

Arthroscopic Minced Cartilage Implantation for Chondral Lesions at the Talus: A Technical Note



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Abstract: In the past few years, autologous chondrocyte implantation has been shown to be the most suitable cartilage reconstructive technique with the best tissue quality. Although this method is part of the standard surgical repertoire in the knee joint, it has so far not been an established method in the ankle because there are no prospective randomized controlled studies to prove a significant advantage over alternative methods of cartilage repair. The methods most frequently used in this context (e.g., marrow stimulation techniques) can, however, at most generate hyaline-like and thus biomechanically inferior regenerates. Minced cartilage implantation, on the other hand, is a relatively simple and cost-effective 1-step procedure with promising biological potential and—at least in the knee joint—satisfactory clinical results. We present an arthroscopic surgical technique by which the surgeon can apply autologous chondrocytes in a 1-step procedure (AutoCart; Arthrex, Munich, Germany) to treat articular cartilage defects in the ankle joint.

Osteochondral lesions of the talus can occur spontaneously, as a result of acute and chronic instability of the ankle, or accompanying an ankle fracture. The incidence is estimated at 38% to 71% in the fracture situation and at 6.5% in acute instability cases.¹⁻³ Even if a traumatic genesis is the leading etiologic factor, various disease-inducing influences have been described in the literature.^{4,5}

Dissections with an intact cartilage shoulder remaining in situ are primarily treated conservatively.⁶ When conservative management fails or when the lesion is

not originally thought to be amenable to operative management, surgical treatment is indicated.⁷

Symptomatic cartilage defects across the ankle joint are currently treated with different cartilage repair techniques.⁸ The body of evidence regarding ankle cartilage repair techniques is based on both low-level and low-quality evidence.⁹ At the moment, treatment of cartilage defects of the ankle is still controversial.

Generally, there is growing evidence that repair tissue quality is related to clinical outcomes.^{9,10} The highest-possible repair tissue quality is connected to cell-based cartilage repair techniques.¹¹⁻¹³ These include autologous chondrocyte implantation (ACI) and autologous particulate cartilage chips (minced cartilage implantation [MCI]).¹⁴ As part of the ACI in a 2-step procedure, culture-expanded autologous chondrocytes are seeded on a scaffold, which is then secured in the lesion.^{8,15} A significant disadvantage of this procedure is that 2 interventions are necessary. Furthermore, it is known to have high costs and limited availability.¹⁶ In contrast, MCI is a 1-step off-the-shelf procedure and must therefore be assessed as an attractive alternative to other cartilage repair techniques.¹⁶⁻¹⁸ MCI is indicated in the knee joint for all (contained, isolated, and unipolar) lesion sizes and can also be applied in osteochondral defects.¹⁹ To what extent this observation also applies to the ankle is unclear. Previous descriptions of the procedure have concentrated exclusively on fresh particulate juvenile allograft chondrocytes transplanted at the lesion site.^{7,20-23} The application as an autologous cartilage

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reconstructive procedure, however, has not yet been described. The aim of this Technical Note is to present autologous minced cartilage transplantation via an arthroscopic approach.

Surgical Technique

The technique can be applied arthroscopically to all symptomatic full-thickness cartilage defects of the ankle joint when the defect zone is accessible to the arthroscopic approach (Video 1). The treatment of a subchondral cyst area is not part of this Technical Note but can also be performed arthroscopically if necessary. In general, the technique can also be performed with an open approach.

The technique presented in this article for a typical lesion of the medial talar shoulder (Fig 1) can also be carried out in other talar regions or on the tibial plafond. Coexisting pathologies such as ligamentous instability and mechanical axis malalignment of the hindfoot are crucial to be identified and treated sufficiently. Such intervention can be performed simultaneously.

Perioperative antibiotic prophylaxis is recommended yet not without conflicting evidence. To avoid negative effects on the platelet-rich plasma (PRP), it is recommended to perform blood drawing (e.g., cubital veins) under sterile conditions before anesthesia is initiated; 10 to 15 mL of PRP is required.

The patient position is supine. Use of a tourniquet is recommended to implant the cartilage under bloodless circumstances. Standard diagnostic ankle arthroscopy (Fig 2 A and B) is performed to address any



Fig 1. Left side, preoperative magnetic resonance imaging showing full-thickness cartilage defect of medial talar shoulder in sagittal plane. The arrows point to the defect area.

concomitant intra-articular pathology. As soon as the defect is identified and the decision is made to perform treatment with minced cartilage via the AutoCart procedure (Arthrex, Munich, Germany), the defect must be prepared meticulously and suitable donor cartilage must be harvested. The use of degenerative cartilage or synovium for further transplantation is not recommended. Degenerative synovial and fibrous tissue parts are removed with a shaver device, thus determining the extent of the defect. The cartilage defect is debrided in a standardized fashion by using a small sharp spoon or ringed curette. After standard debridement of the lesion, the cartilage can subsequently be harvested at this location. The aim is to preserve and harvest vital cartilage areas for transplantation while creating vertical defect margins. The typical and recommended harvest site is the cartilage defect edge. Loose or unattached but visually vital cartilage parts can be included in the removal (Fig 2 C and D). The defect itself should be only minimally enlarged if not enough cartilage can be collected in the surrounding area. Aurich et al.⁵ described a superior redifferentiation of chondrocytes harvested from the edge of the defect compared with non-weight-bearing regions in the knee joint.

It is recommended to harvest cartilage with a 3.0-mm shaver device. A collecting device (e.g., Arthrex Graft-Net) is connected in advance to the shaver for harvesting. By use of this method, cartilage is harvested and then minced into small fragments (paste-like) and collected at once.^{24,25} Subsequently, the minced cartilage chips are mixed with 2 to 3 drops of PRP, resulting a pasty substance. An applicator (obturator) device is loaded with the mixture of chips and PRP. After loading, 3 mL of PRP is inserted into the Thrombinator system (Arthrex) and is gently mixed. After 10 to 15 minutes of incubation, autologous thrombin will be generated. After application of another 5 mL of PRP into the same device, the thrombin will be ready for application onto the defect bed. At the end of the procedure, arthroscopic water influx is discontinued and the joint is dried using swabs or similar devices (Fig 2E).

Any subchondral cancellous bone substitute that may be necessary is distributed in the defect bed and applied in a press-fit manner. The defect filling should be performed to the level of the adjacent subchondral bone. The cancellous bone can also be mixed with PRP if necessary.

The autologous chips are brought into the defective region by using the applicator device (Fig 2 F and G). The chip-PRP paste is distributed over the defect as a whole for complete coverage. It is not necessary to fill to the height of the surrounding cartilage edge; approximately 80% to 90% filling is sufficient. The consistency of the chip paste will provide initial stability. In the next step, the thrombin that has just been gathered from the

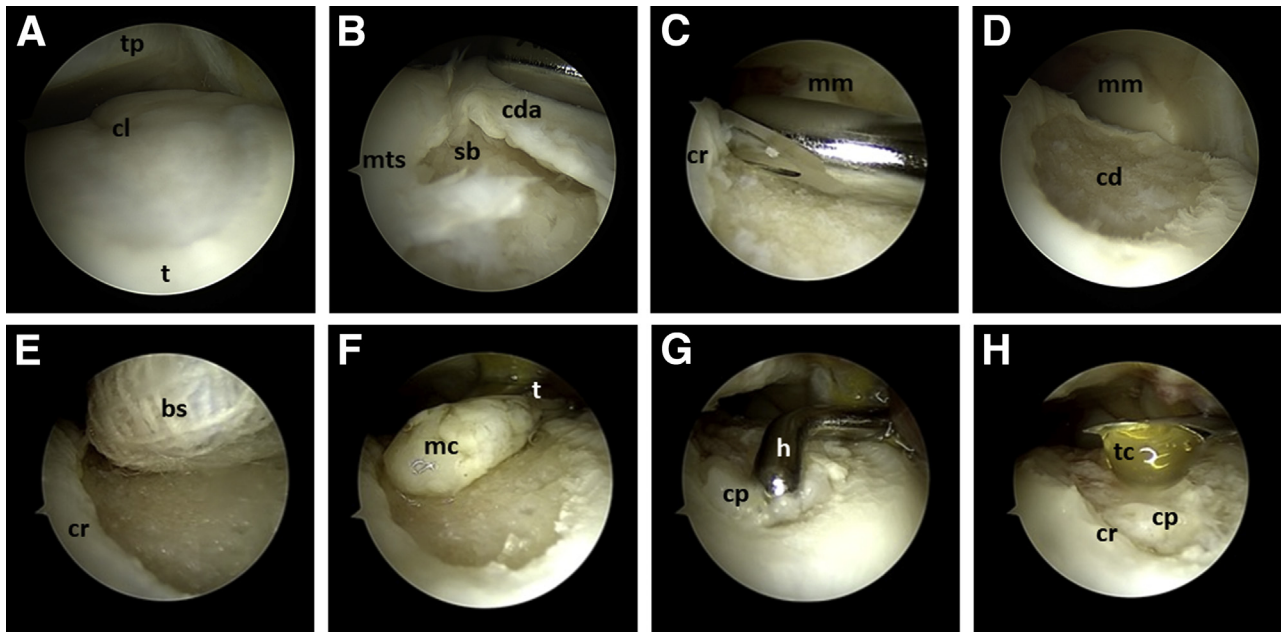


Fig 2. (A) Chondral damage to medial talar shoulder: arthroscopic view from anterolateral portal using 2.8-mm scope with patient in supine position. (cl, chondral lesion; t, talus; tp, tibial plateau.) (B) Unstable chondral lamella. (cda, delaminated area; mts, medial talar shoulder; sb, subchondral bone.) (C) Harvesting of vital cartilage from detached cartilage and from defect edges using 3.0-mm Sabre shaver blade (Arthrex, Naples, FL). (cr, chondral rim; mm, medial malleolus.) (D) Creation of stable vertical wall in lesion area. (cd, cartilage defect; mm, medial malleolus.) (E) Subtle drainage and drying of defect bed. (bs, ball swab; cr, cartilage rim.) (F) Insertion of particulate cartilage through trocar. (mc, minced cartilage; t, trocar.) (G) Distribution of minced cartilage below level of surrounding cartilage. (cp, chondral particles; h, hook.) (H) Application of thrombin for adhesion of particles. (cp, chondral particles; cr, chondral rim; tc, thrombin clot.)

Thrombinator is applied drop by drop over the chip paste (Fig 2H). The thrombin will combine with the PRP within the chips and generate fibrin, which coagulates rapidly, thus fixing the chips within the cartilage defect. One has the option of additionally sealing the tissue with a final layer of fibrin that has been prepared in advance on a back table. This completes the procedure. An optional drain without suction can be applied. The ankle must be fixated in the neutral position in a brace. Initially, approximately 20 to 24 hours of bed rest is suggested. Thereafter, a standardized rehabilitation protocol is suggested as described elsewhere.²⁶

Discussion

Previously, it has been shown that the principle of minced cartilage functions very well regarding repairing chondral and osteochondral lesions.²⁷ So far, most reports have concentrated on the application thereof in the knee joint.

Several techniques have been published displaying success in the repair of joint surface lesions at the ankle. Mostly, drilling procedures, osteochondral transplantations, allogeneic tissue, or empty membranes have been used.⁵ Particularly at the ankle, however, chronic osteochondral lesions or freshly delaminated purely chondral lesions are frequent. Associated chondral material remains vital.²⁸ Such chondrocytes can be used for

location-specific application. This method offers an attractive solution whereby such tissue is not discarded but rather is processed intraoperatively and then directly reimplanted, providing many advantages at the same time. This is a 1-step procedure consisting purely of autologous tissue without creating substantial change during manipulation.

Autologous minced cartilage repair was first introduced in the early 1980s. The principle of minced cartilage techniques is to accomplish hyaline-like chondral repair through the use of "minced" pieces of autologous hyaline cartilage.²⁹ The cartilage fragments are a source of viable chondrocytes that migrate and produce a matrix and collagen.³⁰ The newly established chondrocyte population and cartilage tissue can fill defects and can integrate with existing native cartilage and/or subchondral bone at the treatment site.³¹ Lind and Larsen³² showed equality in cartilage repair capacity between a cell-based 1-step minced cartilage repair procedure and the standard ACI procedure in sheep.

The degree of fragmentation is very important. When cartilage chips are left too large, the surface is too small for chondrocytes to become active. Additionally, large pieces might not incorporate well into existing cartilage.¹⁶ Therefore, the use of a scalpel to yield particulate harvested cartilage is assumed to be unsuitable.²⁵ Morscellation of cartilage into approximately 1-mm³ pieces

Table 1. Pearls and Pitfalls of Minced Cartilage Implantation at Talus

| | |
|---------------------------------------|--|
| Pearls | |
| Pure autologous material | |
| Steep learning curve | |
| One-step procedure | |
| Application of chondrocytes | |
| Arthroscopic application possible | |
| Off-the-shelf application | |
| Pitfalls | |
| Limited availability | |
| Arthroscopic experience | |
| No short- or long-term data available | |
| Generation of fibrous tissue | |
| Conversion to open procedure | |
| Invasiveness | |

might provide sufficient movement of chondrocytes around cartilage fragments and subsequent multiplication and matrix production.³³ Bonasia et al.³⁴ reported that a paste-like appearance provides optimal biological surroundings.

Donor cartilage can be taken from the periphery of the existing lesion where it is necessary to debride into healthy cartilage with a stable 90° rim. Different publications have clearly described that such chondrocytes are viable and could be used for further transplantation.^{35,36}

The newly introduced AutoCart procedure was developed for an all-autologous cartilage regeneration. Small-diameter shaver devices are used for rapid highly standardized fragmentation into a paste-like appearance. Levinson et al.²⁵ reported that chondrocyte viability is not significantly affected. Enrichment with PRP aims to promote chondrocyte proliferation and differentiation, which is assumed to be beneficial for minced cartilage proliferation. Hahn et al.³⁷ have recently shown that chondrocytes exhibit a significant dose- and time-dependent increase in cell number and metabolic cell activity when activated by PRP.

The technique presented in this article comes closest to the that reported by Cugat et al.³⁸ They treated full-thickness chondral or osteochondral defects with autologous cartilage chips embedded in a clot consisting of platelet-poor plasma and PRP in 15 patients. At 15 months postoperatively, improvements were seen in the International Knee Documentation Committee score, Western Ontario and McMaster Universities Osteoarthritis Index score, Lysholm score, visual analog scale score, and radiologic MOCART (Magnetic Resonance Observation of Cartilage Repair Tissue) score.³⁹

Concerning 1-stage solutions for the ankle, there are currently exclusively particulate juvenile articular allograft options available (particulate juvenile cartilage allograft transplantation [PJCAT]).¹⁷ This technique consists of immature live chondrocyte cells within their native extracellular matrix from donors typically younger than 13 years. Fibrin adhesive is used to secure these cartilaginous pieces within the subject's lesion.²¹

Coetzee et al.⁴⁰ published PJCAT outcome data in 23 patients (24 ankles), 14 of whom had at least 1 prior marrow stimulation failure, with 78% showing good to excellent scores on the American Orthopaedic Foot & Ankle Society Hindfoot Scale. Five patients required reoperation to remove symptomatic osteotomy hardware. During 3 of these reoperations, the International Cartilage Repair Society cartilage repair assessment (protocol A) was used to assess the repair tissue. The 3 lesions were deemed grade 2 (nearly normal repair), and 1 partial graft delamination (about 25% of the graft) was diagnosed at 16 months.⁷

Saltzman et al.²¹ conducted a study (review article) on 34 ankles with a mean follow-up period of 14.3 months. In 83.9% of the 31 ankles with clinical outcome data, substantial subjective improvements were reported. Five of these ankles required hardware removal because they were symptomatic or had osteotomy failure.

Dekker et al.⁴¹ performed PJCAT for the treatment of osteochondral lesions of the talus at a single institution. Failure was defined as no change in symptoms or worsening of symptoms and/or the need for an additional cartilage restoration procedure. The overall failure rate was 40%. In summary, the outcomes of various treatments are heterogeneous, with poor results and failures having been reported.³⁹

Further studies are required to clarify the extent to which allogeneic cells such as those mentioned earlier are at a disadvantage regarding the formation of hyaline tissue, but autologous approaches in the animal model showed a higher percentage of hyaline cartilage and fibrocartilage in the short term.⁴² The immunologic risks appear to be low with this technique, but studies in this regard are rare.⁷ Potential disadvantages specific to allografts include, furthermore, the theoretical risk of disease transmission. An important matter that requires further knowledge is fixation techniques. The aforementioned studies used fibrin glue for construct fixation. However, several animal studies have shown the negative effects of fibrin on cell migration and tissue repair.^{43,44} Moreover, there is the possibility that exogenous fibrin may induce an immune response.⁴⁵

Table 2. Advantages and Disadvantages of Minced Cartilage Implantation at Talus

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|-------------------------------------|--|
| Advantages | |
| Inexpensive | |
| Stable transplantation technique | |
| No perpendicular approach needed | |
| Little donor-site morbidity | |
| Disadvantages | |
| Potential age limitation | |
| Application of dry field demanding | |
| Incomplete filling of defect | |
| Manufacturing of chondral particles | |

Irwin et al.⁴⁶ reported good stability of autologous thrombin, which results in natural fibrin when combined with PRP or platelet-poor plasma. Therefore, an autologous thrombin solution in the AutoCart procedure is assumed to increase stability without the aforementioned negative effects on cell differentiation.

Autologous minced cartilage repair is a 1-step approach that does not require manipulation in the laboratory or the use of allografts. It is therefore economically attractive and should not require significant regulations, as other procedures might.

We expect mechanically high-quality tissue and few or no biological effects associated with foreign bodies. Overall, the described technique is easy for the experienced arthroscopist to implement, reproducible, and safe to use. This technique has several clear advantages: It represents a single-stage procedure with a shallow learning curve without donor-site morbidity, it does not require graft contouring, and the need for a perpendicular access path to the defect bed is eliminated (unlike when using osteochondral plugs). Pearls and pitfalls are summarized in Table 1, and advantages and disadvantages are summarized in Table 2.

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