 3 or 4 articular cartilage lesion, by a single surgeon were included in this study. An Outerbridge grade 3 lesion is defined as a cartilage lesion with fragmentation and fissuring in an area more than a half-inch in diameter, and a grade 4 lesion being erosion of cartilage down to bone.²³ Patients were excluded from this study if they were less than 18 years of age or underwent concomitant surgery on joints other than the ankle. Patients were also excluded if English was not their primary language and therefore were unable to complete required follow-up documentation. From September 2009 to August 2012, 46 patients underwent microfracture for the treatment of an articular cartilage lesion of the ankle. Two patients refused to participate, 1 patient underwent subtalar arthrodesis at time of microfracture surgery, 1 patient was under the age of 18 at the time of surgery, and 2 patients did not speak English and were therefore excluded from this study, leaving 40 patients available for follow-up. Detailed operative data and intraoperative findings were documented at the time of surgery. Patients were asked to complete a subjective questionnaire at a minimum of 1 year following ankle surgery, and each consecutive year thereafter. Outcome measures included the Foot and Ankle Disability Index (FADI), the Lysholm score,¹⁹ the Tegner activity scale,²⁷ and patient satisfaction with outcome. All data were collected prospectively and stored in a data registry.

There were 40 patients (21 males, 19 females), with a mean age of 42 years (range, 19 to 65 years), who fit the inclusion criteria and were included in this study. Mean body mass index was 25.4 (range, 19.2 to 39.6). There were 7 patients who underwent surgery within 90 days of injury, 12 patients who underwent surgery between 91 days and 1 year of injury, and 21 patients who underwent surgery more than 1 year from injury. More than half of patients were injured while participating in sports activity (Table 1). Sporting activities and percentages are listed in Figure 1. Thirteen (33%) had previous ankle surgery on the involved ankle (Table 2). Follow-up was obtained for 94% of patients

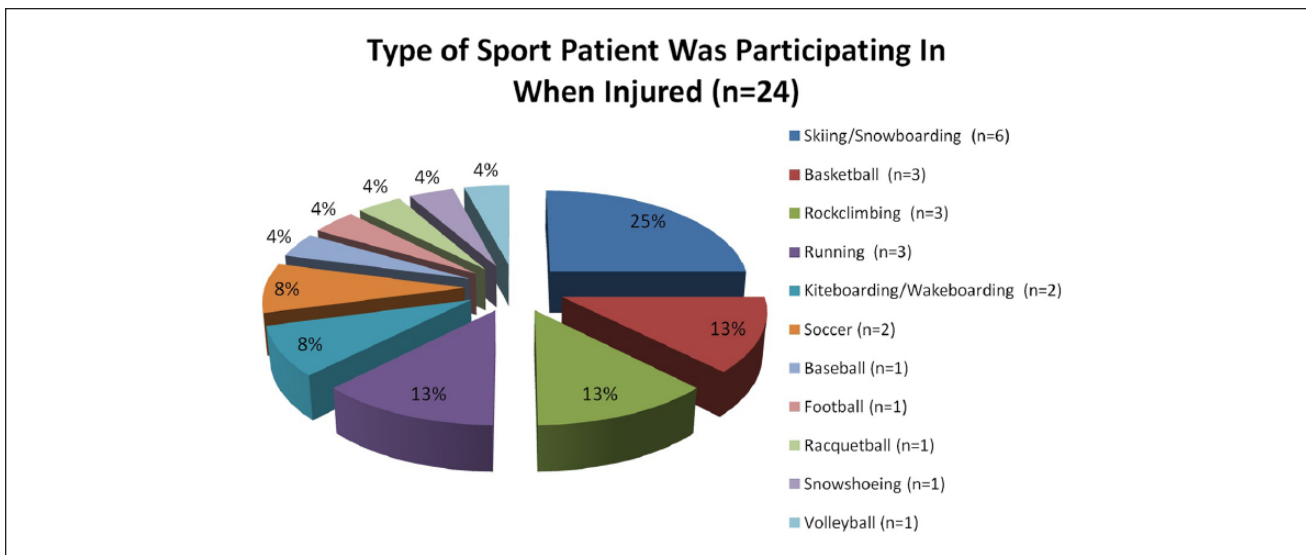


Figure 1. Type of sport patient was participating in when injured.

Table 2. Previous Ankle Operative Procedures From Total Patient Population (n = 40).

Previous Operative Treatment	Percentage of Patients	n
Arthroscopic debridement	13	5
Lateral ligament reconstruction	10	4
ORIF ankle fracture	10	4
Microfracture	8	3
Chondroplasty	5	2
osteochondral autograft or allograft transplantation	5	2
Removal of hardware	5	2
Surgery for anterior impingement	3	1
Bone grafting of open pilon fracture	3	1

In all, 13 patients had previous surgery. There is overlap in procedures as patients may have had multiple procedures performed prior to index surgery.

(n = 34), with a mean follow-up time of 26 months (range, 12-48 months).

Operative Technique

All patients underwent standard diagnostic ankle arthroscopy (Figure 2). Using a curette or arthroscopic shaver, any abnormal cartilage was debrided down to the level of subchondral bone (Figure 3). Care was taken to ensure a stable cartilage rim around the lesion while avoiding creation of an overly large defect from excessive debridement. Once debridement was completed, a series of holes or “microfractures” were created in the exposed subchondral bone, perpendicular to the surface of the bone, to a depth of at



Figure 2. Arthroscopic view of a talar articular cartilage flap with an operative probe.

least 2 mm. Microfracture holes were created using 30 degree, 45 degree, or 60 degree awls, and placed 3 to 4 mm apart to ensure a stable bone bridge (Figure 4). The pressure in the joint was subsequently reduced to confirm that extrusion of fat droplets and bleeding from the microfracture holes was observed (Figures 5 and 6). If patients had concomitant ligamentous injuries of the ankle, these were addressed following completion of the microfracture procedure and removal of the arthroscopic equipment.

Postoperative Management

Postoperative management varied depending on concomitant injuries or procedures performed at the time of index surgery.



Figure 3. Arthroscopic view of a talar articular cartilage lesion prepared for microfracture.



Figure 5. Arthroscopic view during microfracture demonstrating extrusion of a fat droplet, indicating adequate depth has been reached.

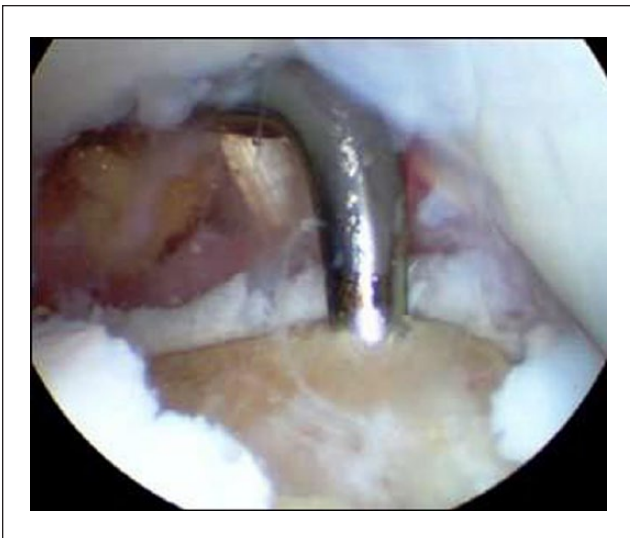


Figure 4. Arthroscopic view of a prepared talar articular cartilage lesion with microfracture being performed using a microfracture awl.



Figure 6. Arthroscopic view of a talar articular cartilage lesion with punctate bleeding following completion of microfracture.

While each rehabilitation protocol was patient specific, the general protocol was as follows. A sterile compressive dressing was applied for 1 to 2 weeks and the patient was kept non-weight-bearing. At the initial postoperative visit, the patient was provided with a walking boot, which could be removed 4 to 5 times per day for work on range of motion of the ankle but remained non-weight-bearing. At 6 weeks postoperatively, progressive weight-bearing was initiated over a 2- to 4-week period. If not already initiated, formal physical therapy was prescribed around the 6-week time frame, with goals of improving range of motion, strength, and

proprioception. Patients gradually returned to normal activities over the 3- to 6-month postoperative period.

Results

Of the 40 patients, 33 patients had cartilage defects of the talus, 3 had cartilage defects of the tibia, and 4 had cartilage defects of the talus and tibia. Mean size of talar cartilage defects was 70 mm² (range, 4 to 300 mm²), and mean size

Table 3. Concomitant Pathologies Documented at Index Surgery for the Total Patient Population (n = 40).

Concomitant Pathology	Percentage of Patients	n
Osteophytes	53	21
Ligamentous injury	35	14
Ankle fracture	20	8
Arthritis	18	7
Posttraumatic	13	5
Osteoarthritis	5	2
Anterior impingement	18	7
Synovitis	15	6
Loose body	8	3
Syndesmosis injury	8	3
Tendon injury	3	1

Three patients did not have any concomitant pathology at time of index surgery. There is overlap in pathologies as patients may have had multiple pathologies documented at index surgery.

of tibia cartilage defects was 31 mm² (range, 8 to 54 mm²). Concomitant pathologies at time of surgery were also recorded (Table 3).

Four patients (10.5%) required subsequent surgery following index microfracture surgery. Mean time to second surgery was 17 months (range, 4 to 32 months). Of these 4 patients, 1 had posttraumatic arthritis, due to a previous open pilon fracture that occurred before the microfracture, which required an ankle fusion. One patient had a persistent articular cartilage lesion that required subsequent arthroscopic debridement and eventual osteochondral autograft transplant. One underwent subsequent arthroscopic surgery due to persistent pain and was found to have good fibrocartilage fill with minor fibrillation, which was debrided. Finally, 1 had a recurrent articular cartilage lesion with exposed subchondral bone that was discovered during removal of painful hardware and underwent repeat microfracture.

Outcomes

Mean Lysholm score was 74 (range, 31-96). For FADI, mean FADI ADL was 81 (range, 33-99), FADI Sport was 62 (range, 13-100), and FADI total score was 77 (range, 28-98). Median Tegner activity scale was 4 (range, 0-10). Median patient satisfaction with outcome was 8 (range, 3-10). Patients who had previous ankle surgery had significantly lower outcome scores versus patients who did not have previous ankle surgery, in terms of FADI ADL (70 vs 81, $P = .029$) and FADI Total (51 vs 77, $P = .028$). Patients who had a longer time between ankle injury and surgery had lower FADI subscales, FADI total score, and Tegner activity scale. Days from ankle injury to surgery were correlated with age at surgery ($r = .323$, $P = .042$). Days from ankle injury to

surgery were also negatively correlated with FADI ADL ($r = -.431$, $P = .014$), FADI Sport ($r = -.490$, $P = .004$), FADI Total ($r = -.429$, $P = .014$), and Tegner activity scale ($r = -.402$, $P = .023$). There was also a significant association between days from ankle injury to surgery and previous surgery ($P = .011$).

Discussion

In our study, approximately 30% of patients had previous ankle surgery and more than half of patients who were treated with ankle microfracture had chronic ankle injuries. Patients who had previous ankle surgery had lower outcome scores, as did patients who had a longer amount of time between ankle injury and surgery. We believe the most important finding in this study was that patients were highly satisfied with their operative outcome. Patients also reported good ankle function, with a mean Lysholm score of 74 and a mean FADI total score of 77.

Our results were similar but somewhat lower than a recent systematic review by Donnenwerth and Roukis. They reported that approximately 80% of patients who underwent microfracture of the talus had good to excellent outcomes, as defined by >80 points on the American Orthopaedic Foot and Ankle Society (AOFAS) Hindfoot Score.⁸ A major difference in their study versus our study was that the primary outcome measure used in their systematic review was the AOFAS Hindfoot Score. This score has not demonstrated acceptable psychometric properties and has been shown to have a high ceiling effect, which could potentially produce inflated outcome scores.^{8,24} This was also noted to be a weakness of that study. Use of different outcome measures could explain the small discrepancy in postoperative scores.

In addition, all of the studies that were included in the systematic review completed by Donnenwerth and Roukis were based on primary treatment of OCLs of the talar dome.⁸ In our study, approximately one-third of patients underwent previous ankle surgery and a large portion of the patients had ankle surgery greater than 90 days from injury. Our study also demonstrated that patients had a longer time from injury to index surgery if they had previous ankle surgery. This could be due to patient apprehension to undergo additional operative treatment. Significantly lower function was reported in patients with previous ankle surgery, as documented by the FADI score. Although our outcome scores were slightly lower than those reported in the systematic review, the fact that our study included patients who had previous ankle surgery, may have contributed to the difference in outcomes.

In a randomized controlled trial by Gobbi et al, outcomes following chondroplasty, microfracture, and OATS for the treatment of OLTs were compared in 33 ankles. They

reported no significant difference in terms of AOFAS Hindfoot Score and Single Assessment Numeric Evaluation (SANE) score when comparing chondroplasty, microfracture, and OATS at 12 and 24 months postoperatively.¹⁴ Although this study reports that there was no significant difference in outcomes for each procedure, inclusion criteria were very strict. Patients who had lesions smaller than 1 cm², bipolar or kissing lesions, diffuse arthritic changes, or concomitant pathologies including ankle fracture, were excluded from this study. Patients who had posterior or central lesions of the talus were also excluded, therefore only including patients with anterior or lateral lesions. Due to these exclusion criteria, it is extremely difficult to compare the outcomes in our study, since patient populations were very different. Therefore, it is difficult to conclude that chondroplasty would produce equivalent outcomes to those of microfracture in our patient population.

In a systematic review of 52 studies, conducted by Zengerink et al, outcomes of various treatments for articular cartilage lesions of the talus were compared. The treatments that were compared included nonoperative treatment, excision, curettage, bone marrow stimulation (microfracture), autogenous bone graft, transmalleolar drilling, OATS, ACI, retrograde drilling, and fixation.²⁹ The primary outcome measure was the AOFAS Hindfoot Score. There were 18 studies that reported the results of bone marrow stimulation (ie, microfracture), with excellent outcomes reported in 85% of patients. Their conclusion was that bone marrow stimulation was the best treatment option, for primary articular cartilage lesions of the talus, due to the high success rates and excellent outcomes that have been consistently reported.

There were several limitations of this study. This study was retrospective; however, all data were collected prospectively. It was conducted at a referral clinic, and therefore may not represent the general population. In this study, early outcomes were documented; however, more research is necessary to determine long-term outcomes in patients undergoing ankle microfracture.

Conclusion

In this study, patients who underwent microfracture for grade 3 or 4 articular cartilage lesions of the ankle had high patient satisfaction. Patients also had good function at a mean follow-up of 2 years. In addition, patients who had previous ankle surgery and a longer time from injury to surgery had lower postoperative ankle function than patients who did not have previous ankle surgery; however, patient satisfaction remained high. This study supports the use of microfracture for treatment of grade 3 and 4 articular cartilage lesions of the ankle. More research, using reliable outcome measures with acceptable psychometric properties, is necessary to determine long-term outcomes of ankle microfracture in this patient population.

Declaration of Conflicting Interests

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