https://doi.org/10.48047/AFJBS.6.2.2024.4208-4219

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

New Outlines of Managing talus osteochondral lesions

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Article History

Volume 6, Issue 2, Apr-Aug 2024

Received: 1 August 2024

Accepted: 15 August 2024

Published: 17 August 2024

doi:10.48047/AFJBS.6.2.2024.4208-4219

Abstract: Talar osteochondral lesions (OCLs) represent a significant clinical challenge due to their location in a weight-bearing joint with limited intrinsic healing capacity. Traditional management strategies have yielded inconsistent results, underscoring the need for refined approaches tailored to lesion characteristics and patient-specific factors. This abstract outlines evolving perspectives on talar OCL management, highlighting advancements in diagnosis, surgical techniques, and rehabilitation protocols. Improved diagnostic modalities, such as high-resolution MRI with advanced sequences, play a crucial role in accurately characterizing lesion size, location, and morphology, guiding treatment decisions. This precise assessment allows for a more individualized approach, moving away from a "one-size-fits-all" strategy. Non-operative management, previously limited to conservative measures with questionable efficacy, is now refined with tailored exercise programs focusing on proprioception and functional strengthening. This approach targets lesion stabilization and pain management, offering a viable option for smaller, stable lesions, particularly in younger, active patients. Surgical intervention remains necessary for larger, symptomatic lesions resistant to conservative treatment. However, surgical approaches are evolving beyond simple debridement or drilling. Techniques such as osteochondral autologous transplantation (OAT), autologous chondrocyte implantation (ACI), and microfracture are being refined with improved techniques and graft preparation methods. Minimally invasive arthroscopic approaches are increasingly favored, reducing surgical morbidity and improving recovery time. Furthermore, the integration of biologics, such as platelet-rich plasma (PRP) and bone marrow aspirate concentrate (BMAC), alongside these techniques is being explored to enhance healing and cartilage regeneration. Post-operative rehabilitation is critical for successful outcome. Structured programs emphasizing progressive weight-bearing, range of motion exercises, and functional activities are tailored to individual patient needs and lesion characteristics. This individualized approach minimizes the risk of re-injury and promotes long-term functional recovery. The integration of advanced imaging techniques to monitor lesion healing and functional outcomes is also becoming increasingly important. In conclusion, the management of talar OCLs is shifting toward a more personalized and evidence-based approach, incorporating advanced diagnostic imaging, refined surgical techniques, and tailored rehabilitation programs to improve patient outcomes and return to function.

Keywords: *talus osteochondral lesions*

Introduction.

Damage to the talar cartilage, including pathological alterations in the underlying bone, is described as osteochondral lesion of the talus (OLT). A history of ankle trauma is reported in nearly 80% of patients with OLT(1,2), and 38% of those patients exhibit ankle ligament laxity. Furthermore, OLT can be observed in 39% of patients who have ankle instability (3,4). Therefore, it appears that the most common causes of OLT are acute trauma and recurrent micro-trauma caused by ankle instability and/or hindfoot malalignment. Synovial fluid infiltrates microchondral lesions in a damaged ankle, causing bone edema by penetrating the subchondral and bone marrow regions. When the joint is under stress, fluid pressure rises, which can lead to cyst forms and the eventual collapse of the chondral bone support (5).

The lack of a universally accepted definition, description, location, or therapy recommendation for OLT is a major issue that can arise in a variety of clinical presentations. We aimed to demonstrate the appropriate course of treatment for each lesion based on its location, depth, vascularity, and healing capacity in our study.

Diagnosis

Most patients over the age of 30 have osteochondral lesions of the talus, which primarily affect men. Symptoms, such as deep ankle discomfort, soreness, and swelling in the medial or lateral gutters of the ankle, which worsen with weight-bearing and athletic activity, usually manifest six to twelve months after the initial injury, such as an ankle sprain or fracture. Ankle locking or catching sensations are occasionally reported by patients. Consistent ankle pain is often accompanied by other foot issues, such as uneven pressure on different parts of the foot. Tenderness, swelling, restricted normal ankle movement, instability of the ankle ligaments, talonavicular and subtalar range of motion, and hindfoot alignment are all symptoms that should prompt a comprehensive clinical evaluation, as would be appropriate for any other medical disease.

Imaging studies and plain radiography of the ankle using the anterior-posterior, lateral, and mortise views should be performed as a first examination in the diagnostic phase because no clinical findings are specific enough to reliably diagnose OLT. While computed tomography (CT) improves visibility of the lesion's bone components, it reveals less about cartilage wear and comes with the drawback of significant radiation exposures. Alternatively, compared to arthroscopy, magnetic resonance imaging (MRI) provides a more accurate assessment of OLT activity and any associated ligament or tendon injuries; nevertheless, compared to arthroscopy, MRI may exaggerate the size and diameter of the cartilage lesion (1).

Although CT and MRI are complementary, Verhagen et al. demonstrated that MRI is more sensitive (0.96 versus 0.81) to identify OLT, making it the preferred approach for evaluation in cases when a plain radiograph comes back negative (2). In addition to its diagnostic and damage assessment capabilities, magnetic resonance imaging (MRI) offers significant prognostic and follow-up value in assessing cartilage regeneration following regenerative and reparative surgical procedures. This noninvasive biopsy relies on the organization of collagen fiber networks, water coordination, and content (3). T2 mapping sequences were shown to have a high ability in a cohort analysis by Rizzo et al. to quantify newly generated tissue and its differences from native cartilage (4).

Imaging with magnetic resonance

With a sensitivity of up to 96% and a specificity of 96%-100%, magnetic resonance imaging (MRI) is the preferred imaging technique. It offers great vision of the articular cartilage, subchondral bone, and nearby soft tissues. Arthroscopic observations are highly correlated with MRI findings and grading, and there is good agreement between observers about these findings. In addition to being better than CT in detecting early-stage lesions confined to the articular cartilage, MRI shows a sensitivity of 97% and specificity of 100% when it comes to identifying unstable lesions. One drawback of magnetic resonance imaging (MRI) is that it can overestimate the size of a lesion or hide its boundaries, which can be problematic for surgical planning, when bone marrow edema is present in the acute stage.

Radiation therapy

The lack of specificity in bone scintigraphy has led to its removal from OLT management. However, single photon emission computed tomography with CT (SPECT-CT) shows a good correlation with images and patient symptoms, suggesting that intervention is more common in patients with SPECT-CT activity than conservative treatment. In patients with more than one lesion, SPECT-CT can help pinpoint the eits-active lesion that is causing symptoms and provide valuable information for surgical planning. Accordingly, SPECT-CT is not the principal imaging modality, but it may be useful as a supplement to surgical planning, particularly for pain recurrence following therapy. As part of a thorough evaluation of the anomaly, it has so been suggested.

Management planning and the function of imaging

Imaging should be used for lesion diagnosis and to guide therapy decisions. Skeletal maturity, lesion size, and instability indicators are significant for clinical decision-making. Other lesion characteristics, such as subchondral alterations and the integrity of the underlying cartilage, also play a role in deciding the proper surgical surgery. Studies have shown that traumatic OLT can recover in children with favorable clinical results and substantial union, however this lesion seldom heals in adulthood.

Age, symptom duration, trauma history, lesion location, and OLT defect size are among the variables that have been found to be the most relevant in predicting clinical failure, according to some investigators. Lesions with dimensions less than 10 mm in diameter, 100 mm2 in cross-sectional area, and 5 mm in depth are often seen optimal for reparative treatments, whereas larger lesions are more suited for replacement procedures. Typically, the choice of intervention is decided by size. On the other hand, there are many who believe that reparative procedures can also be used for lesions that are up to 150 mm2 in size or 15 mm in diameter. The key cut-off point for lesions undergoing debridement and microfracture is a length of 15 mm or a cross-sectional area of 150 mm2. Larger lesions are linked to poor clinical outcomes.

Image analysis can determine the stability or instability of talar osteochondral lesions. Radiographs show a sclerotic border larger than 3 mm and lesions larger than 0.8 cm2 are probably unstable. On the other hand, magnetic resonance imaging (MRI) can reveal other indicators of instability, such as a rounded spot 5 mm or larger in diameter deep to the lesion, which could be a cyst caused by joint fluid seeping into the cancellous bone or cancellous bone resorption. Between 22 and 31 percent of individuals with an unstable OLT show these instability symptoms on MRI, while 50 percent show just one sign of instability. With a sensitivity of 92% to 97%, MRI has shown to be an excellent tool for identifying an unstable OLT.

Osteochondral defects, which appear as unstable fragments on magnetic resonance imaging (MRI), may in fact be a good place to get autologous chondral grafts for chondral restoration. But no studies have evaluated the feasibility of these pieces on MRI, even though there is a lot of literature on OLT. Lesions less than 2 cm2 are best treated with autologous osteochondral operations, while defects larger than 2 cm2 can be filled by matrix-induced autologous chondrocyte implantation (MACI). Lesion sizes more than 1.5 cm2 and depths up to 5 mm are also treated using a cell transplant approach derived from bone marrow (Figure 1).Contemporary medical procedures

The literature discusses a wide range of OLT treatment options, including various methods, patient-reported outcomes, and functional metrics. By alleviating pain and halting the progression of degenerative osteoarthritis, surgeons are continually on the lookout for novel ways to improve patients' quality of life. The choice of treatment among four primary options—conservative, repair, regeneration, and replacement—is determined by the grade, chronicity, and presence of symptoms of the lesion. Sometimes, MRI is used to track the course of a disease in asymptomatic patients. More specifically, our research delves into the topic of surgical therapy alternatives, with an emphasis on regenerative techniques.

Techniques for regenerating cartilage

Regenerative techniques attempt to create new hyaline cartilage that is more similar to the native one, rather than fibrocartilage created through microfractures, by recognizing that the articular hyaline cartilage is avascular and has limited regeneration capacities. In this regard, they are better suited for deeper lesions (> 5 mm) and larger ones (> 10 mm in diameter), making them the go-to choice in more advanced instances like stage IV, cystic lesions, or when cartilage destruction is substantial (6,8). As a result of our understanding that inadequate tissue formation from earlier therapies might cause maltreated minor lesions to grow to bigger ones, similar procedures are now also being used for mild instances (Figure 2).

Hybrid chondrocyte implantation using autologous and matrix-induced chondrocytes

A two-stage process known as autologous chondrocyte implantation (ACI) involves covering the defect with periosteum and then placing cultured chondrocytes obtained from the anterior talus or non-weight bearing knee cartilage over them. MACI is a second-generation technique that uses a matrix or scaffold containing implanted chondrocytes to hold them in place, rather than periosteum.

Matrix utilisation allows for reduced surgical time and morbidity and, in theory, more chondrocytes within the defect, despite the fact that it retains a 2-step process (9). An MRI observation of cartilage repair tissue (MOCART) score of 65 points, an increase in the mean American Orthopaedic Foot & Ankle Society (AOFAS) Score from 60 to 84 points, and an increase in the Foot and Ankle Activity Measurement (FAAM) from 89% were all demonstrated by Lenz et al. with a one-year follow-up (10). Similarly, Schneider and Karaikudi found very similar results for AOFAS, but after approximately two years of follow-up: 60 (range, 25 to 87) to 87 (range, 41 to 100) ($p < 0.0001$)(11).

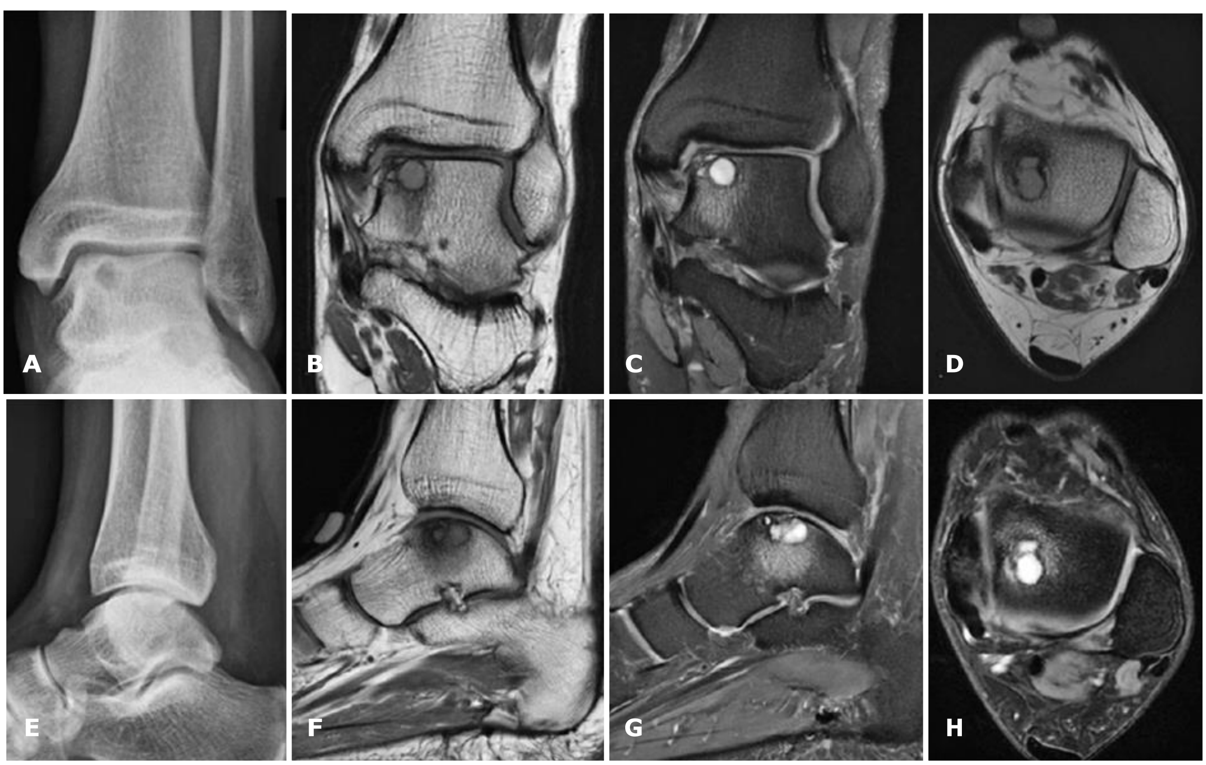

Figure 1. Images of a patient with osteochondral lesions of the talus (Raikin's area 4) with important "prognostic complicating factors": the lesion size, involvement of the shoulder of the talus (unstable lesion), and subchondral cysts. Observing the intense bone marrow edema around the lesion is important, as it is

characterized by signal changes on both T1 and T2 images. (A) AP and (E) Lateral - plain ankle radiographs; (B) T1 and (C) T2 coronal views; (F) T1 and (G) T2 sagittal views; (D) T1 and (H) T2, transverse views.

Autologous matrix-induced chondrogenesis and arthroscopy-autologous matrix-induced chondrogenesis with heterologous membrane

The AMIC method, developed by Behrens in 2005, was first used (12). Microfractures and a bilayer matrix of porcine collagen type I/III are employed to stabilize the clot and maintain pluripotent stem cells in place, with the goal of achieving the same result as ACI and MACI in a single session (6). Additionally, it can be mixed with other regenerating techniques such as platelet-rich plasma (PRP) or bone marrow aspirate concentrate (BMAC), and harvested minced autologous cartilage grafts for the lesion. All parties involved—the patient, the surgeon, and the healthcare system—benefit from this procedure's single-step design, which reduces morbidity, is easier to implement, and costs less than MACI and ACI.

When compared to previously disclosed open procedures, some studies found that primary arthroscopy-AMIC (AT-AMIC) produced good short- to mid-term results with similar functional ratings. The goal of AT-AMIC is to reduce surgical morbidity by avoiding the need for malleolar osteotomy. The method and its mid-term follow-up have shown promising results in a number of trials. Improvements in functional and pain outcomes were demonstrated in at least three more systematic evaluations, with one analysis also indicating improvements in imaging (13,14,15). Lesions less than 2 cm2 in size, with or without subchondral bone failure, are considered indications for this surgery (Figure 3).

Autologous matrix-induced chondrogenesis and arthroscopy-autologous matrix-induced chondrogenesis with biological scaffold

Because of the aforementioned factors, treating cartilage regeneration remains a challenging task. Autologous chondrocytes are still used extensively, despite the disputed restrictions. Given their excellent proliferation and differentiation capabilities as well as their abundant supply, mesenchymal cells are emerging as a promising new option for tissue regeneration in this setting. One drawback, though, is that many places lack the necessary infrastructure and technical knowledge (16). In light of this, there are a number of "biologic scaffolds" demonstrating encouraging outcomes in the regeneration cartilage sector that are both inexpensive and easy to apply, such as platelet rich fibrin (PRF) and bone marrow mononuclear cells (BMMCs).

It is possible to combine platelet rich fibrin, a second-generation platelet concentrate, with chopped autologous cartilage harvested from the talar lesion; this mixture forms a fibrin biomaterial that facilitates the migration and proliferation of fibroblasts and endothelial cells, and it also contains numerous growth factors stored in platelet granules and other cells (17,18). Since this method is safe, inexpensive, and shows promise, it is appropriate to begin considering its adoption, even though there is a dearth of research recognizing its usage on osteochondral lesions.

Balta and Kurnaz recently published a study that examined the rabbits' newly formed cartilage after biological adjuvants (PRF) both singly and in combination. They found statistically significant differences between the two groups, with the first group outperforming the control, particularly when the adjuvants were used together (19). Tafiuk et al. demonstrated successful cartilage regeneration following a surgical procedure combining PRF membranes, synovial grafts, and microfracture (MFx) (20). Wong et al. also created a one-stage technique that included PRF and autologous cartilage autografts, and they reported a very full cartilage repair afterward (21). According to the research, PRF and other biological materials not only have remarkable healing capabilities, but they can also be enhanced by combining them with other procedures. Malleolar osteotomy or an arthroscopy method can potentially be used to conduct this treatment.

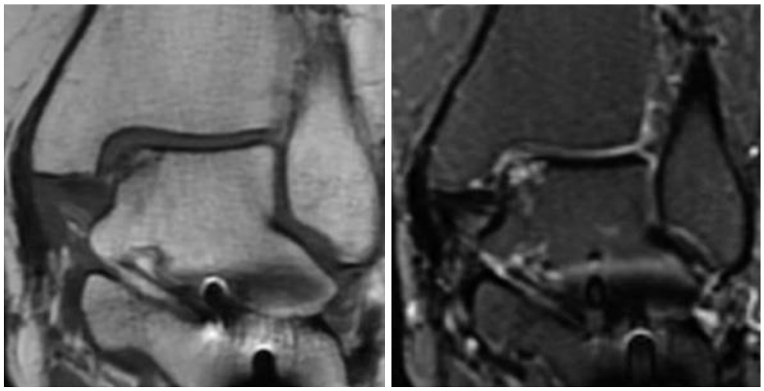

Figure 2. Magnetic resonance images (left-hand T1 and right-hand T2) of a patient with osteochondral lesions of the talus treated through microfractures that progressed unsatisfactorily after eight months.

The technique used by them follows these steps (Figure 4):

- OLT debridement and regularization (open or arthrosco- pically)
- Cancellous autograft from the ipsilateral calcaneus to fill the defect
- Lesion sealing with biological scaffold (PRF membrane)
- Fixation with fibrin glue

The biological scaffold preparation follows the Choukroun process and centrifugation(22) (Figure 5). The generated fibrin clot is mixed with the minced cartilage from the talus and then prepared to cover the cartilage defect (Figure 6).

Direct cartilage repair strategies: Microfractures and retrograde drilling

Two of these methods are retrograde drilling and bone marrow stimulation (micro-fracture), in which holes are punched in the subchondral bone to let bone marrow progenitor cells in and fibrocartilage to grow inside the hole. Because it lacks the Type II collagen found in most hyaline cartilages and is instead mostly constituted of Type I collagen, its biomechanical and structural capabilities are inferior to those of natural cartilage (23). In addition, the positive clinical effects they provide last for a minimum of four years.

The size of the OLT site after these approaches inversely correlate to each other is an important factor to consider regarding the good outcome of these techniques. The success of the surgery was found to depend on the lesion size in a study that analyzed 105 OLT treated arthroscopically, debridement, and microfracture. On the other hand, a cutoff area of 1.2 cm2 was discovered by MRI in another investigation (24). Furthermore, additional variables that contribute to a lack of improvement include the duration of the lesion, the existence of underlying cysts or arthritis, and the presence of an uncontained lesion.

The decline of the first promising outcomes has led some institutions throughout the world to forego these approaches in favor of regenerative medicine, even for moderate instances.

Cartilage replacement strategies: Osteochondral autograft transfer, osteochondral allograft, and particulate juvenile cartilage allograft transplantation

Osteochondral autograft transfer (OAT) involves transferring healthy cartilage from another part of the body, such as the talus or a non-weight bearing area of the knee (mosaicplasty) (Figure 6), Osteochondral allograft involves transferring cartilage from human cadavers (Figure 7), and particulate juvenile cartilage allograft transplantation (PJCAT) involves transferring cartilage from children as young as thirteen years old (Figure 8). Large lesions (1.5 cm2 or larger), talar shoulder, or an unstable periphery of the adjacent cartilage are common indications for their use.

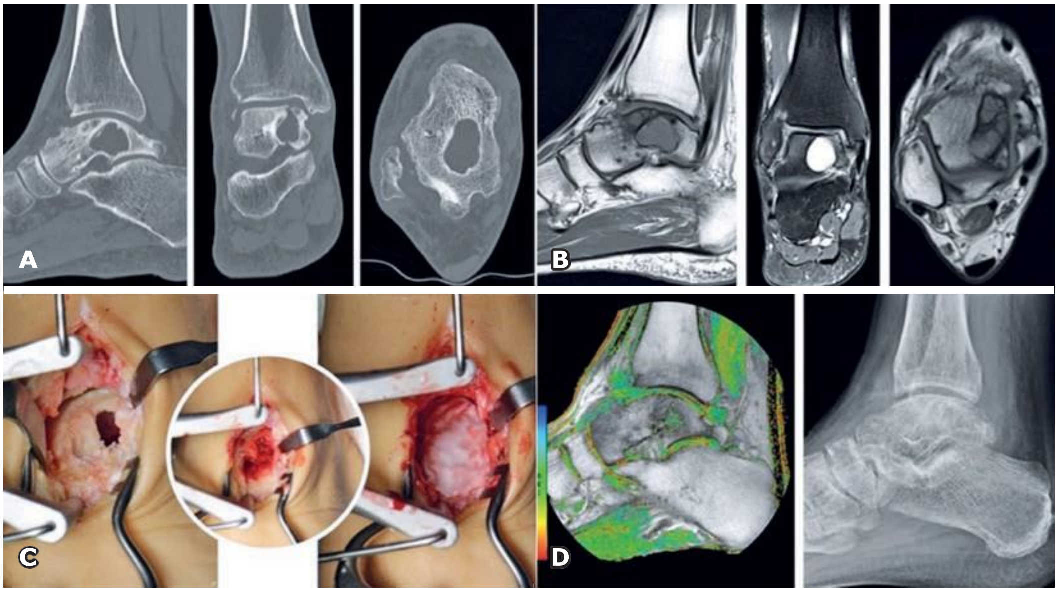

Figure 3. Autologous matrix-induced chondrogenesis (open) in severe osteochondral lesions of the talus with giant cysts: A. Computed tomography images (Sag, Cor, Trans); B. Images (SagT1, CorT2, TransT1); C. Through an anteromedial longitudinal incision and with a pin distractor, the area of the lesion is exposed and the "entrance" of the cystic lesion identified; The lesion is curetted and cleaned, being filled with an autologous cancellous bone graft and then covered with a chondroinductive membrane that is fixed to the bed with fibrin glue; D. T2 map (sagittal) and plain radiograph of the ankle (lateral) showing integration of the membrane into the bed; note the recovery of the tibiotalar joint space on the lateral radiograph.

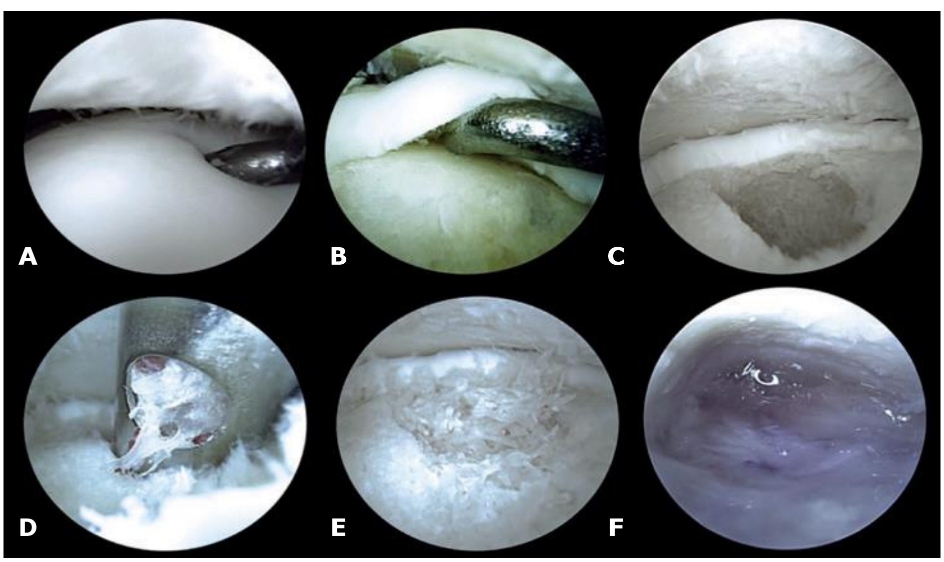

Figure 4. Arthroscopy-autologous matrix-induced chondrogenesis: Arthroscopic images of the procedure performed on the patient shown in Figure 1: A. Identifying the location of the articular cartilage fissure; B. With the probe placed at the cartilage-bone transition, one can identify the limits of the osteochondral lesions of the talus; C. Once all the unstable cartilage has been removed, we debride the subchondral cyst; D. Fenestrated cannula containing autologous cancellous bone that will be impacted into the cyst to create a support base for

the chondroinductive membrane; E. Cyst-filled up with cancellous bone to the level of the original subchondral bone of the injured area; F. Covering the lesion with the membrane and fixing it with fibrin glue. Note: The surgical steps in images D, E, and F are performed in "dry arthroscopy mode," as joint irrigation is interrupted to guarantee the integrity of the tissues that fill and cover the lesion.

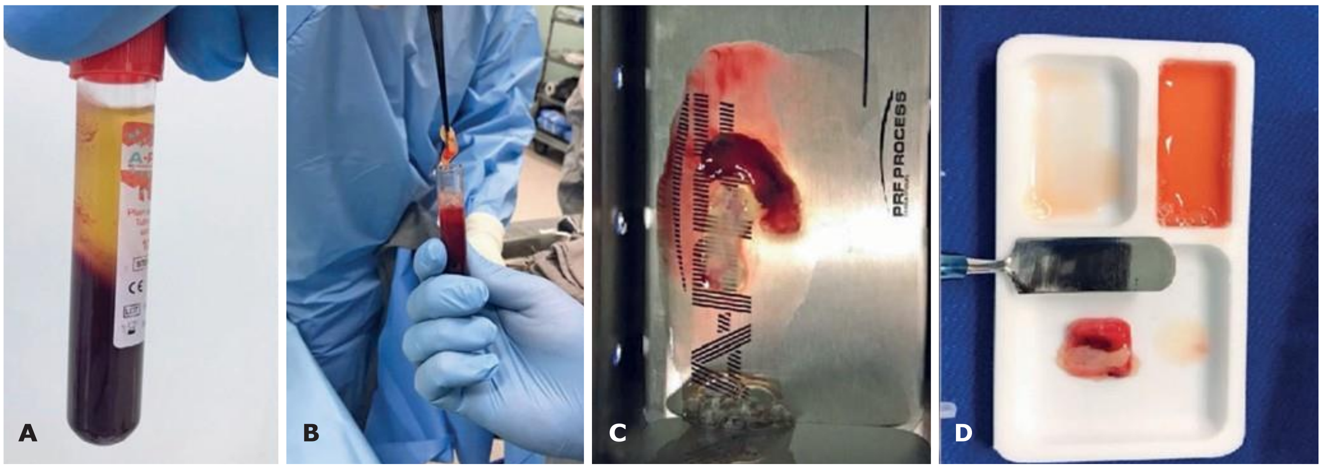

Figure 5. Platelet rich fibrin membrane collection and handling procedure. A: material after centrifugation, with a fibrin clot in the cen- tral portion. B: Fibrin clot removal. C and D: modeling process of the platelet rich fibrin collected material.

Ethical considerations, such as potential donor site morbidity, variations in knee and talus thickness and curvature, and tissue incompatibility, lead to a decrease in the frequency of these procedures. On the other hand, 87%-94% of the cases showed encouraging short- and medium-term results(25). Results from autograft transplantation for primary lesions were 77% successful and for subsequent lesions 90% successful, according to a comprehensive study (26). In addition, autograft had lower rates of failure and revisions at mild-term follow-up compared to allograft, according to Migliorini et al. (27).

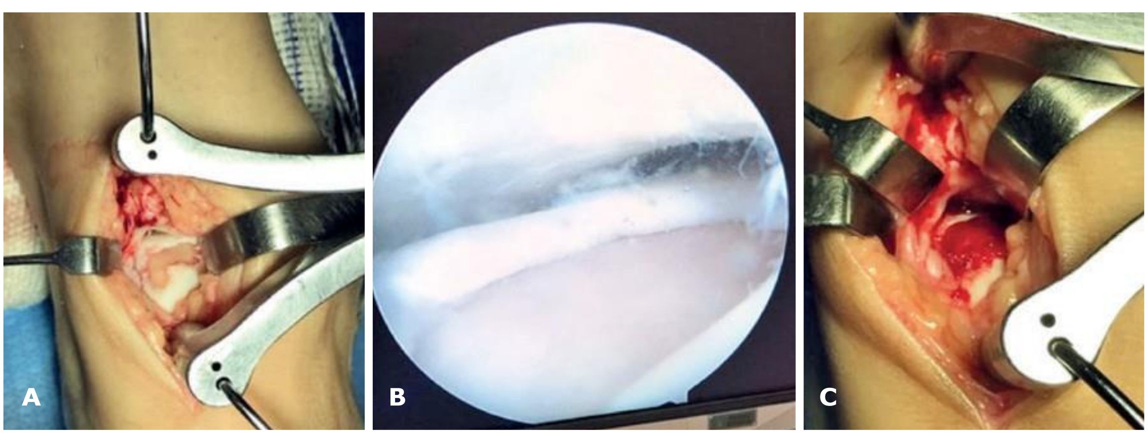

Figure 6. Osteochondral lesions of the talus under direct view after distraction (A) and during arthroscopy (B). Talus lesion covered by collected platelet rich fibrin membrane (C).

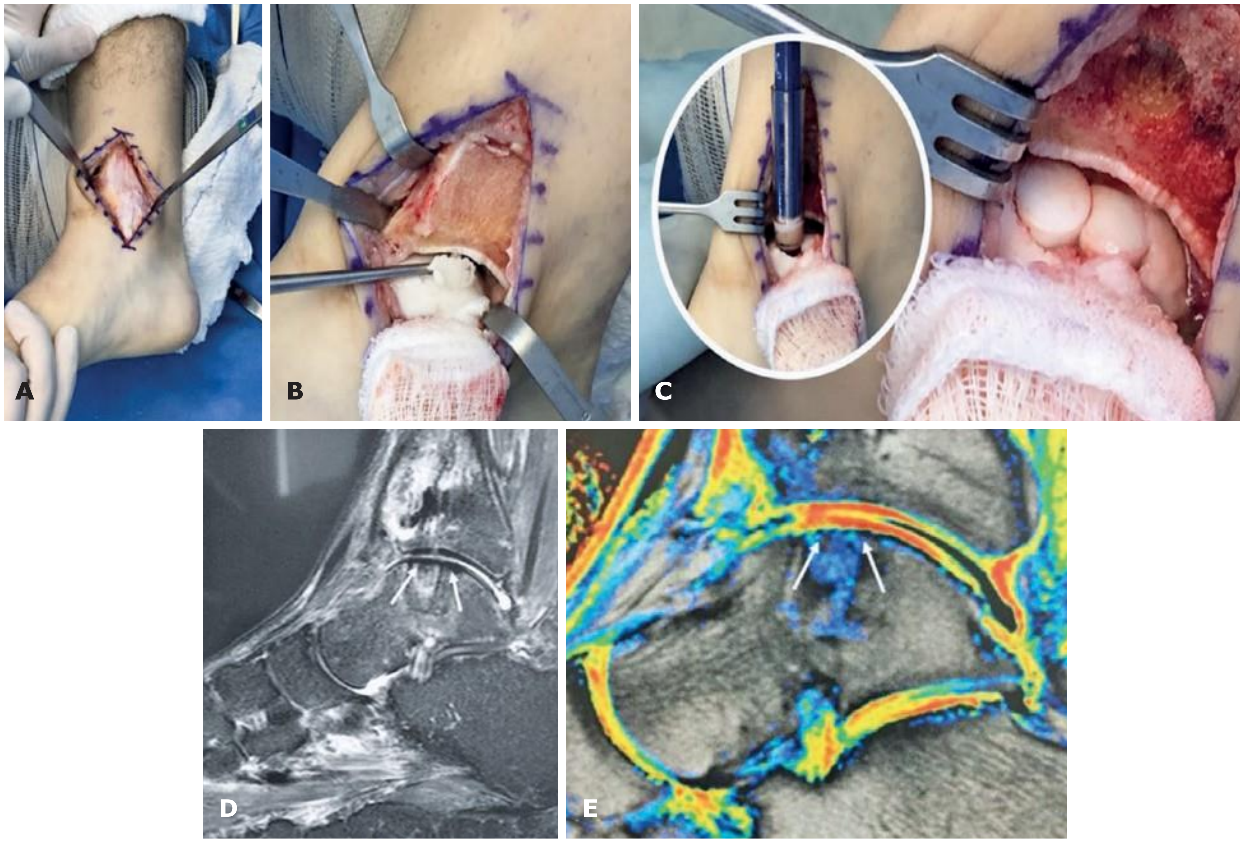

Figure 7. Osteochondral autologous transplantation: A. Medial surgical incision; B. Through a slightly oblique osteotomy that starts from the medial metaphyseal region of the tibia towards the "armpit" of the tibia, the osteochondral lesions of the talus is exposed;
C. Using a set of trephines, the bed of the recipient area is prepared, and the osteochondral cylinders are removed from the donor area to be introduced sequentially into the recipient area. It is important to try to leave as little space as possible on the joint surface without cartilaginous coverage, which can be achieved by overlapping the cylinders; D. Sagittal T2 image showing the integration of the implanted osteochondral cylinders into the body of the talus. Arrows point to the completely restored cartilaginous layer and subchondral bone; E. T2 map showing the signal of the cartilage in the repaired area (arrows), which is equivalent to the signal of the normal cartilage of the distal tibia that can be seen just above (reddish-orange color in this exam).

How to approach an osteochondral lesion
Each osteochondral lesion is addressed differently depending on the procedure to be used and the lesion's location.
Although only malleolar osteotomy can be used to execute mosaicplasty (OAT) when it is necessary (Figure 7A and B), other procedures like as AMIC, ACI, and microfractures can be done either through malleolar osteotomy or minimally invasive methods such arthroscopy or mini-arthrotomy.

Arthroscopy advantage
With the development of more effective surgical methods for OLT, the arthroscopic approach has emerged as the go-to method for treating these lesions. Concerning central, mixed, and posterior lesions, however, many surgeons confront the challenge.

In modern times, arthroscopic treatment of anterior, central, and central-anterior lesions is a breeze. All that is required is plantar flexion of the ankle and noninvasive distraction. Applying Hintermann's spreader (static distraction) laterally or medially while the ankle is in plantar flexion enables visualization of over 80% of the talus. This is a successful strategy for treating lesions in the center, posterior, and central-posterior areas through arthroscopy, with membranes covering the defect.

Malleolar osteotomy

The talus is a challenging joint to approach surgically because of its central location in the hindfoot and its embedding in the tibiofibular clamp. When an arthroscopic approach is not an option, lateral and medial malleolar osteotomy can be performed to achieve optimal accessibility. This problem is already difficult to treat because OLT can happen on either the posterior or medial aspect of this bone. An osteotomy may increase problems, postpone weight-bearing, and return to daily activities once the primary goal of treatment for this illness is to achieve optimal and rapid functional recovery to daily and athletic activities (28).

Some studies have demonstrated the safety of malleolar osteotomy and good short- to mid-term functional and imaging results, despite concerns about the more invasive nature of the procedure compared to the arthroscopic technique. Following osteotomy and arthroscopy, Sadlik et al. noticed no difference in AOFAS and MOCART scores (29). Pardiolleau et al. discovered no particular problems associated with malleolar osteotomy in a multicenter investigation (28). Having said that, there was zero to moderate long-term morbidity and a plethora of re-interventions needed to remove the implants, according to Leumann et al. (30).

Mini access (anteromedial and anterolateral) to avoid malleolar osteotomy

Though the majority of OLTs are amenable to arthroscopic treatment, bigger abnormalities may necessitate a previous arthrotomy to ensure enough access and improved visibility. Although malleolar osteotomy is the usual method of arthrotomy, talar cartilage can be seen 90% of the time with the use of a static spreader (Hintermann's spreader) to reduce the need for this procedure (Figure 3C).

Final considerations

There is a dearth of well-conducted comparative studies or randomized controlled trials that back these approaches, despite the abundance of options for treating this crucial orthopedic condition, which show encouraging results in cartilage restoration, rapid return to daily and athletic activities, and functional outcomes. However, rather than relying on reparative treatments, there is a growing trend towards utilizing advanced methods that focus on cartilage regeneration and replacement. This is particularly true for larger lesions. One promising alternative to existing regeneration methods for treating OLTs is a biologic scaffold made of autologous tissue; this approach is both inexpensive and straightforward to implement.

The primary criteria for choosing a surgical technique, approach, and management strategy should be the condition of the overlaying cartilage, the size of the lesion, the presence or absence of subchondral cysts, and the extent to which the OLT can be contained.

Figure 8. Particulate juvenile cartilage allograft transplantation (Courtesy of Dr. Rebecca Cerrato, MD)

Chronic instability of the medial or lateral ligaments of the ankle and hindfoot malalignment are other prevalent underlying reasons that, whether treated alone or in combination, require simultaneous attention. The probability of failure or poor results seems to be much higher in the absence of treatment for these illnesses.

Unfortunately, there aren't enough comparison studies to suggest one method over another, even though the results of the majority of these approaches are promising. Because of this, each patient needs a tailored treatment plan that includes counseling on expected results as well as the benefits and drawbacks of the proposed method.

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