# 8 Repair by Microfractures and Perforations

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## 8.1 Introduction

Microfractures and microperforations are still the most common technique showing the best results for the repair of chondral lesions with diameter less than 15 mm [1].

The micro-traumas, as a result of excessive stress, may lead to the formation of hemarthroses; but, even as a result of synovial hypertrophy, micro-traumas may provoke the formation of fibrous tissue at joint level that can become a rigid structure with cell degeneration, causing fissures on the chondral surface and thinning of the subchondral bone [2].

The synovial fluid, which is often in excess to compensate for the disease, produces pressure on the chondral surface; and it can lead to joint damage with fissures or flaps up to subchondral cysts and chondral fractures. In the latter case, the applied forces can extend the lesion from the cartilage layer to the subchondral bone, and this process occurs frequently [2–4].

There are also non-traumatic causes of chondral lesions: chronic ankle instability, endocrine and metabolic factors, bad joint alignments, idiopathic avascular necrosis, joint degeneration, systemic vascular disease, and genetic predispositions [1, 5–12].

In case of cartilage injury, mainly acute, the formation of a communication between the cartilage and the underlying trabecular bone may occur, allowing a reparative spontaneous response resulting in the lesion filling [13].

## 8.2 Literature Overview

In 1959, Pridie [14] proposed the concept of therapeutically induced bleeding at subchondral bone level below the articular cartilage damaged regions. The technique involved the removal of unstable cartilage fragments, including the underlying bone, and then the stimulation of the defect healing through the formation of 3–4 $cm^2$ holes with 1.5–2.0 mm diameter and a depth of 2 cm.

Several studies have shown the efficacy of this technique that is still considered the gold standard in the case of injuries mainly characterized by cartilage damage with minimal involvement of the subchondral bone [15–17].

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In 1982, Johnson [18] modified the chondro-abrasion technique (already proposed by Haggary in 1940) claiming that the abrasion must be performed at the “tide-mark” level and it should not reach the cancellous bone, thus reaching a depth of 1–2 mm.

In 1992, Steadman [19] developed the microfracture technique that consisted in drill holes at a distance of 3–4 mm and a depth of 4 mm on the articular surface of the lesion. This procedure, through perforations of smaller diameter with respect to Pridie’s technique (about 0.5–1.0 mm to 1.5–2.0 mm), allowed a minor disturbance to joint biomechanics [19]. This treatment, initially reserved for knee chondropathy, was then extended to the cartilaginous lesions of the ankle joint.

Different recent studies showed good results for these surgical technique [15, 17, 20–22].

## 8.3 Indications

The arthroscopic surgical procedure of microperforations or microfractures for chondral lesions’ repair must consider several variables.

The key issue is to consider whether the etiology of the lesion is due to either an acute injury or multiple traumas. The depth is equally important, also considering the possible presence of subchondral cysts or avascular necrosis zones or bone infarcts. The defect can then be either circumscribed or not with mono- or multipolar sites. The ligamentous integrity of the ankle should also be considered, as well as the alignment (varus or valgus axis deviation) and any previous treatments.

The X-ray imaging is critical in assessing the joint space and the eventual arthritic component (osteophytes or cysts), while the magnetic resonance allows to evaluate the depth of the lesion of the bone bruise and of the avascular necrosis.

We can therefore claim that the main indications for this type of surgery are injuries from 0.5 to 2 $cm^2$, age of the patients from 15 to 50 years, and the absence of alignment and instability deficits.

The contraindications that we can consider as relevant are overweight, joint stiffness, axial deviation, instability, age according to the clinical case, severe osteoarthritis, inflammatory disease, and rheumatoid arthritis.

## 8.4 Surgical Technique

Once the clinical and instrumental diagnosis has been implemented and the characteristics of the lesion and its evolution stage have been identified, the choice of the treatment for a chondral defect of the ankle depends on whether it is measured in the acute phase or in the next phase.

In the acute phase, the chondral defect must be fixed by the use of metal or absorbable synthesis devices. In case of small lesions, the chondral defect is compacted. If the injury is chronic and in an accessible location, we proceed to the removal of any free fragment, treating it as a moving body, implementing a revitalizing treatment of the subchondral bone with perforations or microperforations.

Most of the lesions treated with microfractures take advantage of an arthroscopic anterior access with the ankle in full plantar flexion. This access allows the treatment of lesions located from the middle third ahead of the talar dome and also of posterior lesions partially accessible, thanks to new devices [23].

Surgical treatment with multiple perforations proposed by Ferkel via transtalar and transmalleolar aims at making the perforations, with the aid of a compass, in hardly accessible areas or areas not reachable arthroscopically (Fig. 8.1a, b). To the articular chondro-abrasion, executable through the classic arthroscopic access, are added the perforations performed with motorized tool; but this is a method in disuse because it can pierce the tibia or the talus.

Compared to procedures involving a mini-open creation, arthroscopy shows less invasiveness and a lower morbidity; moreover, it offers an advantage in terms of early rehabilitation and a quicker return to work and recreational activities.

For this type of surgery, which we normally execute without stretch of the ankle joint, sometimes it is necessary to apply a traction sling that allows the articulation diastasis in order to enable a more simple transition of the tools, especially in central and posterior zones. In cases of

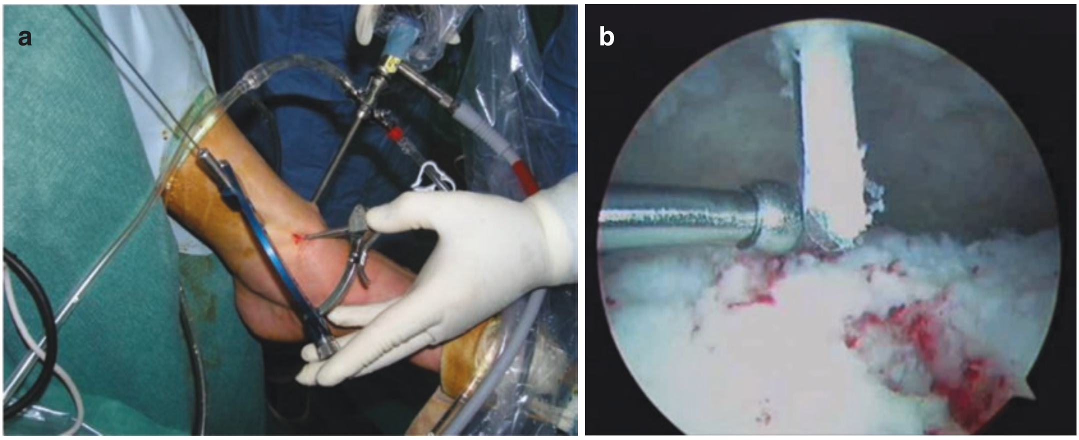


**Fig. 8.1** (**a**) Use of the Ferkel compass for talar perforations. (**b**) Perforations through Ferkel compass via transtibial and transmalleolar

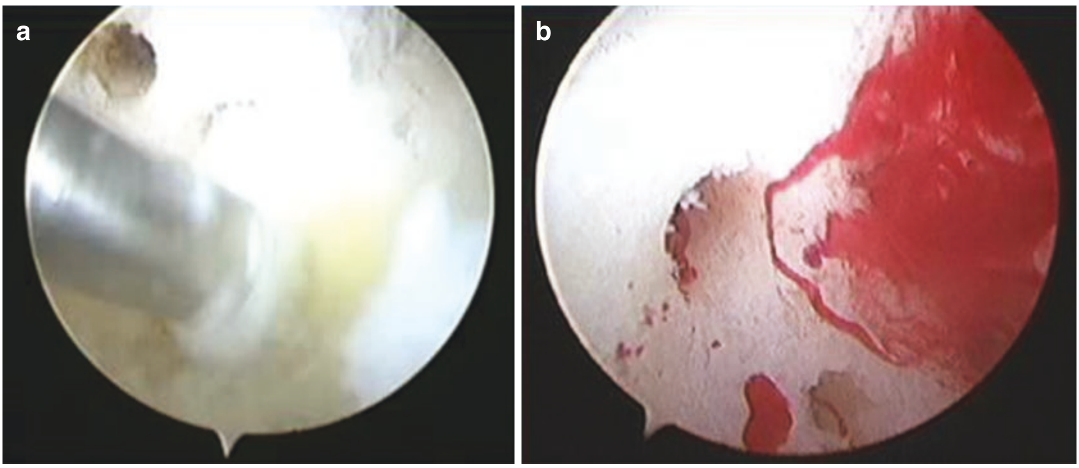


**Fig. 8.2** (**a**) Subchondral bone perforations with Kirschner wire. (**b**) Subchondral bone fracture layer after perforations with a K-wire

clamped joints, the use of the external fixator to allow arthrodiastasis can be decisive.

The subchondral bone can be perforated with the aid of a milling cutter or with a Kirschner wire of 1.5–2 mm diameter (Fig. 8.2a, b) [24, 25].

The microfracture technique, proposed by Steadman [26], has been improved with the use of special perforators that allow greater accessibility to the articular environment, thanks to the extremity curve following the shape required by the articular anatomy (Fig. 8.3a, b) [27].

One possible complication of this procedure occurs at the time of instruments' removal due to the creation of free endoarticular bone fragments that, if they are not removed, can cause a future articular block or cartilaginous damage for loose bodies [28].

The use of a microperforation osteochondral drill (microOCD) has been recently introduced. The main difference between the microfractures and microOCD is determined by the fact that the microfractures, presenting a spinky conformation, cause a chondro-compaction in the deep section which can prevent or reduce the blood flow due to the chondral wall developed in front of the hole that acts as a stopper. In the most superficial portion of the cone, a good cancellous bone is developed, but we do not know if it is

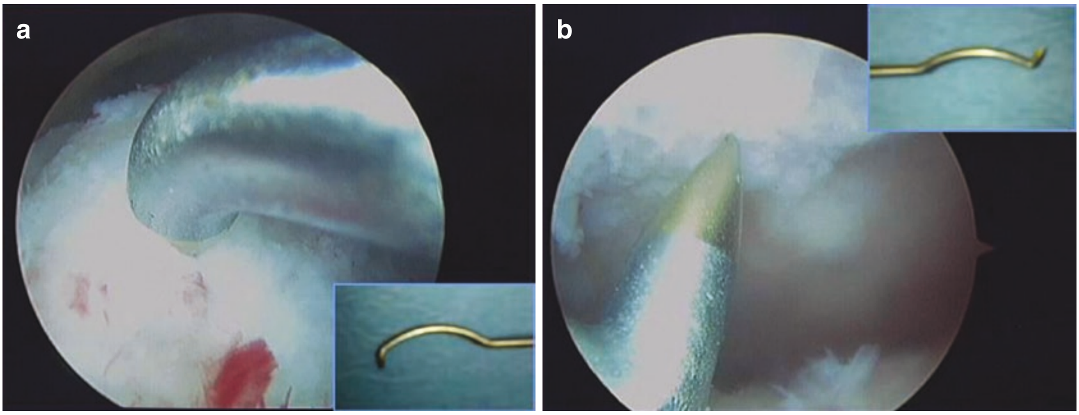


**Fig. 8.3** (**a**) New drills that allow better accessibility to articular talus environment. (**b**) New drills that allow better accessibility to articular tibial environment

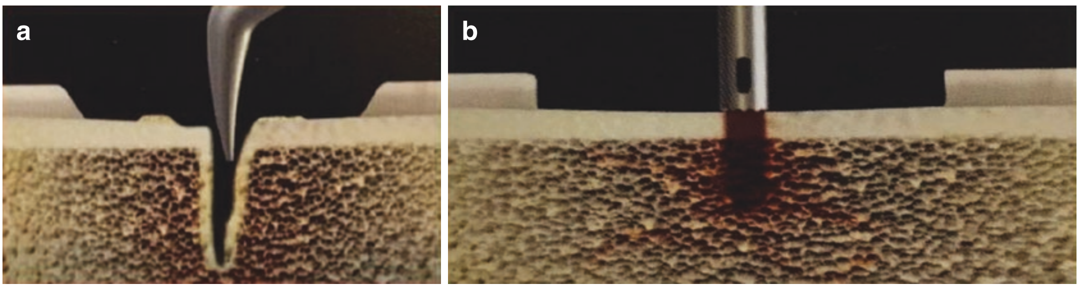


**Fig. 8.4** (**a**) The microfractures, with a spiky conformation, cause a chondro-compaction that can prevent or reduce the blood flow due to the chondral wall developed in front of the hole. (**b**) The microfracture perforates the subchondral bone with the same diameter throughout its length causing a less compaction of the bone

well vascularized. The area affected by the lesion is often accompanied by edema; thus, the vascularization may be sufficient but not abundant due also to the low depth.

The microperforations, however, do not shrink the bone (Fig. 8.4a, b); but they perforate with the same diameter throughout its entire length. This technique allows to reach a greater depth, and it induces the bleeding from all points of the perforations, but it remains the negative element represented by the rotation speed of the perforating tip.

After creating a stable cartilaginous wall around the lesion with the specific curettage (Fig. 8.5), we proceed with a drill on the perforations to be performed at various points with the angle as close as possible to 90°. Moreover, in order to slide the flexible drill with 4.6 mm diameter, it is necessary to use rigid cannulated guides with different inclination angles. The depth of the hole can vary from 4 to 7 mm (or more) and is controlled by the guides characterized by millimeter-graduated caps that are inserted directly on the handgrip of the guides (Fig. 8.6a, b).

The perforation with the drill remains a limit of this technique because it may necrotize the tissue. But the small diameter of the tip and the chance of modulating the speed can reduce this possibility. In addition, another limit to be considered is the movement in a tight joint such as the ankle, which is possible only in anterior portions.

Unlike the knee, in which the articular range ensures an easier access to the chondral lesions and allows also an excellent treatment of patellar injuries that are difficult to treat with other methods, the narrowness of the ankle joint does not always allow to reach

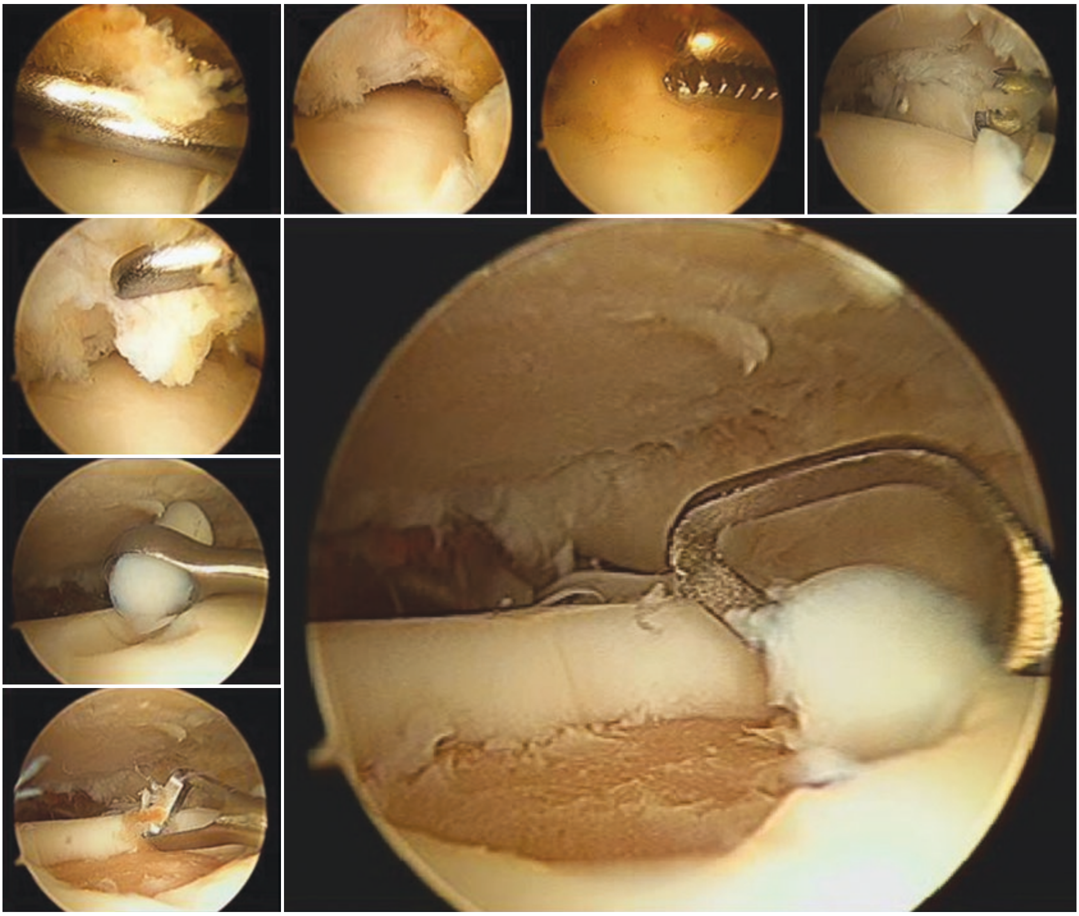

**Fig. 8.5** Preparation of the articular surface for the microfractures

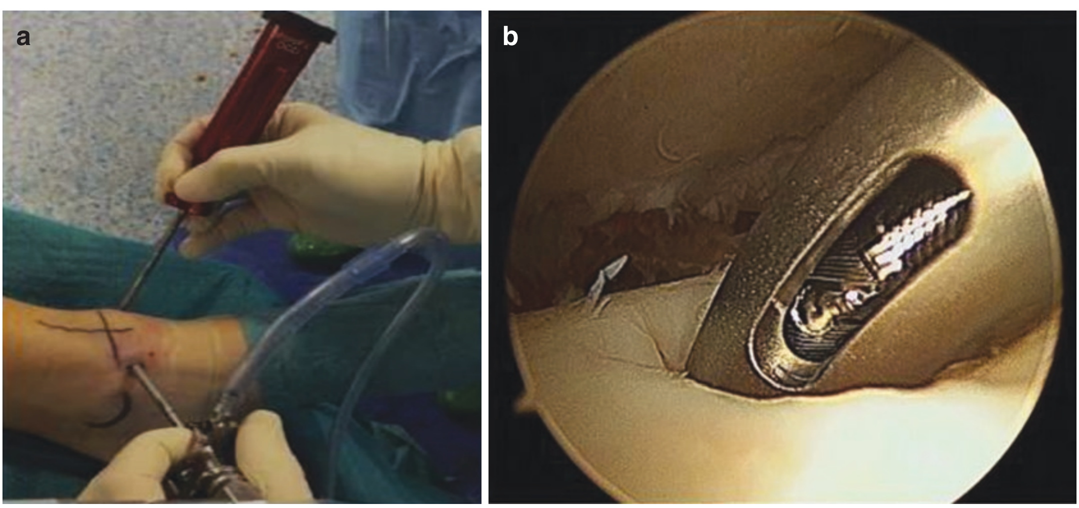


**Fig. 8.6** (**a**) Use of microfractures during ankle arthroscopy. (**b**) The microfractures have graduated caps directly assembled on the handgrip of the guide allowing the choice of the depth to be reached by the perforation


**Fig. 8.7** (**a**) Extraction of cancellous bone for the treatment of an osseous cyst. (**b**) Application of cancellous bone through the cannula of the spinal needle. (**c**) Filling of the talar cysts through the cancellous bone taken from the proximal ipsilateral tibia

all the pathological localizations and perforate them with perpendicular angle. Indeed, in some cases, we perform a mixed treatment consisting in microfractures and microperforations that may be, if confirmed by the follow-up, a surgical solution for access to all the areas affected by the disease. The achievement of these areas of the posterior talar dome is difficult even with the use of a medium-angle cannula, and often the use of a straight cannula is required even if it does not ensure the perpendicularity on the articular surface.

The use of PRP, after performing microperforations, favors the development of semicartilaginous tissue allowing a reduction of the patient's symptomatology.

This technique concerns small chondral lesions with little bone involvement.

For large chondral defects at subchondral bone depth, after performing microfractures, we prefer to fill the bone gap with cancellous bone taken previously from the proximal third of the ipsilateral tibia through a small skin incision (Fig. 8.7a–c).

We perform an incision of about 2–3 cm in the proximal third of the leg; after achieving the osseous plane, using a saw and small chisels, we create an access cortex that allows us to reach the underlying cancellous bone, which is taken through a serrated spoon.

The bone removal is introduced into the lesion with the aid of a small cannula (often we use the covering plastic of the spinal needles); then it is pressed with the blunted trocar of the arthroscope. At the end, we complete the procedure with a spatula to level and control the stability of the cancellous bone. The same procedure is also performed on the knee pathologies.

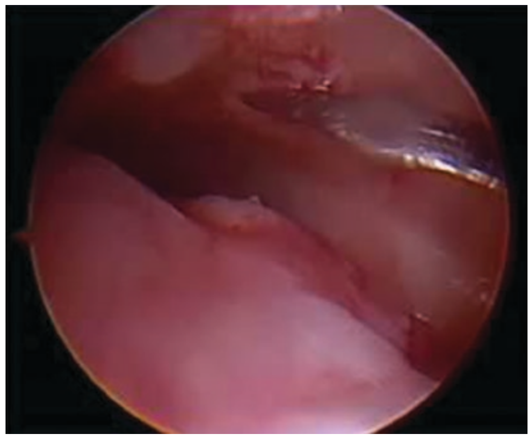

**Fig. 8.8** Application of the bio-collagen in semi-liquid structure with high biocompatibility and ability to be colonized [33]

The bone graft may be coated with swine origin biomaterials (ACIC) that allow, through their matrix structure, to stabilize and maintain the blood cells in situ (Fig. 8.8). These blood cells are released through the microfractures, and they favor the cartilaginous regeneration where it is necessary. New liquid matrices allowed to use this technique arthroscopically, because the injected biological collagen polymerizes in the site where it is positioned [29–31], allowing an immediate rehabilitation.

In a recent publication [29], the cytocompatibility of a bio-collagen (CartiFill) and its ability to be colonized by cells stimulated by the microfractures was analyzed. The study showed a significant decrease in pain and a good increase of the AOFAS score after 6 months.

Actually, there has been a shift from an average AOFAS score of 53.8–86 at follow-up. The same VAS decreased from 6.6 to 1.6. The majority of patients of the study returned to perform athletic activity 6 months after surgery. It therefore appears to be a one-step functional and less expensive (hospitalization, surgery, and biomaterial) method with respect to the two-step procedures, which are still used nowadays [1, 32].

All the lesions offer a repair of the defect with fibrocartilage by covering the talar gap in direct proportion to its size: the smaller the defect, the better the clinical and radiographic results.

Görmeli et al. [33] have analyzed 40 patients who took part of the microfracture procedure; and, during the same surgical procedure, 13 patients have received a PRP infiltration, 14 patients a hyaluronic acid infiltration, and 13 patients a physiological infiltration. The authors reported a better AOFAS score at follow-up for patients treated with microfractures and PRP, suggesting that this method is better compared to the use of hyaluronic acid, also due to the well-known analgesic effect in the early stages of rehabilitation.

## 8.5 Rehabilitation

Our experience allowed us to decrease the discharge times to which the patient has to undergo after surgery. In fact, we reduce the time proposed by Steadman (10–12 weeks) [19] allowing the patient partial weight-bearing after 4–6 weeks and gradually increasing in the last 2 weeks. During the postoperative period, protection of the axial load and the tangential forces must be ensured; moreover, the pain and inflammation must be controlled, and it is needed to regain the movement and the muscle strength.

Starting from the 4th–5th postoperative day, the passive motion of the ankle in flexion-extension that it is gradually increased according to the patient's tolerance during the first 15–20 days begins.

The patient starts to ambulate with the aid of Canadian canes with no weight-bearing on the operated limb for 3 weeks, and then the patient begins the rehabilitation in water always in discharge.

The functional and antalgic results have been more than encouraging, thanks to the rehabilitation in water and to the stabilometric platform Delos, started from the eighth week [34–36].

The clinical data expect a good functional recovery ensuring a marked improvement in operated patients, but it is evident that the perfect filling and coverage of a lesion can be independent from the disappearance of pain or from the functional recovery.

## 8.6 Considerations

According to the literature, the combination of debridement and medullary stimulation probably represents the best available and less expensive treatment to treat cartilaginous injuries of the ankle [36–38].

In orthopedic language with the term "debridement," we mean the cleaning of the damaged cartilaginous surface.

Microperforations and microfractures are the first step in the treatment of symptomatic osteochondral lesions inferior to 1.5 $cm^2$; in fact, these are too small dimensions to be considered for a stabilization of the fragment [39, 40]. The advantage of this method is the execution of the procedure through a mini-invasive approach, without needing dedicated tools that would increase the costs, resulting in limited iatrogenic tissue damage. In the case of a deep localized defect exceeding 15 mm in diameter, it is advisable to associate perforations to the application of a cancellous bone graft, positioned into the defect site after a proper cleaning of the bone bed [41].

Nasaka and colleagues [42] have successfully used the method of microfractures even in rheumatoid patients, thus extending the surgical indications.

We believe that the stimulation of fibrocartilage with microfractures is an unpredictable biological reaction and that it is not possible nowadays to know how the injury will react to the treatment, also due to the different thickness of the cartilaginous talus dome and to the poor vascularization. Certainly, the neoformed fibrocartilage will have a limited duration inducing a progressive reduction of the effectiveness of the treatment.

## 8.7 Conclusions

Despite the relative technical difficulty of the surgical technique of the cartilaginous mantle recovery, arthroscopy is a valuable method to achieve the repair of articular cartilage, with all the advantages that a mini-invasive method can offer compared to an alternative open surgery.

The important consideration is that the neoformed fibrocartilage after microfracture and nano- or microperforations is partly biomechanically valid, but it may face a subsequent deterioration, reducing the effectiveness of the procedure over time.

It is essential to explain to the patient that he will not get the healing of his articulation with this arthroscopic treatment, but a reduction of the symptomatology with an operational restoration. In fact, the certain success of this surgery consists in the length of the patient's benefit.

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