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Original Research

# Functional Medium-Term Results After Autologous Matrix-Induced Chondrogenesis for Osteochondral Lesions of the Talus: A 5-Year Prospective Cohort Study

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ABSTRACT

Autologous matrix-induced chondrogenesis (AMIC) has gained popularity in the treatment of osteochondral lesions of the talus. Previous studies have presented promising short-term results for AMIC talar osteochondral lesion repair, a 1-step technique using a collagen type I/III bilayer matrix. The aim of the present study was to investigate the mid-term effects. The 5-year results of a prospective cohort study are presented. All patients underwent an open AMIC procedure for a talar osteochondral lesion. Data analysis included general demographic data, preoperative magnetic resonance imaging findings, intraoperative details, and German version of the Foot Function Index (FFI-D) scores preoperatively and at 1 and 5 years after surgery. The primary outcome variable was the longitudinal effect of the procedure, and the influence of various variables on the outcome was tested. Of 47 consecutive patients, 21 (45%) were included. Of the 21 patients, 8 were female (38%) and 13 were male (62%), with a mean age of 37 ± 15 (range 15 to 62) years and a body mass index of 26 ± 5 (range 20 to 38) kg/m$^2$. The defect size was 1.4 ± 0.9 (range 0.2 to 4.0) cm$^2$. The FFI-D decreased significantly from preoperatively to 1 year postoperatively (56 ± 18 versus 33 ± 25; $p = .003$), with a further, nonsignificant decrease between the 1- and 5-year follow-up examination (33 ± 25 versus 24 ± 21; $p = .457$). Similar results were found for the FFI-D subscales of function and pain. The body mass index and lesion size showed a positive correlation with the preoperative FFI-D overall and subscale scores. These results showed a significant improvement in pain and function after the AMIC procedure, with a significant return to sports by the 5-year follow-up point. The greatest improvement overall was seen within the first year; however, further clinical satisfaction among the patients was noticeable after 5 years.


Osteochondral lesions (OCLs) are being more frequently diagnosed owing to the better diagnostic tests available and a better awareness of the symptoms. The intrinsic repair mechanisms are poor; thus, good therapeutic options are needed (1,2). Nonoperative treatment should only be considered for stage I, II, or III lesions using the Berndt and Harty classification. Higher stage lesions show better outcomes with operative treatment. Most likely, the causes for OCLs include vascular necrosis (3), systemic vasculopathy, acute trauma (4), chronic microtrauma (5), endocrine or metabolic factors (6), degenerative joint disease (7), joint malalignment (8), and genetic predisposition (9). The primary goal of operative treatment is to restore the blood circulation and regain joint protection most similar to the original hyaline cartilage. The microfracture method has been a promising therapeutic option but with the notable limitation of lesions >150 mm$^2$ in area or >15 mm in diameter (10,11). The aim of microfracturing is to mobilize progenitor cells from the bone marrow such that repair cartilage can develop to cover the defect. Bone marrow stimulation results in mesenchymal cells from the marrow to create a fibrocartilaginous repair tissue at the site of the lesion (12).

Lesions >150 mm$^2$ in area or >15 mm in diameter require a different treatment approach. Osteochondral autologous transplantation and autologous chondrocyte implantation (ACI) are new therapeutic options

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for large lesions (13). Both options harvest cartilage cells from a donor site separate from the location of the actual lesion. ACI is a 2-step procedure that is time consuming and expensive. Recently, a study by Buda et al (14) showed no advantage for ACI compared with bone marrow-derived cell transplantation. They also reported the preferred use of bone marrow-derived cell transplantation compared with ACI (14). Because of limitations, such as sacrificing healthy cartilage, multiple-stage operations, the high cost, and limited graft availability, alternative methods to repair OCLs are needed. Autologous matrix-induced chondrogenesis (AMIC) meets this need by addressing the limitations of other OCL repair methods. AMIC was first described in 1999 by Behrens et al (15) and uses a collagen type I/III bilayer matrix (Chondro-Gide®; Geistlich Pharma AG, Wolhusen, Switzerland) to stabilize the super clot on top of the lesion after microfracturing (16). In AMIC, the matrix is secured at its location using commercially available fibrin glue. After microfracture, mesenchymal progenitor cells migrate toward and adhere to the porous layer of the matrix. With the matrix in place, the loss of cells through leakage into the joint space can be avoided. Also, mechanical stress on the cells in the regeneration zone will be minimized. The combined use of the AMIC matrix and the fibrin glue (Tissucol or Tisseel; Baxter Healthcare, Deerfield, IL) support the chondrogenic differentiation of human mesenchymal stem cells and significantly enhance proteoglycan deposition (17,18).

Although fibrin glue has been used in surgical procedures for more than a decade, serving a variety of purposes, such as sutureless closure of colonic defects (19), corneal lamellar healing (20), bone repair (21,22), and reconstruction of focal cartilage defects (23), its use is not without controversy. A study by Filardo et al (24) showed improvement in postoperative scaffold stability and integrity using fibrin glue. Wang et al (25), however, reported that a bone matrix gelatin and fibrin glue scaffold showed signs of degradation after 8 weeks despite the presence of supporting chondrocyte attachment, proliferation, and biosynthesis of cartilaginous matrix components. Another study proposed that fibrin sealant supports the migration and proliferation of human chondrocytes via thrombin (26).

Although the AMIC procedure seems to have a beneficial effect on OCLs of the talus, diverse results of microfracture and AMIC use have been presented. In a sheep model, Beck et al (27) used a different collagen membrane and showed bone cyst formation after microfracturing with a communication present between the drilling holes and the cysts. Another study, by Zhang et al (28), demonstrated with a short-term follow-up period that the clinical symptoms had significantly improved. Specifically, magnetic resonance imaging (MRI) showed that defect coverage of the lesion of $\leq$75%, with hyaline-like cartilage tissue, was achieved (28).

The different approaches available to examine the effect of AMIC outcomes have been of recent interest. New studies have reported good results for all arthroscopic uses of AMIC (29,30). MRI examination of AMIC-treated patients during a short-term follow-up period showed differences in the collagen matrix and cartilage present (31), with lower glycosaminoglycan content than present in normal hyaline cartilage (32). In patients with high function demands and the need for pain-free joints, such as athletes and patients with increased activity levels, AMIC intervention has provided good results (33,34).

Therefore, the aim of our study was to investigate the mid-term outcomes at the 5-year follow-up point on pain and function in patients who had undergone the AMIC procedure.

## Patients and Methods

### *Study Design*

We performed a cohort study from a single specialized orthopedic foot and ankle clinic using prospective 5-year follow-up data. The institutional review board approved the present study. Patients were included after providing informed consent.

### *Patients*

Of 47 consecutive patients undergoing an open AMIC procedure for a talar OCL without malleolar osteotomy from June 2010 to December 2011, 21 (45%) were included in the study cohort. The exclusion criteria were generalized degenerative changes in the joint, cartilage defects in the corresponding opposite joint surface, inflammatory joint disease, crystal arthropathy, neuroarthropathy, or 5-year follow-up data missing.

### *Surgical Technique*

Preoperative MRI scans of the ankle were used for assessment of cartilage lesions, possible subchondral cysts, areas of necrotic bone, and other accompanying pathologic entities (Figs. 1 and 2).

In all patients, the skin incision was performed using a ventral approach, depending on the location of the defect (either a ventromedial approach between the medial malleolus and the anterior tibial tendon or a ventrocentral approach between the anterior tibial and the extensor hallucis longus tendon). After dissection to the level of the joint capsule, the joint was opened by a longitudinal incision. A 2.0-mm Kirschner wire was drilled into the distal tibia and a second one parallel to it in the talus. Unstable cartilage was radically debrided. All necrotic bone was removed, and any cysts were curetted (Fig. 3). The underlying sclerotic zone was perforated using multiple small drill holes (1.2-mm Kirschner wire) with adequate cooling or microfracture. The osseous defect was reconstructed to the level of the subchondral bone lamella using autologous cancellous bone.

The defect size was measured with the help of aluminum foil, which was pressed into the defect with forceps such that the borders of the cartilage were clearly depicted. The aluminum foil was then cut to size and its exact fit was verified. The collagen matrix, hydrated in a physiologic saline solution, was cut to shape with the help of the template. When hydrated, the matrix expands by 10% to 15%. The matrix has a rough side, which was placed facing the bone, with the smooth side facing the joint. The cancellous bone graft was covered with commercially available fibrin glue, and the collagen matrix was glued onto it (Fig. 4).

Finally, the joint was closed in layers using resorbable suture material. A drain without suction was inserted, when necessary.

### *Postoperative Management*

The operated ankle was completely immobilized at 90° for 48 hours. The drain, if inserted, was removed within the 48-hour period, and continuous passive motion exercises, limited to the 20°-0°-20° range, were started. A splint was used for 2 weeks until wound healing was complete. Partial weightbearing of 10 kg for the first 6 weeks was advised. Thereafter, a stepwise increase in weightbearing, increasing by 10 to 15 kg each week, up to week 12 was allowed. From week 13 onward, the patient was permitted to incur stress from activities of daily living, cycling, and swimming. Patients

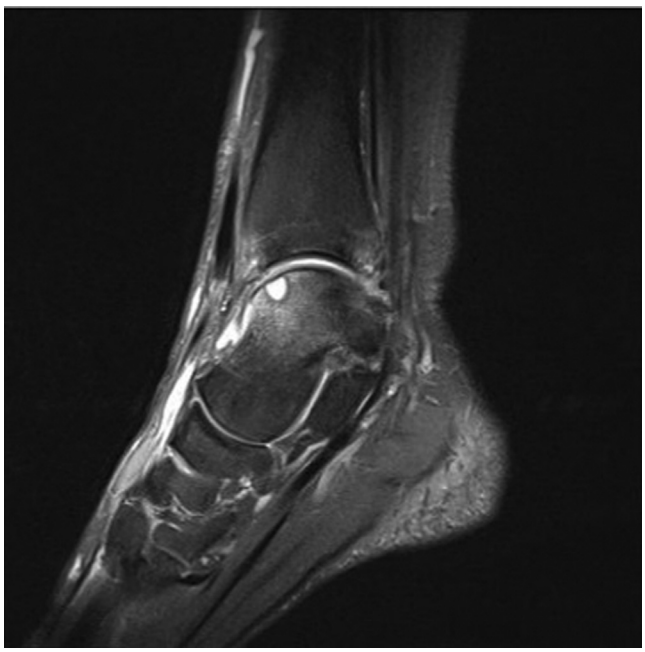

**Fig. 1.** Preoperative magnetic resonance image, sagittal view, of medial osteochondral lesion.