Treatment of Osteochondral Lesions of the Talus With Cell-free Polymer-based Scaffold in Single-Step Arthroscopic Surgery

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Abstract: Arthroscopic techniques have recently gained popularity for the treatment of osteochondral defects of the talus. The microfracture procedure is the most commonly applied arthroscopic technique. However, it is not effective for the treatment of larger lesions. Tissue-engineered scaffolds have been used for cartilage regeneration arthroscopically, and promising results have been reported. We treated larger osteochondral lesions of the talus with polyglycolic acid-hyaluronan scaffold biomaterial (Chondrotissue, BioTissue AG, Zurich, Switzerland) in a single-step arthroscopic surgery. Traction methods and fibrin glue were avoided.

Osteochondral lesions (OCL) of the talus are still one of the most challenging problems in orthopedic surgery. Several methods have been described for the treatment of OCL of the talus.[1] The microfracture technique is the most widely used procedure among them. However, it has disadvantages such as unsuccessful formation of hyaline cartilage and poor results in larger lesions.[2,3]

Autogenous osteochondral transplantation, autologous chondrocyte implantation, and osteochondral allografts are mainly used procedures for larger lesions, but the requirement of open surgery, including malleolar osteotomy that increases morbidity, 2-step surgeries, and disease transmission risk in allograft methods are the main concerns.[4] Particulated juvenile cartilage transplantation is another new technique that can be performed arthroscopically with promising results for larger lesions.[5,6] Autologous matrix-induced chondrogenesis (AMIC) has recently gained attention for the treatment of OCL with good outcomes. In this technique, tissue-engineered scaffolds are implanted after performing the microfracture technique to induce mesenchymal stem cell migration and provide a supportive 3-dimensional structure for them to facilitate transformation into cartilage tissue. This procedure can be performed arthroscopically, and good quality of regenerated cartilage formation has been reported.[7,8] The purpose of this Technical Note is to describe a single-step arthroscopic repair of the talar OCL with cell-free polymer-based scaffold.

Surgical Technique

Preoperative Planning and Positioning

Preoperative magnetic resonance imaging (MRI) is assessed to define the lesion location and depth before the surgery (Fig 1). The patient is positioned depending on the location of the lesion. The lesion location is identified on axial MRI images. We prefer the supine position for anteriorly located lesions to perform surgery through anterior portals or prone position for posterior lesions to use posterior portals. In middle lesions, either anterior or posterior portals may be used depending on the proximity of the lesion. Adequate position is important for better exposure of the lesion because no traction method is applied to avoid associated complications such as soft tissue injury and neuropraxia. After the induction of general anesthesia, ankle examination is performed to evaluate range of

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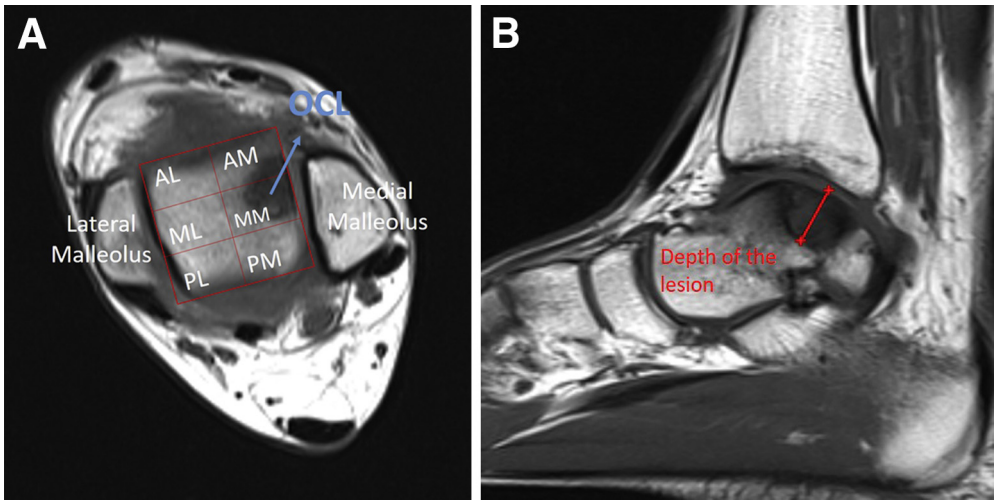


Fig 1. Axial and sagittal preoperative magnetic resonance images of the left ankle. (A) The lesion location is defined on the axial MRI image preoperatively. Anterior and middle lesions can be accessed through the anterior portals by bringing the ankle into plantar flexion. (B) The depth of the osteochondral lesion is measured on preoperative MRI. Preoperative identification of the lesion depth is important for bone graft decision. (AL, anterolateral; AM, anteromedial; ML, midlateral; MM, midmedial; MRI, magnetic resonance imaging; OCL, osteochondral lesion; PL, posterolateral; PM, posteromedial.)

motion or associated instability existence. A tourniquet is placed on the upper thigh. If the patient is positioned supine, a pad is placed under the ankle joint to allow ankle maneuvers (Fig 2). If prone position is chosen, the patient is positioned as the ankle joint is placed out of the surgical table and a pad is placed under the ankle to allow dorsiflexion maneuver (Fig 3). The surgical leg is prepared in a sterile fashion. The iliac crest region is also prepared in a sterile fashion to harvest bone graft for deeper (>10 mm) lesions defined on sagittal or coronal MRI. The tourniquet is inflated.

Anteromedial and Posteromedial Portal Placement

In the supine position, the anteromedial (AM) portal, or in the prone position, the posteromedial (PM) portal is initially established to introduce an arthroscope. A 30° arthroscope is used for the procedure.

The *AM portal* is created just medial to the tibialis anterior tendon at the joint line. Saline (20 cc) is injected into the ankle joint first. Skin incision is made at the same point of injection, and a blunt trocar is inserted into the joint. The arthroscope is then introduced (Fig 2).

The *PM portal* is created just medial to the Achilles tendon at the joint line. Saline (20 cc) is injected into the ankle joint first. Skin incision is made at the same point of injection, and a blunt trocar is inserted into the joint. The arthroscope is then introduced (Fig 3).

Diagnostic Arthroscopy

The entire ankle is evaluated through the AM or PM portal previously to see if there are associated pathologies such as synovial hypertrophy, impingement, or ligament injuries. Medial gutter, deltoid ligament, medial and lateral talar domes, anterior and posterior tibia, and tibial joint surface are visualized. Accompanying pathologies must be treated in the same surgery to prevent their negative effects on healing. The OCL is then identified. Forced plantar flexion of the ankle in an anterior approach (Fig 4) or dorsal flexion in a posterior approach (Fig 5) allows us to visualize the lesion more clearly. The ankle position can be maintained by an assistant surgeon manually during the surgery.

Once the lesion is adequately isolated, anterolateral (AL) (for anterior lesions) or posterolateral (PL) (for posterior lesions) portals are made to introduce arthroscopic surgical tools.

The *AL portal* is created just lateral to the peroneus tertius tendon at the joint line. Saline (20 cc) is injected into the ankle joint first. Skin incision is made at the same point of injection, and a blunt dissection is performed through the subcutaneous tissue to access the joint (Fig 2).

The *PL portal* is created just lateral to the Achilles tendon at the joint line. Saline (20 cc) is injected into the ankle joint first. Skin incision is made at the same point of injection and a blunt trocar is inserted into the joint. In the posterior approach, it is important to carry out debridement from the medial to lateral side to avoid damaging the medial neurovascular bundle. Keeping the shaver on the lateral side of the flexor hallucis longus tendon is another way to not harm this bundle (Fig 3).

Debridement and Microfracture Procedure

At times, there is a massive synovial hypertrophy, and synovial tissue is removed using an arthroscopic shaver

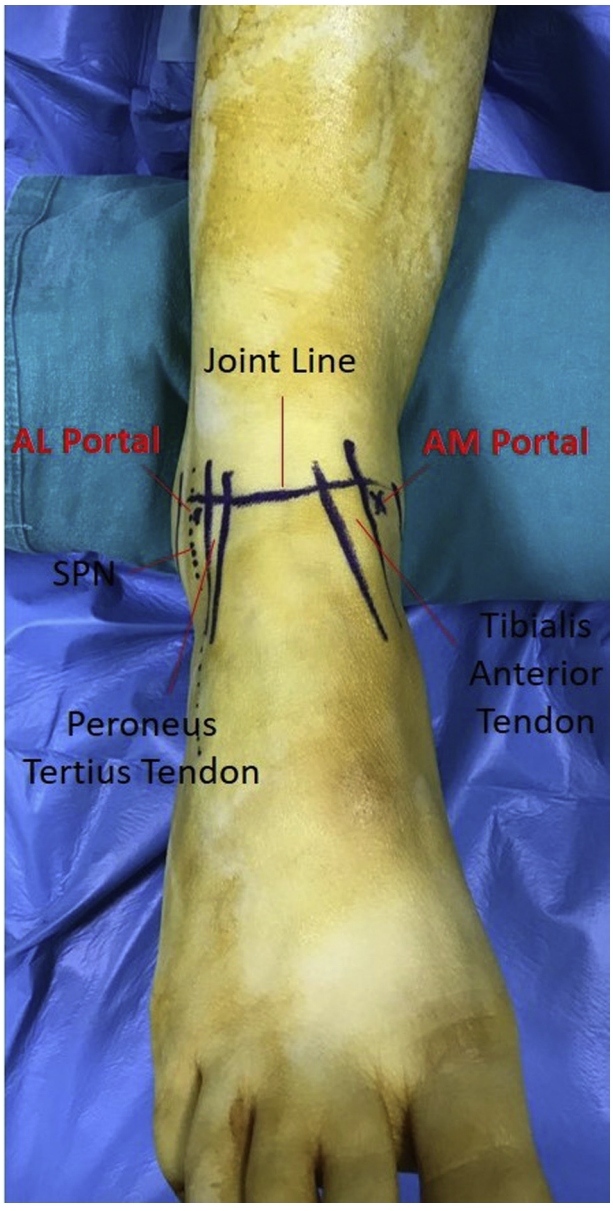


Fig 2. The patient is in the supine position. A pad is placed under the ankle joint to apply forced plantar flexion during surgery. An anteromedial (AM) portal is placed just medial to the tibialis anterior tendon, and an anterolateral (AL) portal is placed just lateral to the peroneus tertius tendon at the joint line. Care should be taken not to harm the superficial peroneal nerve (SPN, dotted line) located just lateral to the AL portal point.

(4.0-mm Tomcat shaver, Stryker, Kalamazoo, MI) through the AL (in the anterior approach) or PL (in the posterior approach) portals for a better view. A probe is then introduced through these portals and the lesion is elevated. The surrounding cartilage and bone are assessed to define stable and healthy tissue borders that cannot be elevated easily (Fig 6A). Unhealthy cartilage tissue is loose and easily detached from the underlying subchondral bone with the manipulation of the probe. Loose and detached fragments are removed using a curved Mosquito clamp. Frayed cartilage is debrided with an arthroscopic shaver (4.0-mm Tomcat shaver, Stryker) (Fig 6B). Unhealthy cartilage borders and subchondral necrotic bone are then removed by an arthroscopic curette to the healthy tissue (Fig 6C). The lesion is finally debrided by an arthroscopic shaver for the last time to smoothen the surface and remove the remaining damaged cartilage. After the debridement process, all tissue borders including cartilage and subchondral bone should be re-evaluated with a probe to ensure that all borders are stable without loose cartilage and necrotic subchondral bone tissue. At this point, a microfracture is performed with an angled awl introduced through the AL (in the anterior approach) or PL (in the posterior approach) portals onto the underlying healthy subchondral bone (Fig 7A). Holes are created 4 or 5 mm apart from each other and should be perpendicular to the subchondral bone. The awl is inserted into the subchondral bone until fat droplets are seen, which informs that the appropriate depth has been reached (Fig 7B; Video 1).

Bone Grafting

The defect depth is measured by a probe after the microfracture procedure to confirm the preoperative depth value. If there is a bone defect deeper than 10 mm that has been identified on preoperative MRI (Figs 1B and 8A) and confirmed intraoperatively, the defect is then filled with an autogenous cancellous bone graft after the microfracture procedure. The cancellous bone graft is harvested from the anterior iliac crest in the supine position or the posterior iliac crest in the prone position.

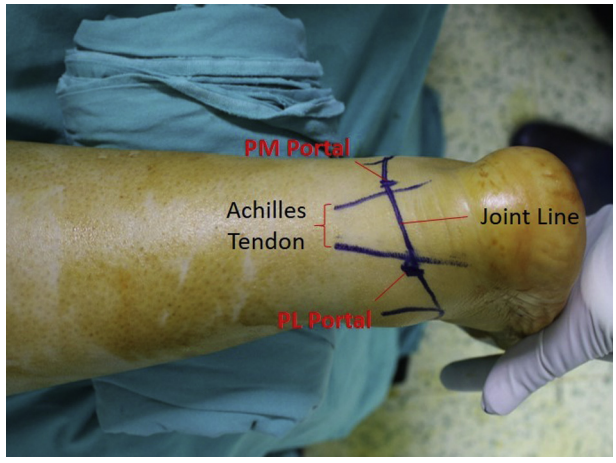


Fig 3. The patient is in the prone position. The ankle is positioned out of the surgical table and a pad is placed under the ankle to apply ankle maneuvers. A posteromedial (PM) portal is placed just medial to the Achilles tendon, whereas a posterolateral (PL) portal is just lateral at the joint line.

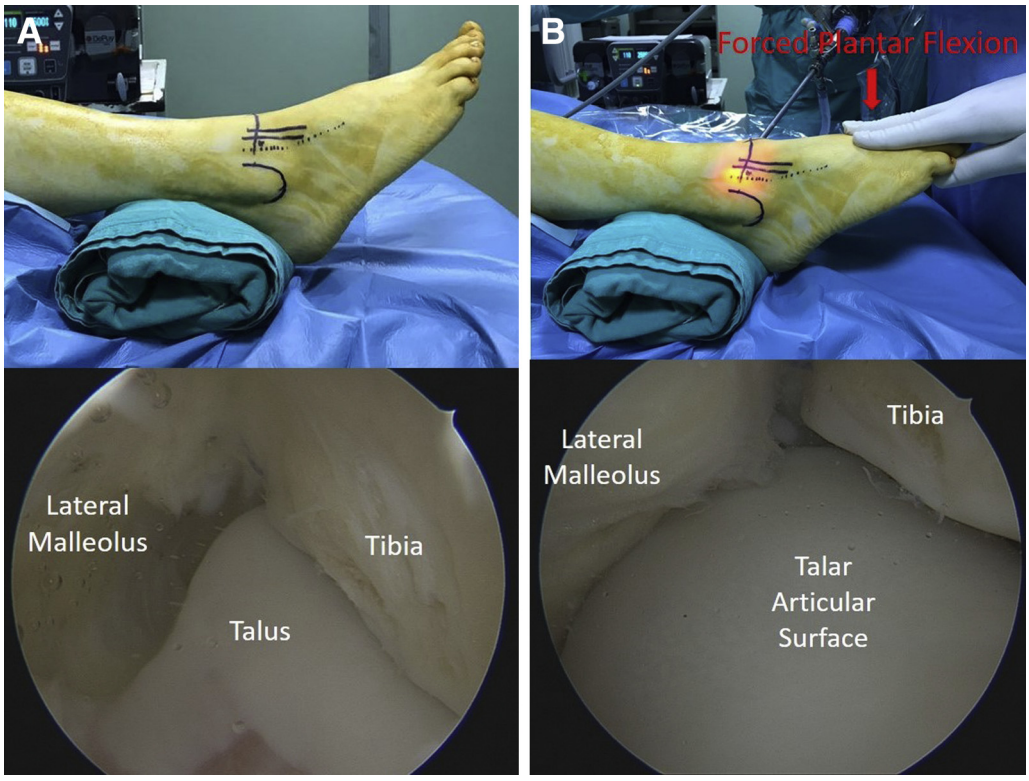


Fig 4. The patient is in the supine position. (A) No forced plantar flexion is applied to the ankle (top panel). In the bottom panel, the arthroscopic image is seen through the anteromedial portal. Note that without forced plantar flexion, visualization of the talar surface is very limited. (B) Forced plantar flexion is applied to the ankle by an assistant surgeon (top panel). On the arthroscopic image of the same patient through the anteromedial portal, it is clear that visualization of the talar surface is much better with forced plantar flexion, which allows us to perform surgery without the need of the traction method (bottom panel).

Anterior Iliac Crest Bone Harvest

Approximately 4- to 5-cm incision is made 3 cm above the anterior superior iliac spine along the iliac crest. The bone is approached through the muscles, and the periost is elevated subperiosteally with a periosteal elevator. Parallel 2 cuts are made 2 cm apart from each other with an osteotome perpendicular to the iliac crest, and an approximately 2 × 2 cm cortical window is elevated with a curved osteotome and a rongeur. The cortical window is kept carefully in a saline solution or a wet swab. The cancellous bone graft is extracted with a bone curette through the window as much as necessary. Once the desired amount of graft is harvested, the cortical bone piece is placed on the window and the wound is closed layer by layer.

Posterior Iliac Crest Bone Harvest

An oblique incision is made over the posterior iliac crest. The muscles are elevated subperiosteally and the iliac bone is approached. The cluneal nerves should be dissected carefully and protected. A 2 × 2 cm cortical window is elevated as in the anterior iliac crest bone harvest approach, and the cancellous bone graft is harvested. The remaining procedure is like as in the anterior iliac bone graft approach.

The harvested cancellous bone graft is shredded into small pieces, introduced to the defect with a mosquito clamp and impacted using a probe through the AL (in the anterior approach) or PL (in the posterior approach) portal (Fig 8B). The defect is filled, and the bone graft is impacted until achieving the same level with the surrounding subchondral layer (Fig 8C; Video 1). We do not close the iliac crest wound until the achievement of the adequate level of impacted graft to harvest more graft in case of inadequacy. Once the appropriate level is achieved, the iliac wound is closed.

Placement of the Scaffold

After the microfracture procedure or bone grafting (in deep lesions), defect size is defined by measuring the longitudinal and horizontal axis of the lesion with an arthroscopic probe introduced through the AL (in the anterior approach) or PL (in the posterior approach) portal. Polyglycolic acid-hyaluronan matrix/scaffold biomaterial (Chondrotissue, BioTissue AG, Zurich, Switzerland) is shaped according to these values to match the defect properly. The scaffold is then introduced and placed into the lesion using a forceps through the medial portal for medial lesions or the lateral portal for lateral lesions (Fig 9A). The closest portal allows the manipulation of the scaffold more easily, and the other portal is used as an arthroscope portal. The scaffold may not be fit

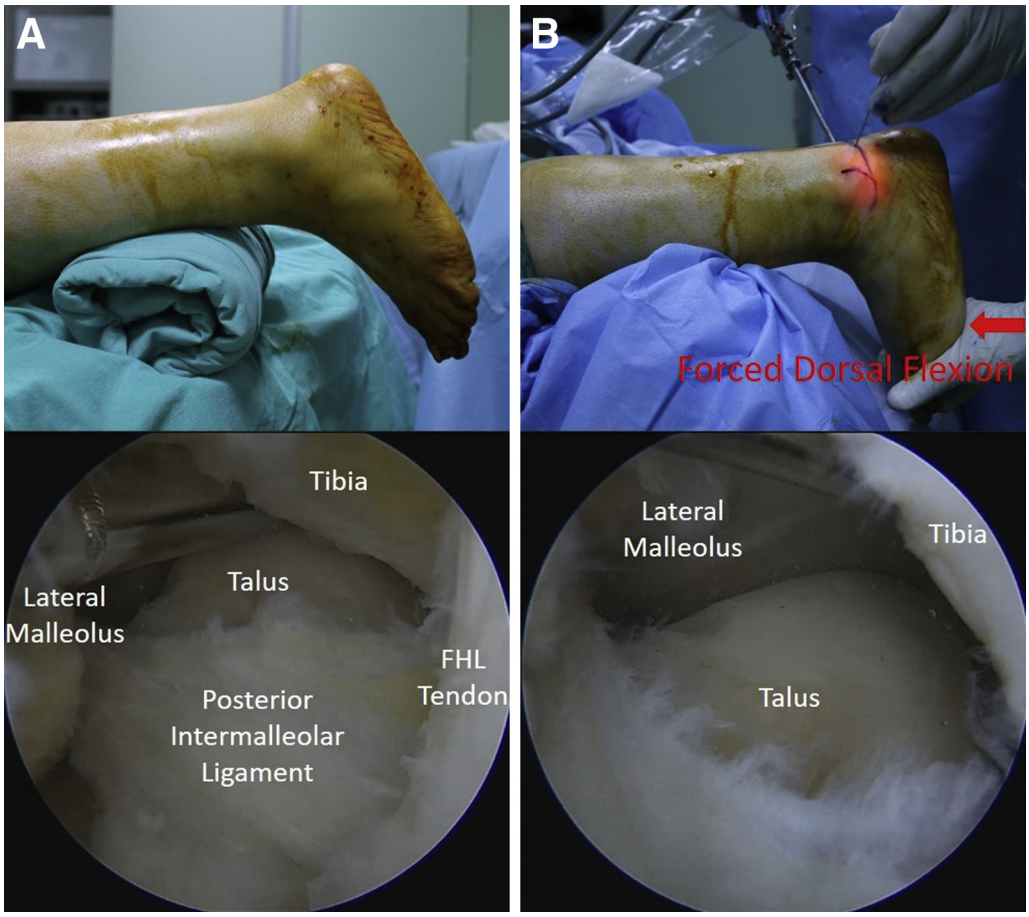


Fig 5. The patient is in the prone position. (A) No dorsiflexion maneuver is applied to the ankle (top panel). On the same patient's arthroscopic image through the posteromedial portal, it is seen that talar surface visualization is very poor to carry out the surgery. (B) Dorsiflexion maneuver (top panel) results in the enhancement of joint visualization seen on the arthroscopic image through the posteromedial portal. There is also enough space that allows the insertion of an arthroscope and arthroscopic surgical instruments. (FHL, flexor hallucis longus.)

well at the first time because of its soft structure. Therefore, the scaffold may be manipulated with a probe through the closest portal to provide better surface continuity (Fig 9B). Once good continuity between the lesion border and the scaffold is achieved, the ankle is brought to the neutral position. The neutral position of the ankle keeps the scaffold in a steady position by compressing it between the joint surfaces inside the joint (Fig 9C). The instruments are removed, and the portals are closed and draped in a sterile fashion. We do not use any fixation

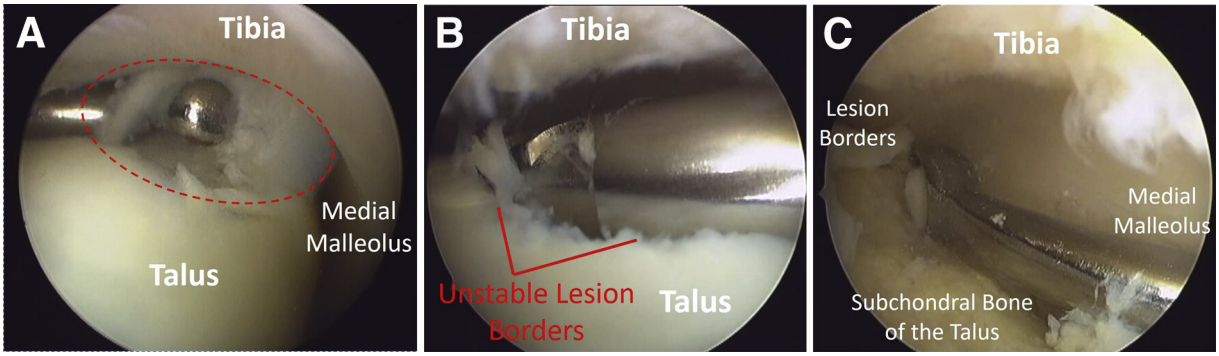


Fig 6. The patient is in the supine position. The anteromedial views of the osteochondral lesion on the medial shoulder of the right talus (A). The lesion is identified through the anteromedial portal, and the surrounding cartilage is evaluated with a probe to define loose cartilage borders (B). The loose and frayed cartilage is initially debrided with a shaver. (C) Unstable cartilage borders and necrotic subchondral bone are debrided to the stable borders with a curette.

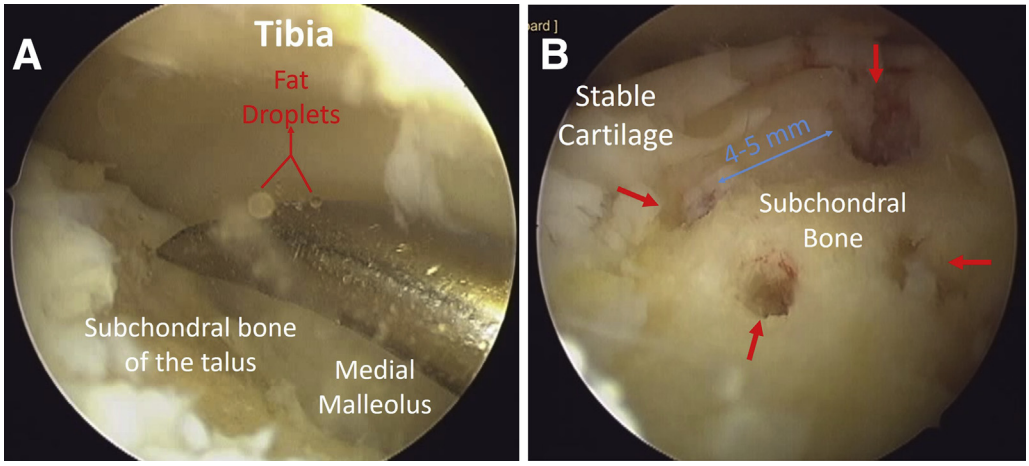


Fig 7. The patient is in the supine position. The anteromedial views of the osteochondral lesion on the medial shoulder of the right talus. (A) Microfracture procedure is performed on the underlying stable subchondral bone using an awl. The awl is inserted to the bone until fat droplets are seen. (B) The microfracture holes (red arrows) are created 4-5 mm apart from each other.

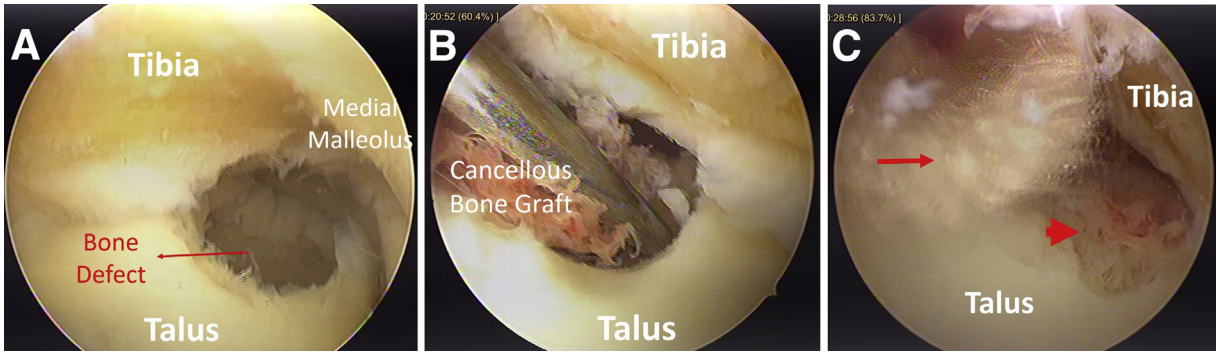


Fig 8. The patient is in the supine position. The anteromedial views of the osteochondral lesion on the medial shoulder of the right talus. (A) Large bone defects may exist after subchondral bone debridement in patients with accompanying bone cysts. After the debridement process, the depth of the defect is re-evaluated. (B) In the case of a deep bone defect (>10 mm), the defect is filled with a cancellous bone graft harvested from the iliac crest. The graft is introduced to the defect with a forceps until accessing the same level with the surrounding subchondral layer. (C) The graft is also impacted using a probe before scaffold placement to gain an appropriate surface (thin arrow: scaffold; arrowhead: cancellous bone graft).

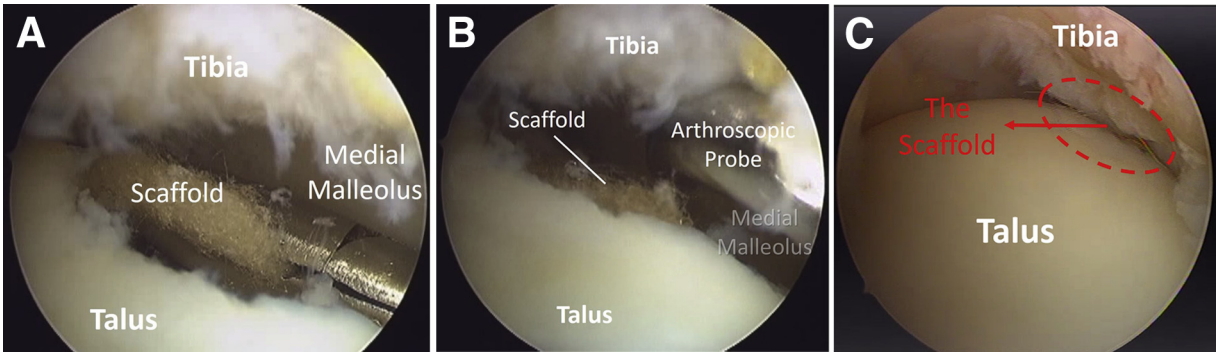


Fig 9. The patient is in the supine position. The anterolateral views of the osteochondral lesion on the medial shoulder of the right talus (A). Once an adequate lesion bed is prepared, the scaffold is then placed on the defect through the anteromedial portal, which is the closest portal to the lesion. This allows easier manipulation. (B) The scaffold is manipulated using a probe or a clamp to fit the bed properly. (C) Stabilization of the scaffold is maintained by the neutral position of the ankle. This position compresses the scaffold between the joint surfaces and prevents its mobilization.

materials such as fibrin glue or pins (Video 1). Therefore, a short leg brace in the neutral ankle position is applied as soon as the surgery is completed to maintain the steady position of the scaffold.

Rehabilitation

A short leg brace in the neutral ankle position is required to restrict motion for 3 weeks. Weight bearing is not allowed. Motion restriction is very important

Table 1. Surgical Steps

Decision of the patient position (supine position for anterior lesions, prone position for posterior lesions)
Tourniquet placement
Portal placement
Debridement of synovial tissue if needed
Identification of the lesion
Plantar flexion maneuver for anterior lesions or dorsal flexion maneuver for posterior lesions for a better view
Debridement and excision of damaged cartilage and underlying bone to the stable tissue
Microfracture procedure
Bone graft application if necessary (for defects >10 mm depth)
Placement of the scaffold using a forceps or arthroscopic grasper
Manipulation of the scaffold to fit properly using a probe
Brace application in the neutral position to keep the scaffold in the stable position by compressing it between the joint surfaces

because neutral position is an important factor for the scaffold stability. After 3 weeks, the brace is removed, and range of motion exercises are initiated without weight bearing. Full weight bearing is recommended after 6 weeks. Intensive sports activities are not permitted until the completion of 4 months of follow-up. Starting time for intense physical exercises is decided according to clinical assessment of the patient, and most often begins after 6 months (Tables 1 and 2).

Discussion

Several surgeries such as autogenous osteochondral transplantation, autologous chondrocyte implantation, and osteochondral allograft transplantation have been described for larger OCL of the talus, but these are demanding techniques that require open surgery. Particulated juvenile cartilage transplantation is another new procedure that has promising early results for larger lesions. It can be applied arthroscopically; however, it is also a demanding surgery that requires traction and graft preparation, and the long-term results are unknown.[6] Tissue-engineered scaffolds have gained attention for the treatment of OCL in recent years. The AMIC technique has been described with an open exposure, and successful results have been reported.[7,9] Usuelli et al. recently reported 20 patients treated with the AMIC technique, arthroscopically. Their study showed good clinical and radiological results with a follow-up time of 24 months. In their technique, they distracted the ankle by a spreader and glued the scaffold to the lesion by synthetic fibrin glue.[8]

We treated larger OCL of the talus with polymer scaffolds in a single-step arthroscopic surgery. The patients were positioned according to the lesion location to gain better visualization either through anterior or posterior portals. We also used dorsiflexion and plantar flexion maneuvers for better access to the lesion. Traction techniques were avoided to prevent associated complications. Stability of the scaffold is also maintained by a neutral position of the ankle so that the scaffold can be compressed into the ankle joint. Ankle position maneuvers provide us better exposure and shortened surgical duration, besides the advantages of the arthroscopic procedure such as less morbidity and shorter duration of the surgery.[10]

This technique has advantages that it can be performed in a single-step arthroscopic procedure and does not require traction, fibrin glue, or pins for scaffold stabilization. Avoidance of traction and fibrin glue or pin makes the surgical duration shorter as well as providing an easier procedure and eliminating neuropraxia risk of traction. However, there are a few disadvantages, as well. The technique requires an assistant to maintain an appropriate ankle position for a clear view during the surgery. Accessibility to anterior lesions from posterior portals or posterior lesions from anterior portals is restricted because no traction is applied. Plantar or dorsal flexion maneuvers provide clear vision of only the anterior or posterior side of the ankle. So, proper preoperative evaluation of the lesion location is mandatory to choose an appropriate position and portals. Because the scaffold is not stabilized with fibrin glue or a pin, the neutral position of the ankle must be maintained meticulously for 3 weeks (Table 3). We treated larger (>1.5 cm^2) OCL of the talus with this technique, and good outcomes have been found with mid-term results (31 months) (Fig 10). In conclusion, this technique allows us to treat larger OCL of the talus in a single-step arthroscopic procedure without the need of traction and fibrin glue.

Table 2. Pearls and Pitfalls of Arthroscopic Cell-free Implantation

Pearls
Lesion localization is properly defined in preoperative magnetic resonance imaging to select an appropriate position and portals.
Plantar flexion for anterior lesions or dorsal flexion for posterior lesions is applied to gain a better view.
Unhealthy cartilage and subchondral bone are debrided to the stable tissue.
Deep (>10 mm) bone defects are grafted with a cancellous bone autograft harvested from the iliac bone.
Scaffold is shaped according to the lesion size measured with an arthroscopic probe.
Scaffold is introduced through the closest portal to the lesion to apply easier manipulation.
Scaffold stabilization is provided by keeping foot in a neutral position that holds it between the joint surfaces. Neutral position is continued for 3 wk using a brace.
Pitfalls
Because no traction is applied, it is impossible to access anterior lesions through posterior portals or posterior lesions through anterior portals.
Because of the soft structure of the scaffold, its placement may be difficult through the regular portals.
Not proper application of the short leg brace in the neutral position may result in the mobilization of scaffold and failure of the treatment.

Table 3. Advantages and Disadvantages of the Technique

Advantages	Disadvantages
Single-step arthroscopic procedure	
No requirement of traction, which eliminates neuropraxia risk	Restricted visualization of an anterior lesion from posterior portals or a posterior lesion from anterior portals
The scaffold is not fixated with fibrin glue or pins	It is mandatory to keep the ankle in the neutral position for 3 wk to hold the scaffold in a steady position
Shorter surgical time and easier application	Assistant surgeon is necessary for ankle maneuvers

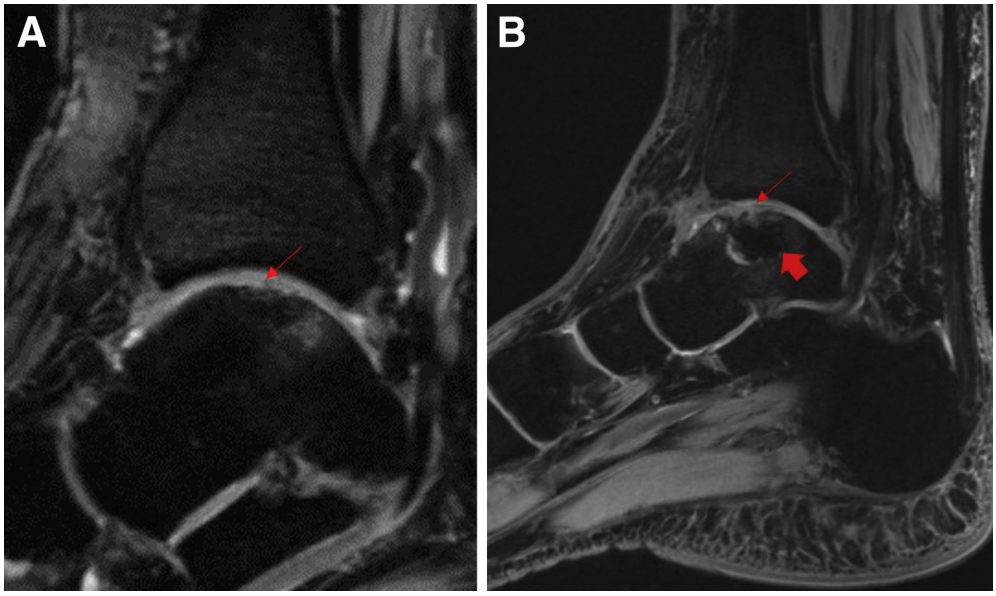


Fig 10. Postoperative magnetic resonance imaging (MRI) scans. (A) A sagittal MRI scan of a patient who was treated with polyglycolic acid-hyaluronan scaffold (Chondrotissue, BioTissue AG) with 51-month follow-up. A regenerated cartilage tissue is shown with good continuity (thin arrow). (B) A sagittal MRI scan of a patient who was treated with previous bone grafting (thick arrow) and scaffold biomaterial with 61-month follow-up. Successful cartilage formation is seen over the bone graft (thin arrow).

References

1. Savage-Elliott I, Ross KA, Smyth NA, Murawski CD, Kennedy JG. Osteochondral lesions of the talus: A current concepts review and evidence-based treatment paradigm. *Foot Ankle Spec* 2014;7:414-422.
2. Murawski CD, Kennedy JG. Operative treatment of osteochondral lesions of the talus. *J Bone Joint Surg Am* 2013;95:1045-1054.
3. van Bergen CJ, Kox LS, Maas M, Sierevelt IN, Kerkhoffs GM, van Dijk CN. Arthroscopic treatment of osteochondral defects of the talus: Outcomes at eight to twenty years of follow-up. *J Bone Joint Surg Am* 2013;95:519-525.
4. Badekas T, Takvorian M, Souras N. Treatment principles for osteochondral lesions in foot and ankle. *Int Orthop* 2013;37:1697-1706.
5. Coetzee JC, Giza E, Schon LC, et al. Treatment of osteochondral lesions of the talus with particulated juvenile cartilage. *Foot Ankle Int* 2013;34:1205-1211.
6. Min KS, Ryan PM. Arthroscopic allograft cartilage transfer for osteochondral defects of the talus. *Arthrosc Tech* 2015;4:e175-e178.
7. Valderrabano V, Miska M, Leumann A, Wiewiorski M. Reconstruction of osteochondral lesions of the talus with autologous spongiosa grafts and autologous matrix-induced chondrogenesis. *Am J Sports Med* 2013;41:519-527.
8. Usuelli FG, D'Ambrosi R, Maccario C, Boga M, de Girolamo L. All-arthroscopic AMIC(R) (AT-AMIC(R)) technique with autologous bone graft for talar osteochondral defects: Clinical and radiological results. *Knee Surg Sports Traumatol Arthrosc* 2016.
9. Kubosch EJ, Erdle B, Izadpanah K, et al. Clinical outcome and T2 assessment following autologous matrix-induced chondrogenesis in osteochondral lesions of the talus. *Int Orthop* 2016;40:65-71.
10. Zengerink M, van Dijk CN. Complications in ankle arthroscopy. *Knee Surg Sports Traumatol Arthrosc* 2012;20:1420-1431.