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Special Article

Surgical treatment for talus osteochondral lesions: What's new?

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Abstract

Osteochondral lesions of the talus (OLTs) are a common pathology encountered by foot and ankle surgeons. Symptomatic cartilage lesions in the ankle pose a significant challenge and often require surgical intervention to alleviate pain, improve joint function, and restore the integrity of the articular surface. Possible treatment options, including operative and nonoperative management, have been widely discussed in the literature, with substantial heterogeneity regarding treatment approaches and resulting patient-reported outcomes and joint function metrics. A general problem regarding OLT is that this entity is not clearly defined, nor its description, location, or best treatment for each type that may be required in some symptomatic presentations. The focus of our paper was to show the proper treatment for each lesion, including location, deepness, vascularity, and capability of healing.

Level of evidence V; Expert opinion.

Keywords: Osteochondral; Talus/injuries; Talus/surgery; Arthroscopy; Ankle.

Introduction

Osteochondral lesion of the talus (OLT) describes damage to the talar cartilage, including pathological changes in the underlying bone. In nearly 80% of patients with OLT, a history of ankle trauma can be found[1,2], and 38% present ankle ligament laxity. In addition, 39% of patients with ankle instability can present OLT[3,4]. Subsequently, acute trauma and repetitive micro-trauma due to ankle instability and/or hindfoot malalignment seem to be a leading cause of OLT. In an ankle with chondral damage, the synovial fluid penetrates these micro-chondral lesions, infiltrating the subchondral and bone marrow area and leading to bone edema. The joint load increases the fluid pressure that can induce failure of the chondral bone support and, later on, cyst formations[5].

A general problem regarding OLT is that this entity is not clearly defined, nor its description, location, or best treatment for each type that may be required in some symptomatic presentations. The focus of our paper was to show the proper treatment for each lesion, including location, deepness, vascularity, and capability of healing.

Diagnosis

Osteochondral lesions of the talus predominate in males, mostly affecting patients over 30 years. Patients typically present symptoms from six to 12 months after an initial trauma (ankle fracture or sprain); typical symptoms are deep ankle pain, tenderness, and swelling in the medial or lateral gutters of the ankle that increases with weight-bearing and sports activity. Occasionally, patients report locking or catching sensations in the ankle. Frequently, recurrent sprains and unbalanced loading of the entire foot coincide with the ankle problem. Like any other condition, a thorough clinical

Study performed at the Hospital Felício Rocho, Belo Horizonte, MG, Brazil.

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examination should be performed to identify tenderness, swelling, limitations of ankle normal movements, subtalar and talonavicular range of motion, ankle ligaments stability, and hindfoot alignment.

However, none of the clinical findings are specific enough to diagnose OLT securely; hence, the diagnostic procedure should include imaging exams and plain radiography of the ankle using the anterior-posterior, lateral, and mortise views as a first examination. Computed tomography (CT) allows better visualization of bony parts of the lesion but with the inconvenience of high radiation exposures and less information on cartilage wear. Magnetic resonance imaging (MRI), on the other hand, can evaluate the OLT activity and possible accompanying tendons and ligament injuries better, but it may overestimate the size and diameter of the cartilage lesion when compared to arthroscopy[1].

Verhagen et al. showed that MRI has a higher sensitivity than CT (0.96 versus 0.81) to detect OLT and is thus the tool of choice to evaluate when a plain radiograph is negative, but these methods are complementary[2]. Besides the diagnostic utility of MRI and its better capacity to analyze the level of damage to the cartilage, it has an important prognostic and follow-up value in evaluating its regeneration after reparative and regenerative surgical treatments, in a kind of noninvasive biopsy, depending on collagen fiber network organization, water coordination, and content[3]. In a cohort study, Rizzo et al. demonstrated the good capacity of T2 mapping sequences in providing quantitative information about the newly formed tissue and its differences from the native cartilage[4].

Magnetic resonance imaging

Magnetic resonance imaging is the imaging technique of choice since it provides excellent visualization of the articular cartilage, subchondral bone, and adjacent soft tissues; it has a sensitivity of up to 96% and a specificity of 96%–100%. There is a close correlation of MRI findings and grading with arthroscopic findings, along with good interobserver agreement. MRI also demonstrates a sensitivity of 97% and specificity of 100% for identifying unstable lesions, and it is superior to CT for identifying early-stage lesions limited to the articular cartilage. The perceived disadvantage of MRI is due to the presence of bone marrow edema in the acute stage, which may lead to overestimation of lesion size or obscure lesion margins, information that may be required for surgical planning.

Nuclear medicine

Although bone scintigraphy is no longer utilized in the management of OLT due to the lack of specificity, the single photon emission computed tomography with CT (SPECT-CT) presents a good correlation with image and patient's symptoms, demonstrating that activity on SPECT-CT is more common in patients submitted to intervention compared to those treated conservatively. In patients with multiple lesions, SPECT-CT can also identify the symptomatic lesion due to its activity and help in surgical planning by demonstrating the extent of the lesion. Hence, while it is not considered the primary imaging modality, there is evidence that SPECT-CT can act as an adjunct in surgical planning, especially in the recurrence of pain after first treatment. It has, therefore, been recommended as part of a comprehensive assessment of the abnormality.

Role of imaging in management planning

The role of imaging is to diagnose the lesion and to inform an appropriate treatment pathway. While important factors for clinical decision-making include skeletal maturity, lesion size, and evidence of instability, other lesion characteristics, such as integrity of the overlying cartilage and subchondral changes, are also important to help decide the appropriate surgical intervention. There is a higher healing potential of traumatic OLT in children, with studies showing significant union and good clinical outcomes, but in adults, this lesion rarely heals.

Some authors have stated that OLT defect size is the single most important prognostic factor, and others, such as age, symptom duration, history of trauma, or lesion location, had no association with clinical failure. The choice of intervention is usually dictated by size, with lesions measuring smaller than 10 mm in diameter, less than 100 mm^2 in cross-sectional area, and less than 5 mm in depth are considered ideal for reparative procedures, and larger lesions being more suitable for replacement procedures. However, others have advocated that lesions up to 15 mm in diameter or measuring up to 150 mm^2 can also be treated with reparative techniques. A length of 15 mm or a cross-sectional area of 150 mm^2 is considered a critical cut-off point, with poor clinical outcome associated with larger lesions submitted to debridement and microfracture.

Osteochondral lesions of the talus stability or instability can be assessed by imaging. On radiographs, lesions measuring 0.8 cm^2 are likely unstable, and a sclerotic margin measuring more than 3 mm can be noted. Other signs of instability can be identified in MRI, including a 5 mm or bigger, rounded deep to the lesion, representing a cyst, possibly due to intrusion of joint fluid into the cancellous bone or cancellous bone resorption. These signs of instability are seen in 22% to 31% of patients with an unstable OLT, but 50% demonstrate only one sign of instability on MRI. MRI has proven excellent for detecting an unstable OLT, with sensitivity ranging between 92% and 97%

On MRI, the osteochondral defect (unstable fragment) can also be a viable source of autologous chondral graft to allow chondral reconstruction. However, despite extensive literature on OLT, no studies assess the viability of these fragments on MRI. Autologous osteochondral procedures are recommended for lesions smaller than 2 cm^2, while matrix-induced autologous chondrocyte implantation (MACI) can be performed for defects measuring more than 2 cm^2. Similarly, a bone marrow-derived cell transplant technique is used for lesions bigger than 1.5 cm^2 in area and up to 5 mm deep (Figure 1).

Modern treatments

There are many possibilities for OLT treatment discussed in the literature, encompassing different approaches, patient-reported outcomes, and functional metrics. Constantly, surgeons are looking for new methods that bring back patient's quality of life by reducing pain and preventing evolution to degenerative osteoarthritis. Treatment can be divided into four main categories: cartilage repair, cartilage regeneration, cartilage replacement, and conservative, in which the chosen option depends on the lesion grade, its chronicity, and the presence of symptoms. Asymptomatic cases are often followed with MRI for progression. In our paper, we discuss in more detail only operative treatment options, mainly regenerative strategies.

Cartilage regeneration strategies

Acknowledging that the articular hyaline cartilage is avascular and with limited regeneration capacities, the regenerative methods aim to form new hyaline cartilage more like the native one when compared to the fibrocartilage produced with microfractures[5,6,7]. In this context, they are more suited for larger (> 10 mm in diameter) and deeper lesions (> 5 mm), thus being preferred in advanced cases such as stage IV, cystic lesions, or when there's severe damage to the cartilage[6,8]. More recently, these methods are also being used for mild cases, as we know that maltreated small lesions can progress to bigger due to the inadequacy of the tissue formed by older treatments (Figure 2).

Autologous chondrocyte implantation and matrix-induced autologous chondrocyte implantation

Autologous chondrocyte implantation (ACI) is a 2-step procedure in which cultured chondrocytes acquired from the anterior talus or the non-weight bearing knee cartilage are placed over the defect, followed by its coverage with periosteum. MACI is a second-generation procedure in that instead of periosteum, the implanted chondrocytes are kept in place with a matrix or scaffold containing these cells.

Even though it keeps a 2-step procedure, the matrix usage allows a lower surgical time, morbidity, and, theoretically, more chondrocytes within the defect[9]. Lenz et al. showed significant improvement in the mean American Orthopaedic Foot & Ankle Society (AOFAS) Score – 60 points to 84, Foot and Ankle Activity Measurement (FAAM) of 89%, and an MRI observation of cartilage repair tissue (MOCART) score of 65 points, all with one-year follow-up[10]. Similarly, Schneider

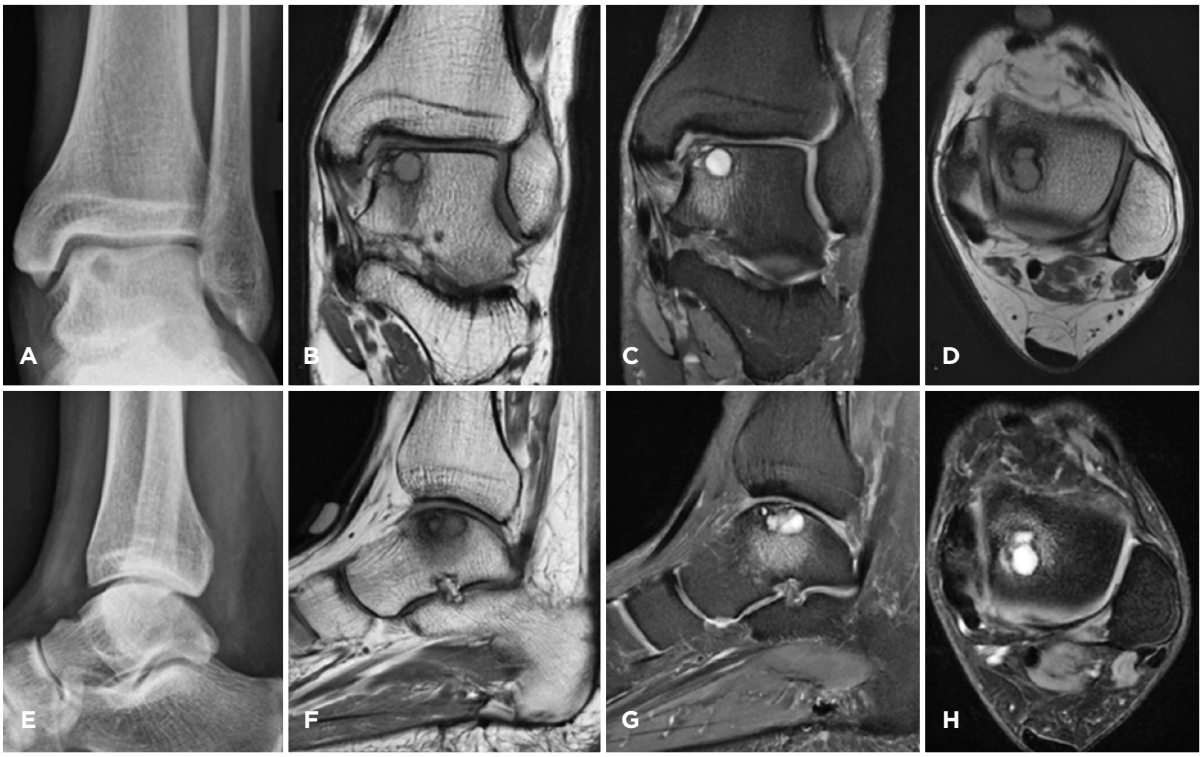

Figure 1. Images of a patient with osteochondral lesions of the talus (Raikin's area 4) with important "prognostic complicating factors": the lesion size, involvement of the shoulder of the talus (unstable lesion), and subchondral cysts. Observing the intense bone marrow edema around the lesion is important,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

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].

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

In 2005, Behrens introduced the autologous matrix-induced chondrogenesis (AMIC) technique[12]. The idea is to achieve the same goal of ACI and MACI through a single session procedure that consists of the combination of microfractures and the application of a porcine collagen type I/III bilayer matrix, used to stabilize the clot formed and hold pluripotent stem cells[6]. It can also be combined with other regenerative methods, like bone marrow aspirate concentrate (BMAC) or platelet-rich plasma (PRP) and minced autologous cartilage graft harvest for the lesion. Since this procedure is performed in a single step, leading to less morbidity, it is more technically easier and economically affordable, but not inferior to MACI and ACI, which benefits both patient and surgeon.

Some studies published good short to mid-term results following primary arthroscopy-AMIC (AT-AMIC), with similar functional scores compared to previously described open techniques. The idea of AT-AMIC is to avoid malleolar osteotomy, leading to an even less morbid procedure. Some studies have already demonstrated the technique and mid-term follow-up with good results. At least three systematic reviews further showed improvement in functional and pain outcomes, with one also showing imaging improvements[13,14,15]. The indication to perform this procedure encompasses lesions smaller than 2 cm^2 with or without fail of the subchondral bone (Figure 3).

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

Cartilage regeneration keeps posing many difficulties in its treatment due to previously described conditions. Yet, even with the debated limitations, autologous chondrocytes continue to be widely applied. In this context, mesenchymal cells are gaining space as a superior alternative for tissue regeneration due to their high capacity for proliferation, differentiation and for the large sources of mesenchymal cells. However, an inconvenience is that facilities and technical expertise are required, which are not accessible in many locations[16]. Given that, bone marrow mononuclear cells (BMMCs) and platelet rich fibrin (PRF) are some examples of what is called a "biologic scaffold" showing promising results around regenerative cartilage field, with lesser cost and easy technique.

Platelet rich fibrin is a second-generation platelet concentrate that contains many growth factors stored in platelet granules and other cells, constituting a type of "supermembrane," which can also be mixed with chopped autologous cartilage that was collected from the talar lesion itself but can also be considered a fibrin biomaterial, as it serves as a matrix for the migration and proliferation of fibroblasts and endothelial cells[17,18]. There is a lack of studies acknowledging the use of this technique on osteochondral lesions, but it is reasonable to start thinking about adopting it due to its safety, relatively low cost, and promising results.

A recent paper conducted by Balta and Kurnaz analyzed histologically and macroscopically the formed cartilage in rabbits after biological adjuvants (PRF) individually and in combination, showing statistical differences in favor of the first group against the control, especially when used in combination[19]. Tafiuk et al. showed an effective regeneration of cartilage defects after a surgical treatment integrating microfracture (MFx), synovial grafts, and PRF membranes[20]. Further, Wong et al., after developing a one-stage method that combined PRF and autologous cartilage autografts, reported a relatively complete cartilage repair[21]. Hence, the literature shows that besides having great regenerative capacities, PRF and other biological materials can be combined with other techniques that potentialize its results. This technique can also be performed with malleolar osteotomy or through arthroscopy approach.

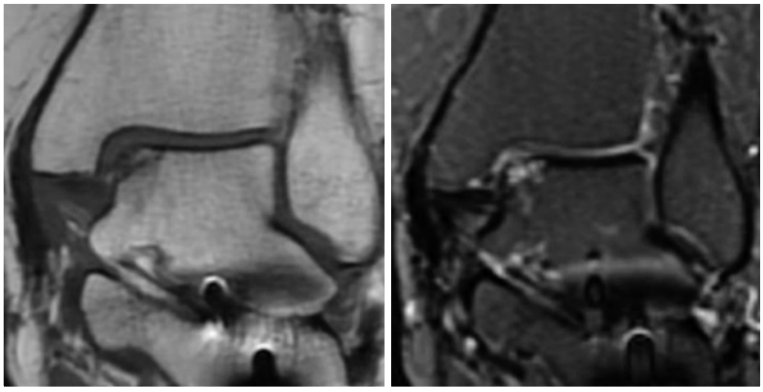

Figure 2. Magnetic resonance images (left-hand T1 and right-hand T2) of a patient with osteochondral lesions of the talus treated through microfractures that progressed unsatisfactorily after eight months.

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

- OLT debridement and regularization (open or arthroscopically)
- 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

These techniques include bone marrow stimulation (microfracture) and retrograde drilling, where perforations on the subchondral bone are performed, allowing the infiltration of bone marrow progenitor cells and the formation of fibrocartilage within the defect. As it is composed primarily of Type I collagen, rather than Type II, which composes most hyaline cartilages, it has inferior biomechanical and structural properties than the natural one[23]. Besides that, they produce good clinical outcomes that remain for at least four years.

A point to note regarding the successful outcome of these techniques is the size of the OLT site once they inversely correlate to each other. In a study analyzing 105 OLT treated arthroscopically, debridement, and microfracture, the lesion size was determinant for the procedure's success, whereas the cutoff area, determined through MRI in another study, is 1.2 cm^2[24]. In addition, other factors lead to less improvement, such as the lesion time, presence of arthritis and underlying cysts, and when there is an uncontained lesion.

In recent years, these strategies have been abandoned in multiple centers worldwide due to deterioration of the initial good results, favoring regenerative methods, even for mild cases.

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

All these three techniques describe the substitution of the lesioned cartilage for another healthy one from different sources—osteochondral autograft transfer (OAT): harvested cartilage from talus or non-weight bearing area of the knee (mosaicplasty) (Figure 6); Osteochondral allograft: harvested from human cadavers; particulate juvenile cartilage allograft transplantation (PJCAT): particulate juvenile cartilage from deceased donors up to 13-years old (Figure 7).

They are often indicated for big lesions (1 – 1,5 cm^2, or even bigger ones), talar shoulder, or unstable rim of the surrounding cartilage.

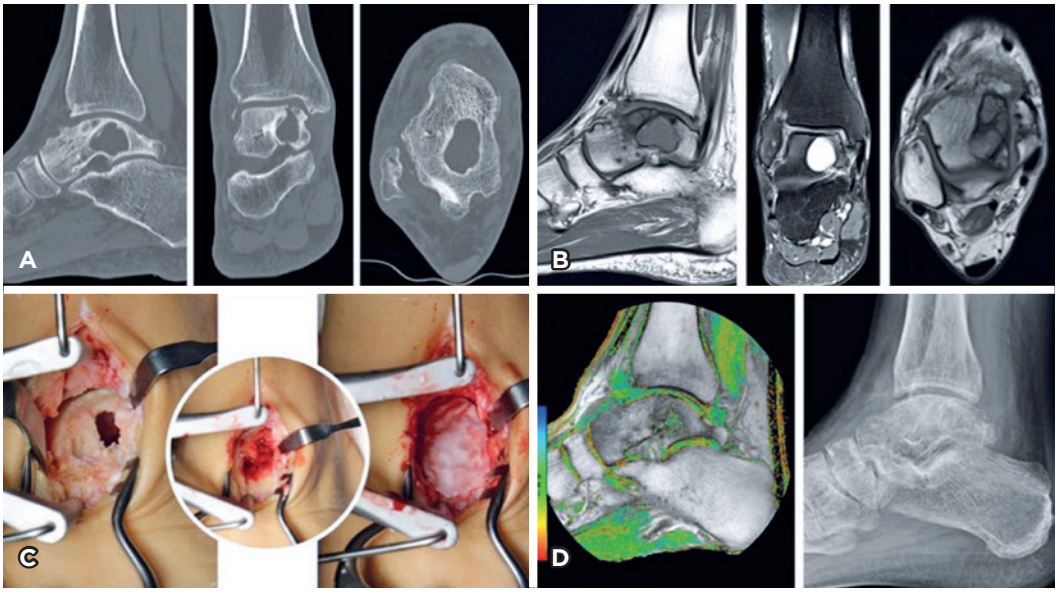

Figure 3. Autologous matrix-induced chondrogenesis (open) in severe osteochondral lesions of the talus with giant cysts: A. Computed tomography images (Sag, Cor, Trans); B. Images (SagT1, CorT2, TransT1); C. Through an anteromedial longitudinal incision and with a pin distractor, the area of the lesion 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.

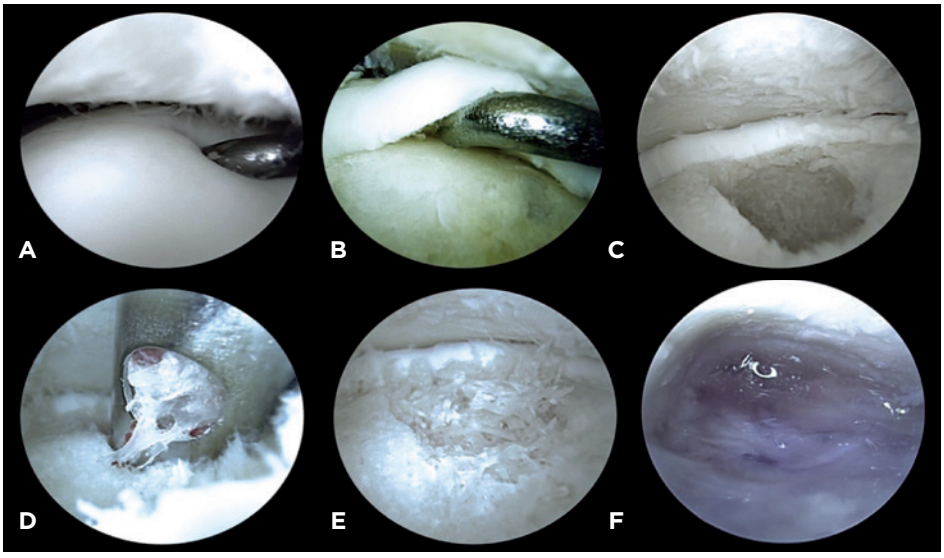

Figure 4. Arthroscopy-autologous matrix-induced chondrogenesis: Arthroscopic images of the procedure performed on the patient shown in Figure 1: A. Identifying the location of the articular cartilage fissure; B. With the probe placed at the cartilage-bone transition, one can identify the limits of the 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.

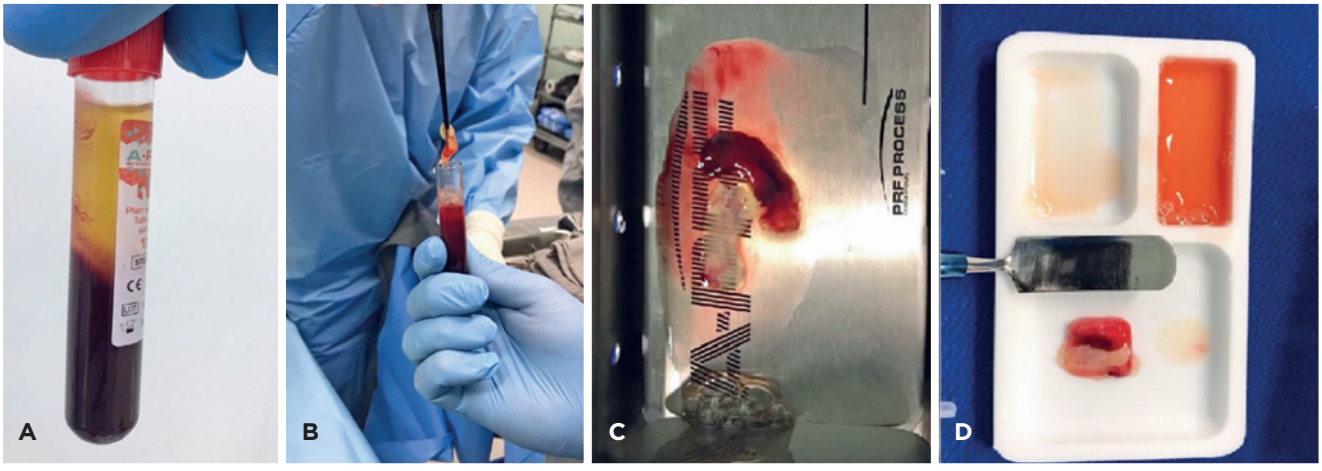

Figure 5. Platelet rich fibrin membrane collection and handling procedure. A: material after centrifugation, with a fibrin clot in the central portion. B: Fibrin clot removal. C and D: modeling process of the platelet rich fibrin collected material.

These techniques are less frequently performed due to ethical concerns, among other questions: donor site morbidity, thickness and curvature differences between knee and talus, and tissue incompatibility. However, short- and mid-term results have been published with promising outcomes in 87%–94% of the cases[25]. In a systematic review, a success rate of 77% was found after autograft transplantation for primary lesions and 90% for secondary lesions[26]. Further, Migliorini et al.[27] found fewer rates of failure and revisions after autograft at mild-term follow-up compared to allograft.

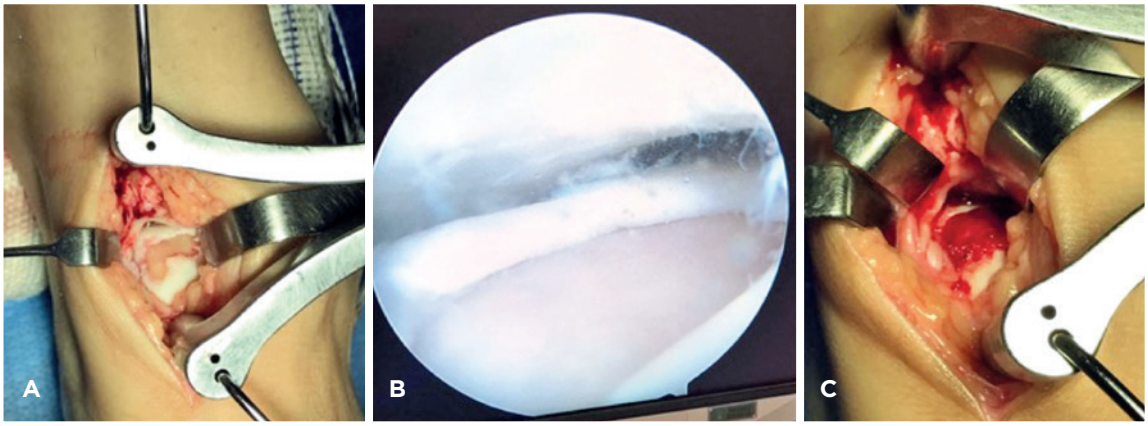

Figure 6. Osteochondral lesions of the talus under direct view after distraction (A) and during arthroscopy (B). Talus lesion covered by collected platelet rich fibrin membrane (C).

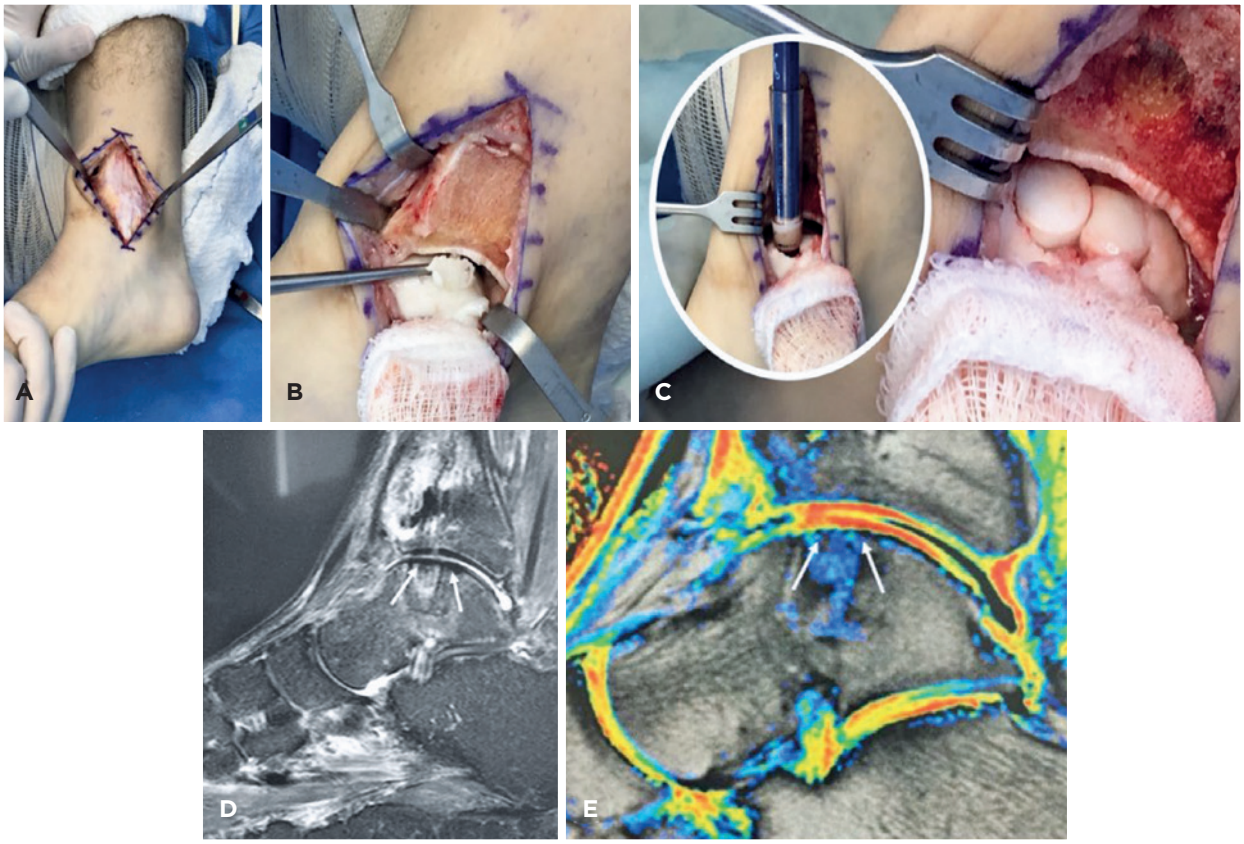

Figure 7. Osteochondral autologous transplantation: A. Medial surgical incision; B. Through a slightly oblique osteotomy that starts from the medial metaphyseal region of the tibia towards the "armpit" of the tibia, the osteochondral lesions of the talus is exposed; C. Using a set of trephines, the bed 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

The approach to each osteochondral lesion is related to the technique that will be performed and the location of the lesion.

When a mosaicplasty (OAT) is indicated, this procedure can only be performed through malleolar osteotomy (Figure 7A and B), but AMIC, ACI, and microfractures, can be performed minimally invasive (arthroscopy or mini-arthrotomy) or through malleolar osteotomy.

Arthroscopy advantage

As new surgical options for OLT evolved over the years, the arthroscopic approach has become the gold standard for these lesions. However, many surgeons face the dilemma of approaching central, combined, and posterior lesions.

Nowadays, anterior, central, and central-anterior lesions are easily treated arthroscopically, with the ankle in plantar flexion and noninvasive distraction. For central, posterior, and central-posterior lesions, the use of Hintermann's spreader (static distraction) applied laterally or medially with the ankle in plantar flexion allows visualization to more than 80% of the talus, being a successful strategy to treat these lesions through arthroscopy, using membranes to cover the defect.

Malleolar osteotomy

Due to its central position in the hindfoot and embedded in the tibiofibular clamp, surgical access to the talus is difficult. As stated previously, OLT can occur either on the posterior aspect of this bone, which makes this condition even harder to treat; thus, lateral and medial malleolar osteotomy can be performed to gain optimal accessibility whenever an arthroscopic approach is not possible. However, once the main treatment concern about this condition is to achieve optimal and fast functional recovery to daily and sports activities, an osteotomy may enhance complications, delay weight-bearing, and return to daily activities[28].

Despite the concern about the more invasive nature of the malleolar osteotomy compared to the arthroscopic approach, some studies have already shown its safety and good short- to mid-term functional and imaging results. Sadlik et al. showed similar AOFAS and magnetic resonance observation of cartilage repair tissue (MOCART) scores after osteotomy and arthroscopy[29]. In a multicenter study, Pardiolleau et al. found no specific complications associated with malleolar osteotomy[28]. However, Leumann et al. showed no short to mid-term morbidity but little long-term morbidity and the necessity of many re-interventions for implant removal[30].

Mini access (anteromedial and anterolateral) to avoid malleolar osteotomy

Even though most OLTs can be treated arthroscopically, when it comes to larger defects, a former arthrotomy may be required for better visualization and proper access. Most of the time, arthrotomy is achieved through the malleolar osteotomy, but some distractions using a static spreader (Hintermann's spreader) allow 90% visualization of talar cartilage, decreasing the indication of malleolar osteotomy (Figure 3C).

Final considerations

Even though there are many possibilities to treat this important orthopedic condition, with good promising results in cartilage restoration, fast return to daily and sports activities, and functional outcomes, there is a lack of well-conducted comparative studies or randomized controlled trials that support these techniques. Despite that, we can see

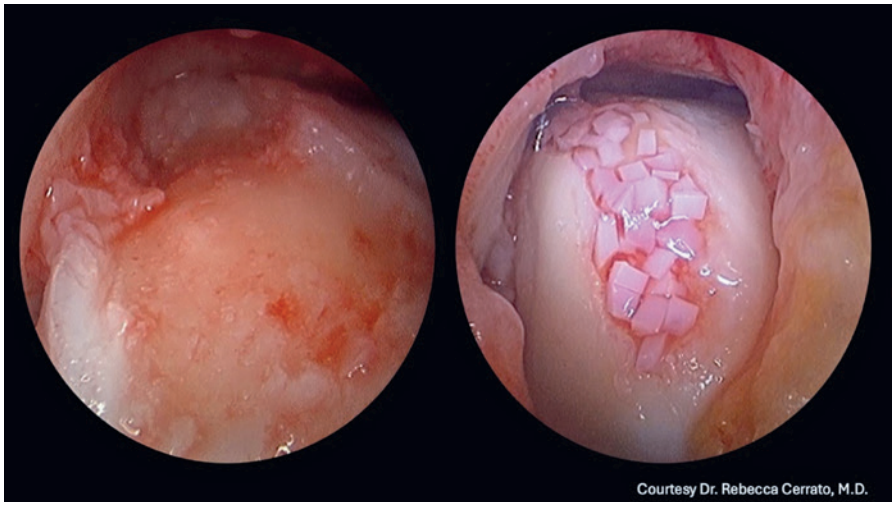

Figure 8. Particulate juvenile cartilage allograft transplantation (Courtesy of Dr. Rebecca Cerrato, MD)

an increasing tendency to adopt advanced techniques that aim at cartilage regeneration and replacement, especially for increased lesion sizes, rather than reparative ones. For example, a biologic scaffold consisting of autologous tissue, technically easy to conduct and financially affordable, might be a great option to treat OLTs, together with other regenerative strategies.

The surgical technique-surgical approach and managing strategy should be primarily selected depending on the status of the overlying cartilage, lesion size, presence of subchondral cists (size and number), and OLT containment.

Further common underlying causes are chronic lateral or medial ligamentous ankle instability and hindfoot malalignment in either isolation or combination, which must be treated simultaneously. Without addressing these pathologies, the likelihood of poor results or failures appears much higher.

Although the outcomes of most of these techniques are encouraging, it is impossible to recommend one procedure over another due to a lack of comparative analyses. Consequently, treatment should be individualized for every patient, with appropriate counseling regarding outcomes and associated pros and cons of the recommended technique.

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