The Journal of Foot & Ankle Surgery ■■ (2017) ■■–■■

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Original Research

Arthroscopic Treatment of Osteochondral Lesions of the Talus Using Juvenile Articular Cartilage Allograft and Autologous Bone Marrow Aspirate Concentration

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ARTICLE INFO

Level of Clinical Evidence: 4

Keywords:
arthroscopic treatment
de novo natural tissue graft
juvenile articular cartilage
osteochondral lesions

ABSTRACT

Juvenile allogenic chondrocyte implantation (JACI; DeNovo NT Natural Tissue Graft®; Zimmer, Warsaw, IN) with autologous bone marrow aspirate concentrate (BMAC) is a relatively new all-arthroscopic procedure for treating critical-size osteochondral lesions (OCLs) of the talus. Few studies have investigated the clinical and radiographic outcomes of this procedure. We collected the clinical and radiographic outcomes of patients who had undergone JACI-BMAC for talar OCLs to assess treatment efficacy and cartilage repair tissue quality using magnetic resonance imaging (MRI). Forty-six patients with critical-size OCLs (≥6 mm widest diameter) received JACI-BMAC from 2012 to 2014. We performed a retrospective medical record review and assessed the functional outcomes pre- and postoperatively using the Foot and Ankle Outcome Score (FAOS) and Short-Form 12-item general health questionnaire. MRI was performed preoperatively and at 12 and 24 months postoperatively. Cartilage morphology was evaluated on postoperative MRI scans using the magnetic resonance observation of cartilage tissue (MOCART) score. The pre- to postoperative changes and relationships between outcomes and lesion size, bone grafting, lesion location, instability, hypertrophy, and MOCART scores were analyzed. Overall, the mean questionnaire scores improved significantly, with almost every FAOS subscale showing significant improvement postoperatively. Concurrent instability resulted in more changes that were statistically significant. The use of bone grafting and the presence of hypertrophy did not result in statistically significant changes in the outcomes. Factors associated with outcomes were lesion size and hypertrophy. Increasing lesion size was associated with decreased FAOS quality of life subscale and hypertrophy correlating with changes in the pain subscale. Of the 46 patients, 22 had undergone postoperative MRI scans that were scored. The average MOCART score was 46.8. Most patients demonstrated a persistent bone marrow edema pattern and hypertrophy of the reparative cartilage. Juvenile articular cartilage implantation of the DeNovo NT allograft and BMAC resulted in improved functional outcome scores; however, the reparative tissue still exhibited fibrocartilage composition radiographically. Further studies are needed to investigate the long-term outcomes and determine the superiority of the arthroscopic DeNovo procedure compared with microfracture and other cartilage resurfacing procedures.

Osteochondral lesions (OCLs) of the talus often occur after traumatic ankle injuries such as sprains, fractures, and recurrent instability. The incidence of talar OCLs is difficult to define owing to ambiguity with the diagnosis and the presence of asymptomatic lesions; however, OCLs have been reported to occur in 17% to 79% of ankle fractures (1–7) and ≤38% of sprains (8). Microfracture has been considered the

Financial Disclosure: None reported.
Conflict of Interest: None reported.
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https://doi.org/10.1053/j.jfas.2017.09.009

standard of care for small- to medium-size lesions (<15 mm in diameter), because it is a simple, single-stage procedure that can be performed arthroscopically. The success rates have varied, with good to excellent results occurring in 39% to 96% of cases in the short term (9). However, instead of producing normal articular cartilage, microfracture produces fibrocartilage composed of both type I and type II collagen, which is weaker than native hyaline cartilage (primarily type II collagen). The long-term efficacy and inferior biomechanical properties of the reparative tissue, which can degrade more quickly over time, have been questioned (10). Moreover, this reparative cartilage technique has been less successful in treating larger lesions (>15 mm in diameter) (11–13), many of which often require secondary procedures, such as osteochondral allografting, autografting, or autologous chondrocyte implantation (14–17). However, many of these procedures require an osteotomy for access, result in donor site morbidity at a cartilage harvest site, or require a staged procedure. This associated morbidity has led surgeons to search for other methods to improve the quality of the reparative tissue through minimally invasive techniques with biologic adjuncts, including growth factors, mesenchymal stem cells, and minced allograft tissue.

Juvenile allogenic chondrocyte implantation (JACI) with autologous bone marrow aspirate (BMAC) is a relatively new all-arthroscopic procedure that uses a prepackaged particulated articular cartilage allograft from donors aged 2 to 12 years (DeNovo NT Natural Tissue Graft®; Zimmer, Warsaw, IN). The graft is implanted into the base of the lesion and secured with a fibrin sealant diluted with BMAC. The use of BMAC is indicated, because it has been shown to improve the biomechanical and structural components of the reparative tissue (15,18–20). Immature juvenile chondrocytes have greater metabolic activity and a propensity to regenerate hyaline-like cartilage compared with adult chondrocytes (15,21), giving this repair method the potential to reliably reproduce hyaline cartilage without the morbidity and technical difficulties associated with other restorative techniques. However, few studies have investigated the clinical and radiographic outcomes of this procedure.

Our hypothesis was that the JACI with BMAC (JACI-BMAC) technique would effectively treat critical-size OCLs of the talus, with patients showing statistically and clinically significant improvement after 24 months. The purpose of the present study was to collect the clinical and radiographic outcomes data from patients who had undergone JACI-BMAC for talar OCLs to assess the efficacy of the treatment and evaluate the quality of cartilage repair tissue using magnetic resonance imaging (MRI).

Patients and Methods

Study Population and Design

After approval from our institutional review board, patients were consecutively recruited by all of us from our clinical practices after the diagnosis of a critical-size OCL (≥6 mm widest diameter) or a lesion that had failed conservative treatment or previous bone marrow-stimulation procedures. Patients were excluded if they were smokers, had rheumatoid or inflammatory joint disease, were immunosuppressed, or had uncontrolled diabetes, an autoimmune disorder, or systemic inflammatory disease. We discussed the procedure in detail with each patient and provided a letter detailing the study and information regarding the procedure. After the patients had provided informed consent, we performed a retrospective medical record review. The patient demographic information and whether the patient had a history of trauma to the ankle joint affected by the OCL were recorded. A total of 46 patients met the inclusion criteria and agreed to participate in the present study. Of the 46 patients, 21 were male and 25 were female, with an average age of 37.6 (range 14 to 67) years.

Routine functional outcome scores, including the Foot and Ankle Outcome Score (FAOS) and Short-Form 12-item, version 2 (SF-12v2) score, were collected preoperatively at the last patient visit before surgery and at the 6-, 12-, and 24-month postoperative evaluations. MRI was performed preoperatively and at 12 and 24 months postoperatively.

Table 1
Magnetic resonance observation of cartilage tissue scoring system for evaluation of juvenile allogenic chondrocyte implantation bone marrow aspirate concentrate using DeNovo NT Natural Tissue Graft®

Scoring Category and Variables (Score)	MRI Characteristics
1. Degree of defect infill	
Complete (20)	On level with adjacent cartilage
Hypertrophy (15)	Over level of adjacent cartilage
Incomplete	Under level of adjacent cartilage; underfilling
>50% of Adjacent Cartilage (10)	
<50% of Adjacent Cartilage (5)	
Subchondral Bone Exposed (0)	
2. Integration to border zone	
Complete (15)	Complete integration with adjacent cartilage
Hypertrophy (15)	
Incomplete	Incomplete integration with adjacent cartilage
>50% of Adjacent Cartilage (10)	Presence of fissure or defect
<50% of Adjacent Cartilage (5)	
Subchondral Bone Exposed (0)	
3. Surface of repair tissue	
Surface intact (10)	Lamina splendens intact
Surface damaged	Fibrillations, fissures, and ulcerations
<50% of Repair Tissue Depth (5)	
>50% of Repair Tissue Depth (0)	
Degeneration (0)	
4. Structure of repair tissue	
Homogenous (5)	
Inhomogeneous (0)	
5. Signal intensity of repair tissue	
Isointense (30)	
Moderately hyperintense (10)	
Markedly Hyperintense (0)	
6. Subchondral lamina	
Intact (5)	
Not Intact (0)	
7. Subchondral bone	
Intact (5)	
Not Intact (0)	Edema, granulation tissue, cysts, sclerosis
8. Adhesions	
Yes (0)	
No (5)	
9. Effusion	
Yes (0)	
No (5)	

Scores from 0 to 100 represent the percentage of the total possible achievable score.

MRI Assessment

A radiologist trained in musculoskeletal radiology reviewed all MRI scans and evaluated the articular cartilage morphology using a modified magnetic resonance observation of cartilage tissue (MOCART) score. The MOCART scoring system has been accepted as a reliable method for assessing cartilage repair with low interobserver variability (22). The system uses 9 parameters to evaluate the morphology and signal intensity of the repair tissue compared with the native cartilage (Table 1).

Of the 46 patients who participated in the present study, 22 underwent postoperative MRI studies that could be scored using the MOCART system. MRI scans were performed across multiple institutions largely owing to patient convenience in terms of location and insurance requirements. The MRI scans were performed at our institution (n = 14), in the private radiology facility of 1 of the participating surgeons (n = 4), and at outside facilities (n = 4).

Surgical Technique

The surgical technique was performed as described by Drakos and Murphy (23). The patient is placed supine on the operating table, a tourniquet was applied to the proximal thigh, and general anesthesia and a nerve block were administered. The patient and operative leg were prepared and draped in the standard sterile fashion, with the leg elevated and placed in a positioner to keep the hip and knee flexed at 60° and 70°, respectively. Approximately 60 mL of bone marrow was aspirated from the anterior superior iliac crest and then concentrated in the Magellan Autologous Platelet Separator (Anteriocyte Medical Systems, Cleveland, OH), yielding about 3 mL of BMAC. If bone grafting was necessary owing to the presence of any bony defects below the articular cartilage in the talus, the graft was harvested at this point from either the iliac crest