Autologous Matrix-induced Chondrogenesis in Osteochondral Lesions of the Talus

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KEYWORDS

• AMIC • Talus • Osteochondral lesion • SPECT-CT

KEY POINTS

• Recurrent ankle sprains and other trauma as well as ankle malalignment can lead to chronic osteochondral lesions (OCLs) of the talus.
• Several operative treatment techniques exist; however, the choice of the right procedure is difficult.
• This article presents a new surgical technique suitable for treatment of OCLs that combines bone plasty and a collagen matrix.

INTRODUCTION

Recurrent ankle sprains are frequently encountered in young people active in sports. Although acute ankle sprains are known to cause acute talar chondral lesions,\textsuperscript{1} chronic instability resulting from recurrent sprains is suspected as the major cause of chronic talar osteochondral lesions (OCLs).\textsuperscript{2}

Previous trauma is reported as the main cause of OCLs in lateral lesions (93\%–98\%) and less so in medial lesions (61\%–70\%).\textsuperscript{3,4} Nontraumatic OCLs have been described in identical twins and siblings.\textsuperscript{5,6} Etiologic factors other than genetics include talar malrotation/tilt (medial-posterior talar OCLs in posterior tibial tendon insufficiency or medial ankle instability), ankle malalignment (posttraumatic varus or valgus ankle), ischemia with necrosis, and endocrine or vascular factors.\textsuperscript{3,7,8}

Conservative treatment fails frequently.\textsuperscript{8–10} Common operative treatment methods include débridement and microfracturing,\textsuperscript{11} osteochondral autograft transfer system

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and mosaicplasty,12–14 matrix-induced autologous chondrocyte transplantation,15 autologous chondrocyte implantation,16 and bulk allograft transplantation.17 Although good results have been reported, only two of those techniques (osteochondral auto-
graft transfer system and allograft) take into account the reconstruction of large bony
defect present in large cystic lesions.

The aim of this article is to demonstrate a novel treatment approach for OCLs of the
talus following the principle of the autologous matrix-induced chondrogenesis (AMIC).
This technique was first reported by Behrens and colleagues18,19 in 2005 and 2006 for
treatment of full-thickness chondral lesions in the knee joints. An acellular collagen I/III
matrix is placed onto the blood clot generated by microfracturing to provide a suitable
environment for cartilage regeneration. Clinical results with up to 5 years’ follow-up
were encouraging.20 Contrary to knee cartilage lesions, OCL of the talus often involves
degeneration of the subchondral bone tissue. Large cysts are frequently found and
need to be addressed during surgery. The authors, therefore, modified the existing
AMIC technique by adding an additional step to reconstruct the bony defect after
débridement of the cysts. Spongiosa is harvested from a suitable site (iliac crest or
distal tibia [through the medial malleolus osteotomy window]) and is used to fill out
the defect. The collagen matrix is placed on top to seal the spongiosa from the joint
cavity.

**Indications and Contraindications**

**Inclusion criteria**
- Purely chondral and OCLs
- All stages according to the CT classification by Hepple and colleagues21
- Lesion >1.0 cm²
- Patients ages 18 to 55 years
- Primary and revision procedure

**Exclusion criteria**
- Metabolic arthropathies
- Kissing lesions
- Major, nonreconstructable defects
- Noncorrectable hindfoot malalignment
- Chronic inflammatory systemic disorders
- Obesity (body mass index >30)

**Preoperative Planning**

Clinical examination of the ankle joint includes documentation of range of motion,
sagittal and inversion/eversion stability, location of pressure pain, and alignment of
the hindfoot.

Initial diagnostic imaging of the foot and ankle consist of plain radiographs (weight-
bearing standard anteroposterior/lateral radiographs, Saltzman and el-Khoury view22)
to assess alignment and exclude other pathologies than an OCL. MRI is performed to
examine the condition of the cartilage and accompanying soft tissue pathologies. To
adequately assess the extent of the bony lesion and amount of remodeling activity, the
authors additionally perform a technetium Tc 99m dicarboxypropane diphosphonate
single-photon emission CT–CT (SPECT-CT). Integrated hybrid systems like the
SPECT-CT are a new approach, allowing acquisition of functional SPECT and
anatomic CT images in a single diagnostic procedure.23 The authors use SPECT-CT
as part of a routine algorithm for diagnostics of all degenerative joint disease of the
foot and ankle joints. In cases of no scintigraphic uptake at the OCL, the lesion is not surgically addressed and the focus of surgical treatment is on instability and malalignment correction.

**Operative Technique**

The procedure can be performed either in spinal or general anesthesia in supine position. A tourniquet is applied. An initial arthroscopy of the ankle joint is performed to verify the size and location of the defect and the condition of the lateral and medial ankle ligaments. A standard anteromedial or anterolateral approach for arthrotomy is used, depending on OCL location (Fig. 1A). If the OCL cannot be accessed after capsular incision, a malleolar osteotomy should be performed. After the lesion has been exposed, the defective cartilage and the typically necrotic and sclerotic bony lesion underneath need to be débrided and microdrilled (see Fig. 1B–D). In cases of subchondral cysts, the fibrotic tissue within the cysts needs to be fully removed and the sclerotic cyst walls microdrilled. Sequentially, spongiosa bone is harvested from the iliac crest (alternatively, the distal tibia through the medial malleolus osteotomy) (see Fig. 1E). The spongiosa is impacted into the bony defect to fill it up. Next, a commercially available acellular collagen I/III matrix of porcine origin (Chondro-Gide, Geistlich Surgery, Wolhusen, Switzerland) is prepared. An aluminum template is used to determine the size of the lesion on the talus situs. The matrix is cut to size and then glued over the spongiosa with commercially available fibrin glue (Tissucol, Baxter, Deerfield, Illinois). For the knee joint, Drobnic and colleagues showed that fibrin glue fixation provides primary stability, which is comparable to suture fixation of a collagen membrane. Care is taken not to overlap the surrounding healthy cartilage with the matrix (see Fig. 1F). Then, the ankle is moved several times throughout the whole range of motion and correct positioning of the membrane is checked.

If preoperative examination and radiographs show malalignment of the hindfoot, corrective osteotomies (calcaneal or supramalleolar) can be performed. If ankle joint instability is noted during clinical examination and confirmed by ankle arthroscopy, ligament repair using a modified Brostrom-Gould procedure is recommended.

**Postoperative Care**

Postoperative care consists of immobilization using a walker (Aircast Walker, DJO Global, Vista, California) and functional physiotherapy with 15 kg partial weight bearing, maximal range of motion of 20° with a continuous passive motion machine, and lymphatic drainage massage for the first 6 weeks. This initial phase is followed by an intensive rehabilitation phase with progression to full weight bearing and strengthening of the ankle joint stabilizing lower leg muscles and proprioception training for the following 6 weeks (up to 12 weeks). The patients are seen in an outpatient clinic 6 and 12 weeks after the surgery for a clinical follow-up examination and conventional radiographs. After 12 weeks, light sports exercising (swimming and cycling) are allowed. Return to competitive sports after 5 to 6 months. Postoperative care is identical for cases with corrective osteotomy and/or ligament reconstruction.

**DISCUSSION**

Only a few reports exist evaluating the clinical outcome after AMIC-aided treatment of talar OCL. The technique was initially described in a case report by Wiewiorski and colleagues in 2011. Valderrabano and colleagues reported approximately 15 cases...
Fig. 1. Case of a 25-year-old man with posttraumatic OCL. Preoperative imaging (A–D): conventional radiographs (A) show a large partly detached fragment at the lateral talar edge; MRI with frontal fat-suppressed T1 images (B) reveals the cystic nature of the lesion, whereas sagittal T2 images (C) show the centrolateral location and impressing anteroposterior extent and depth of the lesion; and SPECT-CT shows highly increased bone uptake in and around the lesion (D). The total volume of the bony defect was calculated as 7054 mm³. Surgical procedure (E–H): arthotomy revealed a highly unstable osteochondral fragment, which was bluntly removed (E); the subchondral cysts seen on MRI and SPECT-CT were opened, cleaned of all fibrotic tissue, and microfractured (F); spongiosa from the iliac crest was impacted into the defect (G); the collagen matrix was glued on top of the spongiosa graft (H); and the surgery was finalized with a mediolateral ligamentoplasty and a medial sliding calcaneal osteotomy. Postoperative imaging at 4 years’ follow-up (I–K): conventional radiographs show good integration of the graft into the talus (I); sagittal T1 fat-suppressed MRI shows a minor residual bone marrow edema (J); and a sagittal DESS sequence shows a complete defect repair with an intact surface and nearly normal signal intensity (K).
with first-time surgery at 12 months' follow-up. The American Orthopaedic Foot and Ankle Society hindfoot score improved significantly from 63.1 points preoperatively to 86 points on follow-up. Walther and colleagues\textsuperscript{31} reported approximately 42 cases with a minimum follow-up time of 12 months. In this cohort, the American Orthopaedic Foot and Ankle Society hindfoot score improved from 47.3 points to 88.3 points. A single report describes the use of the AMIC technique in a talar OCL revision case\textsuperscript{32} and in a case of a rare isolated OCL of the distal tibia.\textsuperscript{33} Other reports regarding the AMIC-aided cartilage repair technique focus on operative treatment of trochlear and retropatellar cartilage lesions of the knee joint.\textsuperscript{34,35} Several clinical outcome studies have reported good results for short-term follow-up.\textsuperscript{36–38} Those studies, however, addressed solely cartilaginous lesions, not combined OCLs.

The currently used operative techniques for treatment of OCLs of the talus face certain drawbacks: sacrificing healthy cartilage (osteochondral autograft transfer system and mosaicplasty), multiple-stage operative procedures (matrix-induced autologous chondrocyte transplantation and autologous chondrocyte implantation), high costs (autologous chondrocyte implantation and allograft), and limited availability (allograft). The AMIC procedure provides 2 major advantages. First, it is a 1-step procedure with no need of cartilage harvesting, potentially leading to donor site morbidity. Second, it is cost effective with no need of in vitro cell expansion.

In the described technique, cancellous bone is used to reconstruct the osseous lesion. Cancellous bone grafting for OCLs of the talus has been described elsewhere.\textsuperscript{39,40} The rationale behind this procedure is to allow cartilage regeneration on the base of healthy bony tissue. Because cancellous bone makes a loose nonstructural graft, the authors believe that a bony reconstruction can be successfully achieved only with an adequate sealing of the graft tissue against the joint cavity, in this case with a collagen matrix. To ensure the bone graft healing properly, all fibrotic tissue from underneath the diseased cartilage needs to be removed. An open approach with an optional malleolar osteotomy may be needed to address centrally or posteriorly located large cystic lesions appropriately. An arthroscopic approach for the AMIC-technique, however, has also been described previously for the knee\textsuperscript{41} and talus.\textsuperscript{42}

The authors emphasize the importance for additional procedures. Most talus OCLs are posttraumatic conditions and are frequently accompanied by instability or hindfoot malalignment. Aurich and colleagues\textsuperscript{43} regard concomitant treatment of posttraumatic deformities (malalignment), ligamentous instabilities, and the reconstruction of bony defects as compulsory. The authors share the same view. Changing a pathomechanical joint into an almost normal biomechanical joint by correcting osseous malalignment (eg, calcaneal ostetomies) and improving joint stability (lateral/medial ankle ligament reconstruction; posterior tibial tendon reconstruction) might be essential for healing of the reconstructed defect. Otherwise, remaining pathologic stress on the repair tissue could eventually lead to graft failure and new pain symptoms. Evidence for this is sparse, however. Ligament repair in cases of talus OCL accompanied by ankle joint instability has been previously described in a few cases.\textsuperscript{44,45} Regarding corrective osteotomies, Giannini and colleagues\textsuperscript{45} report 1 case of metatarsal osteotomy in the presence of a cavus foot.

SUMMARY

The modified AMIC technique is a promising novel method for operative treatment of OCLs of the talus. A conclusion regarding advantage over other treatment methods, however, cannot be made at this point due to lack of evidence.
REFERENCES


