Autologous Matrix-induced Chondrogenesis in Osteochondral Lesions of the Talus

Martin Wiewiorski, MD[a,b], Alexej Barg, MD[a],
Victor Valderrabano, MD, PhD[a,*]

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,[1] chronic instability resulting from recurrent sprains is suspected as the major cause of chronic talar osteochondral lesions (OCLs).[2]

Previous trauma is reported as the main cause of OCLs in lateral lesions (93%–98%) and less so in medial lesions (61%–70%).[3,4] Nontraumatic OCLs have been described in identical twins and siblings.[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.[3,7,8]

Conservative treatment fails frequently.[8–10] Common operative treatment methods include débridement and microfracturing,[11] osteochondral autograft transfer system

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 autograft 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 colleagues[18,19] 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 colleagues[21]
- Lesion >1.0 cm^2
- 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 view[22]) 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.[24] 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. 1**A). 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. 1**B–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. 1**E). 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[25] 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. 1**F). 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.[26,27] If ankle joint instability is noted during clinical examination and confirmed by ankle arthroscopy, ligament repair using a modified Brostrom-Gould procedure is recommended.[28]

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 anthe 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.[29] Valderrabano and colleagues[30] reported approximately 15 cases
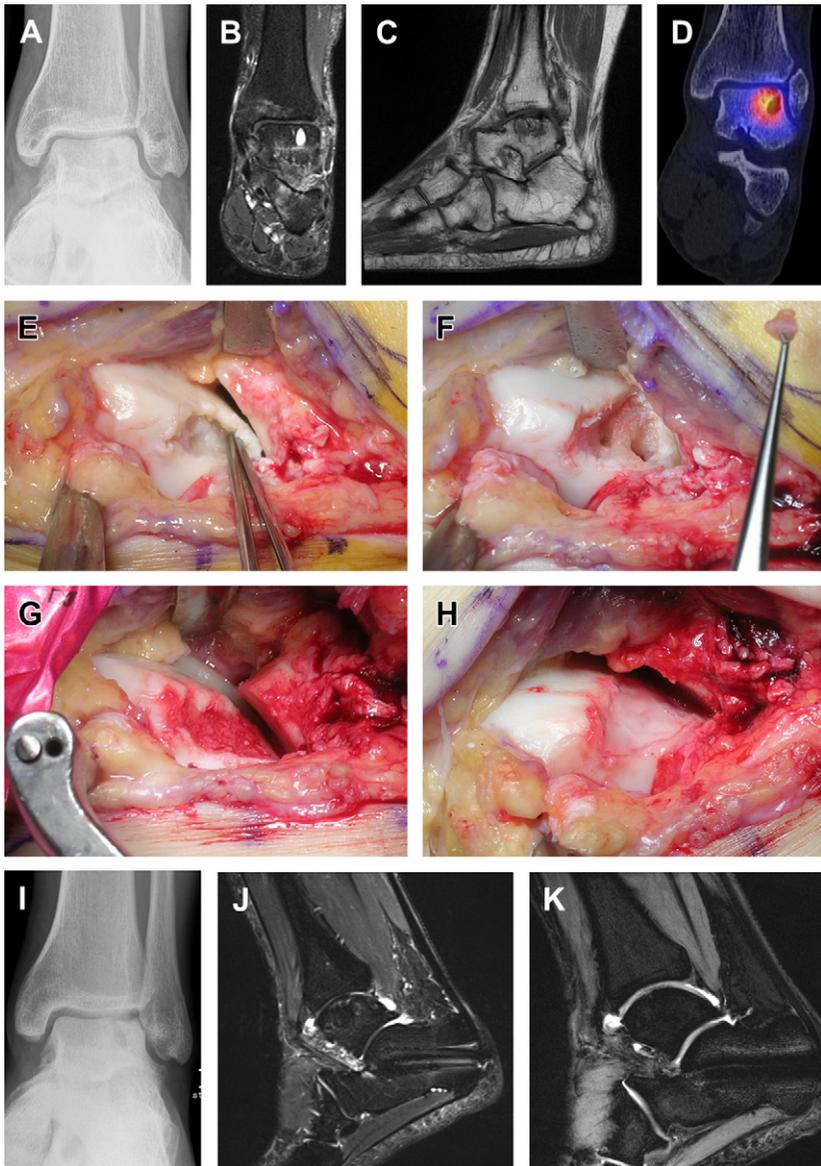
Fig. 1. Case of a 25-year-old man with posttraumatic OCL. Preoperative imaging (*A–D*): conventional radiographs (*A*) show a large partly detached fragment at the lateral talar edge; MRI with frontal fat-supressed T1 images (*B*) reveals the cystic nature of the lesion, whereas sagittal T2 images (*C*) 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[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[32] and in a case of a rare isolated OCL of the distal tibia.[33] Other reports regarding the AMIC-aided cartilage repair technique focus on operative treatment of trochlear and retropatellar cartilage lesions of the knee joint.[34,35] Several clinical outcome studies have reported good results for short-term follow-up.[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.[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[41] and talus.[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[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.[44,45] Regarding corrective osteotomies, Giannini and colleagues[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

1. Taga I, Shino K, Inoue M, et al. Articular cartilage lesions in ankles with lateral ligament injury. An arthroscopic study. Am J Sports Med 1993;21(1):120–6 [discussion: 126–7].
2. Hintermann B, Boss A, Schafer D. Arthroscopic findings in patients with chronic ankle instability. Am J Sports Med 2002;30(3):402–9.
3. Verhagen RA, Struijs PA, Bossuyt PM, et al. Systematic review of treatment strategies for osteochondral defects of the talar dome. Foot Ankle Clin 2003;8(2):233–42, viii–ix.
4. Flick AB, Gould N. Osteochondritis dissecans of the talus (transchondral fractures of the talus): review of the literature and new surgical approach for medial dome lesions. Foot Ankle 1985;5(4):165–85.
5. Anderson DV, Lyne ED. Osteochondritis dissecans of the talus: case report on two family members. J Pediatr Orthop 1984;4(3):356–7.
6. Woods K, Harris I. Osteochondritis dissecans of the talus in identical twins. J Bone Joint Surg Br 1995;77(2):331.
7. Abu-Shakra M, Buskila D, Shoenfeld Y. Osteonecrosis in patients with SLE. Clin Rev Allergy Immunol 2003;25(1):13–24.
8. Canale ST, Belding RH. Osteochondral lesions of the talus. J Bone Joint Surg Am 1980;62(1):97–102.
9. Hakimzadeh A, Munzinger U. 8. Osteochondrosis dissecans: results after 10 or more years. c). Osteochondrosis dissecans of the ankle joint: long-term study. Orthopade 1979;8(2):135–40 [in German].
10. Pettine KA, Morrey BF. Osteochondral fractures of the talus. A long-term follow-up. J Bone Joint Surg Br 1987;69(1):89–92.
11. Steadman JR, Rodkey WG, Rodrigo JJ. Microfracture: surgical technique and rehabilitation to treat chondral defects. Clin Orthop Relat Res 2001;(Suppl 391):S362–9.
12. Hangody L. The mosaicplasty technique for osteochondral lesions of the talus. Foot Ankle Clin 2003;8(2):259–73.
13. Hangody L, Kish G, Modis L, et al. Mosaicplasty for the treatment of osteochondritis dissecans of the talus: two to seven year results in 36 patients. Foot Ankle Int 2001;22(7):552–8.
14. Imhoff AB, Paul J, Ottinger B, et al. Osteochondral transplantation of the talus: long-term clinical and magnetic resonance imaging evaluation. Am J Sports Med 2011;39(7):1487–93.
15. Ronga M, Grassi FA. Treatment of deep cartilage defects of the ankle with matrix-induced autologous chondrocyte implantation (MACI). Foot Ankle Surg 2005;11:29–33.
16. Giannini S, Buda R, Grigolo B, et al. Autologous chondrocyte transplantation in osteochondral lesions of the ankle joint. Foot Ankle Int 2001;22(6):513–7.
17. Raikin SM. Fresh osteochondral allografts for large-volume cystic osteochondral defects of the talus. J Bone Joint Surg Am 2009;91(12):2818–26.
18. Behrens P. Matrixgekoppelte Mikrofrakturierung. Arthroskopie 2005;18:193–7.
19. Behrens P, Bitter T, Kurz B, et al. Matrix-associated autologous chondrocyte transplantation/implantation (MACT/MACI)—5-year follow-up. Knee 2006;13(3):194–202.
20. Gille J, Schuseil E, Wimmer J, et al. Mid-term results of Autologous Matrix-Induced Chondrogenesis for treatment of focal cartilage defects in the knee. Knee Surg Sports Traumatol Arthrosc 2010;18(11):1456–64.

21. Hepple S, Winson IG, Glew D. Osteochondral lesions of the talus: a revised classification. Foot Ankle Int 1999;20(12):789–93.
22. Saltzman CL, el-Khoury GY. The hindfoot alignment view. Foot Ankle Int 1995; 16(9):572–6.
23. Carlsson AM. Assessment of chronic pain. I. Aspects of the reliability and validity of the visual analogue scale. Pain 1983;16(1):87–101.
24. Wiewiorski M, Pagenstert G, Rasch H, et al. Pain in osteochondral lesions. Foot Ankle Spec 2011;4(2):92–9.
25. Drobnic M, Radosavljevic D, Ravnik D, et al. Comparison of four techniques for the fixation of a collagen scaffold in the human cadaveric knee. Osteoarthr Cartil 2006;14(4):337–44.
26. Knupp M, Stufkens SA, Bolliger L, et al. Classification and treatment of supramalleolar deformities. Foot Ankle Int 2011;32(11):1023–31.
27. Pagenstert G, Leumann A, Hintermann B, et al. Sports and recreation activity of varus and valgus ankle osteoarthritis before and after realignment surgery. Foot Ankle Int 2008;29(10):985–93.
28. Brostrom L. Sprained ankles. VI. Surgical treatment of "chronic" ligament ruptures. Acta Chir Scand 1966;132(5):551–65.
29. Wiewiorski M, Leumann A, Buettner O, et al. Autologous matrix-induced chondrogenesis aided reconstruction of a large focal osteochondral lesion of the talus. Arch Orthop Trauma Surg 2011;131(3):293–6.
30. Barg A, Miska M, Wiewiorski W, et al. Autologous Matrix-induced Chondrogenesis (AMIC) for Reconstruction of Osteochondral Lesions of the talus. Presented at the 18th Annual Meeting of German Society of Foot and Ankle Surgery. Dresden, Germany, March 23, 2012.
31. Walther M. Treatment option in osteochondral lesions: open ACT/AMIC. Presented at the 18th Annual Meeting of German Society of Foot and Ankle Surgery. Dresden, Germany, March 23, 2012.
32. Wiewiorski M, Miska M, Nicolas G, et al. Revision of failed osteochondral autologous transplantation procedure for chronic talus osteochondral lesion with iliac crest graft and autologous matrix-induced chondrogenesis: a case report. Foot Ankle Spec 2012;5(2):115–20.
33. Miska M, Wiewiorski M, Valderrabano V. Reconstruction of a Large Osteochondral Lesion of the Distal Tibia with an Iliac Crest Graft and Autologous Matrix-induced Chondrogenesis (AMIC): a case report. J Foot Ankle Surg 2012;51(5):680–3.
34. Benthien JP, Behrens P. Autologous Matrix-Induced Chondrogenesis (AMIC): combining microfracturing and a collagen I/III matrix for articular cartilage resurfacing. Cartilage 2010;1:65–8.
35. Benthien JP, Behrens P. Autologous matrix-induced chondrogenesis (AMIC). A one-step procedure for retropatellar articular resurfacing. Acta Orthop Belg 2010;76(2):260–3.
36. Steinwachs M, Kreuz PC. Autologous chondrocyte implantation in chondral defects of the knee with a type I/III collagen membrane: a prospective study with a 3-year follow-up. Arthroscopy 2007;23(4):381–7.
37. Niemeyer P, Pestka JM, Kreuz PC, et al. Characteristic complications after autologous chondrocyte implantation for cartilage defects of the knee joint. Am J Sports Med 2008;36(11):2091–9.
38. Gooding CR, Bartlett W, Bentley G, et al. A prospective, randomised study comparing two techniques of autologous chondrocyte implantation for osteochondral defects in the knee: periosteum covered versus type I/III collagen covered. Knee 2006;13(3):203–10.

39. Lahm A, Erggelet C, Steinwachs M, et al. Arthroscopic management of osteo-chondral lesions of the talus: results of drilling and usefulness of magnetic resonance imaging before and after treatment. Arthroscopy 2000;16(3): 299–304.
40. Taranow WS, Bisignani GA, Towers JD, et al. Retrograde drilling of osteochondral lesions of the medial talar dome. Foot Ankle Int 1999;20(8):474–80.
41. Piontek T, Ciemniewska-Gorzela K, Szulc A, et al. All-arthroscopic AMIC procedure for repair of cartilage defects of the knee. Knee Surg Sports Traumatol Arthrosc 2012;20(5):922–5.
42. Walther M, Becher C, Volkering C, et al. Therapie chondraler und osteo-chondraler Defekte am Talus durch Autologe Matrix Induzierte Chondrogenese. Fuss Sprungg 2012;10(2):121–9.
43. Aurich M, Venbrocks RA, Fuhrmann RA. Autologous chondrocyte transplantation in the ankle joint. Rational or irrational? Orthopade 2008;37(3):188, 190–5. [in German].
44. Kono M, Takao M, Naito K, et al. Retrograde drilling for osteochondral lesions of the talar dome. Am J Sports Med 2006;34(9):1450–6.
45. Giannini S, Buda R, Faldini C, et al. Surgical treatment of osteochondral lesions of the talus in young active patients. J Bone Joint Surg Am 2005;87(Suppl 2):28–41.