Technical Note

Osteo-core Plasty: A Minimally Invasive Approach for Subchondral Bone Marrow Lesions of the Knee

Dawid Szwedowski, M.D., Ignacio Dallo, M.D., Eleonora Irlandini, and Alberto Gobbi, M.D.

Abstract: "Bone marrow lesion" (BML) is a common term used to describe the presence of fluid in the bone marrow. Although various pathologies can cause BMLs seen on magnetic resonance imaging, in this Technical Note we focus on treating the lesions associated with osteoarthritis in the knee joint. The role of the subchondral bone in transferring loads within the knee joint, as well as in cartilage homeostasis, is well established. In addition, cartilage and subchondral bone are increasingly considered as an osteochondral unit, rather than as 2 separate structures. Knee osteoarthritis, along with insufficiency fracture, is one of the main indications for the treatment of painful BMLs. Nowadays, there is a growing interest in this field, and new approaches are being developed. Our technique can be defined as a surgical procedure aimed directly at pathology within the subchondral bone and is named "osteo-core plasty." It consists of 2 parts: The first is decompression of bone marrow to decrease intraosseous pressure, and the second is administration of bone marrow aspirate concentrate for better healing potential and bone autograft to deliver supportive tissue. It should be noted that the cause of BMLs must be known before this kind of treatment is performed.

The subchondral bone is a structure present underneath cartilage consisting of 2 major parts: the bone plate and the spongiosa. It is responsible for cartilage nutrition and plays an important role in the healing of chondral lesions.[1] However, it is still an underappreciated component of joint health that should be viewed as a critical element of the osteochondral unit.

Focal changes in the subchondral bone, termed "bone marrow lesions" (BMLs), are features detected by magnetic resonance imaging (MRI). A BML describes an alteration of bone marrow signal intensity, with high signal on fluid-sensitive sequences (T2 and/or proton density with fat suppression and short tau inversion recovery [STIR]), with or without low T1-weighted imaging signal. These MRI alterations may correspond histologically to true edema but also to trabecular necrosis, cysts, fibrosis, and cartilage fragments. Therefore, instead of the commonly used term "bone marrow edema," the expression "bone marrow edema–like signal" or "BMLs" is more appropriate. In patients with knee osteoarthritis (OA), BMLs can correlate with faster joint degeneration[2,3] and more pain.[4,5] Intense research is focused on the use of biologics to help maintain and improve cartilage health.[6,7] Nonetheless, treatment options taking into account the subchondral bone are still limited.

Osteo-core plasty is a minimally invasive procedure for treating subchondral pathologies to prevent the progression of OA. The main indications are painful bone marrow edema and subchondral cysts associated with OA. During osteo-core plasty, the surgeon injects high-quality bone marrow (Marrow Cellution; Aspire Medical Innovation, Munich, Germany) and small dowels of autologous bone into the affected area under fluoroscopic imaging control to fill the intertrabecular space, thereby inducing improved bone remodeling.

Diagnosis

MRI is an essential diagnostic tool that allows for the recognition of BMLs. Additionally, it is widely used as the gold standard for evaluation of the morphologic status of cartilage. BMLs are easily visible on fat-saturated T2-weighted and short tau inversion

From Orthopaedic Arthroscopic Surgery International (OASI) Bioresearch Foundation Gobbi NPO, Milan, Italy.

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Address correspondence to Dawid Szwedowski, M.D., Orthopaedic Arthroscopic Surgery International (OASI) Bioresearch Foundation Gobbi NPO, Milan, Italy. E-mail: dszwedow@yahoo.com

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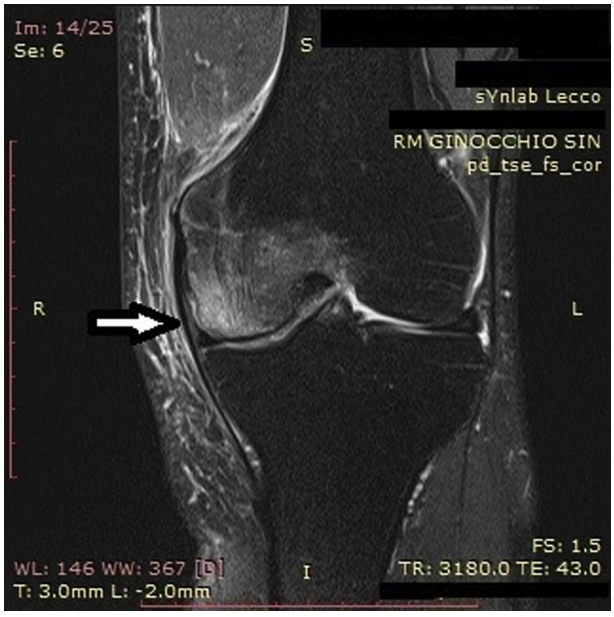


Fig 1. A magnetic resonance image (coronal view) of the left knee reveals a bone marrow lesion in the medial condyle (arrow). (I, inferior; L, left; R, right; S, superior.)

recovery (STIR) sequences and appears as hyperintense regions within the trabecular subchondral bone, often at the site of increased mechanical stress[8-10] (Fig 1). The clinician should expect to see BMLs after acute trauma. In this case, the lesions are poorly defined with heterogeneous patterns of subchondral signal changes.[11] The differential diagnosis includes stress fractures, complex regional pain syndrome (Sudeck syndrome), primary bone tumors, metastases to the femur, infection, rheumatoid arthritis, osteomyelitis, and avascular bone necrosis. In the setting of knee OA, the diagnosis of BMLs can only be recognized after more aggressive and irreversible diseases with similar clinical symptoms have been excluded. The patient's history and symptoms can be helpful in evaluating the meaning of these BMLs.



Fig 2. The patient is in the supine position, with the left iliac crest shown. The area is draped in the usual sterile fashion for bone marrow aspiration. The introducer needle with a sharp stylet is placed in the cancellous bone between the cortices.



Fig 3. A dedicated aspiration kit is used to harvest approximately 7 to 10 mL of bone marrow from the iliac crest.

Indications

The main indication for the described technique are BMLs and subchondral cysts associated with knee OA. Additionally, this technique has been used to treat insufficiency fractures, subchondral cysts, and avascular necrosis with good early results.

Surgical Technique

The procedure is initiated by aspiration of the bone marrow from the ipsilateral iliac crest using a sharp trocar with a hollow aspiration sleeve. The introducer needle with a sharp stylet is placed in the cancellous bone between the cortices (Fig 2). When 1 mL of bone marrow is aspirated to ensure proper positioning of the needle tip, a sharp stylet is replaced with a blunt one. From a single stick, the Marrow Cellution system is capable of collecting up to 10 mL of high-quality bone marrow (Fig 3). Additionally, a sharp trocar is used to harvest some bone dowels (Figs 4 and 5).

The patient, under regional or spinal anesthesia, is placed in the supine position as for a standard knee arthroscopy. Before Marrow Cellution injection proceeds, any concomitant abnormalities such as chondral lesions, meniscal tears, and ligament lesions should be addressed and treated. Limb alignment plays a crucial role in cartilage lesion treatment; therefore, any abnormalities should be treated as well. A 30° 4.0-mm



Fig 4. A sharp trocar is used to harvest some bone dowels from the left iliac crest.

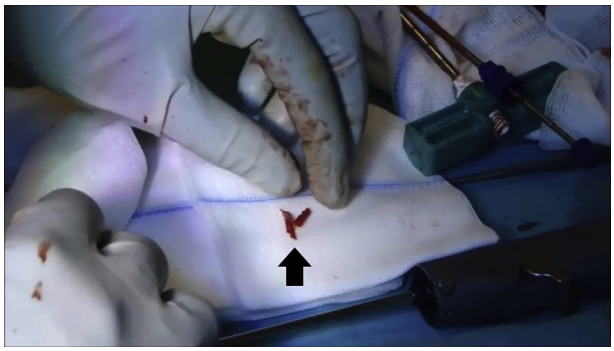


Fig 5. Bone autografts (arrow) from the iliac crest.

arthroscope (Smith & Nephew, Andover, MA) is used to perform a comprehensive arthroscopic examination of the knee. Anteroposterior and lateral fluoroscopic images cross-referenced with the MRI study are used to place the guide pin exactly in the bone marrow edema (Figs 6 and 7). A cannula is then placed over the guide pin, which is subsequently removed. It is left in the bone for a few minutes to perform core decompression. Furthermore, bone dowels are inserted into the cannula and pushed through into the subchondral lesion by a blunt trocar (Figs 8 and 9). Then, the

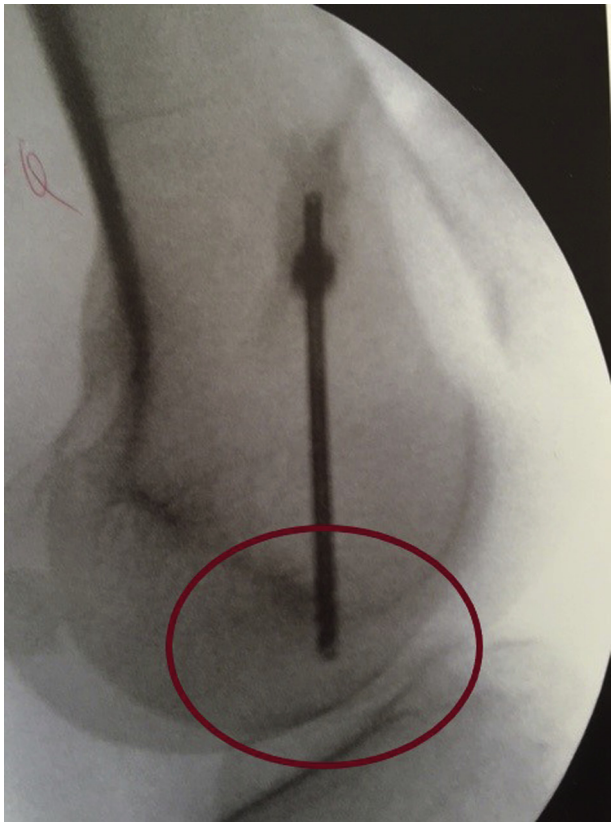


Fig 6. Anteroposterior and lateral fluoroscopic images cross-referenced with the magnetic resonance imaging study are used to place the guide pin exactly in the subchondral bone (circle).

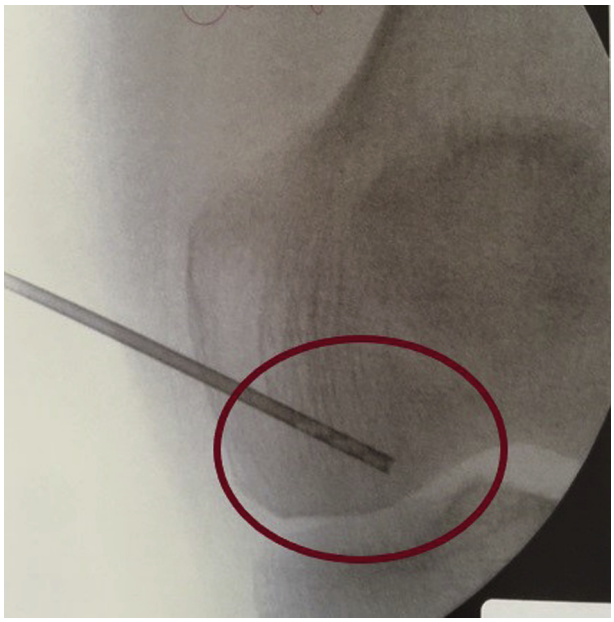


Fig 7. Anteroposterior and lateral fluoroscopic images cross-referenced with the magnetic resonance imaging study are used to place the guide pin exactly in the subchondral bone (circle).

Marrow Cellution bone marrow is inserted through the cannula into the treated area (Fig 10). A final arthroscopic look is taken to confirm lack of intra-articular leakage (Fig 11). Osteo-core plasty is shown in Video 1.

Postoperative Protocol

The postoperative protocol must be adjusted according to the concomitant procedures conducted during surgery. The most important aspects of early postoperative rehabilitation are achieving pain control, maintaining the range of motion, and preventing muscle atrophy.

Touch-down weight bearing is allowed at 3 to 4 weeks postoperatively; full weight bearing is achieved at approximately 6 weeks. Immediately after the procedure, continuous passive motion and a cryo-cuff are applied to lessen pain and swelling and to



Fig 8. Bone dowels (arrow) are inserted into the cannula.

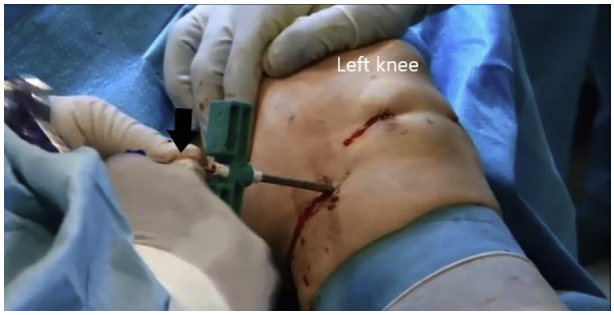


Fig 9. Bone dowels are pushed through the cannula into the subchondral lesion by a blunt trocar (arrow).

maintain the joint fluid motion. On the second day after the procedure, isometric and isotonic exercises are introduced. After wound healing, pool exercises can be initiated to regain a normal gait pattern.

Discussion

The subchondral bone plays an important role in natural cartilage healing. Certain diseases of the cartilage are actually diseases of the osteochondral unit rather than diseases of the cartilage alone. Imhof et al.[12] showed the presence of arteriovenous complexes penetrating the subchondral bone plate and reaching into the calcified cartilage, so consequently, it possesses a blood supply layer up to the tidemark. A study by Lane et al.[13] showed higher vascular perforations at the areas of higher stress, indicating that the subchondral bone responds to high loads by increasing the blood supply. However, overloading of the degenerated joint will impede the flow of nutrients from the subchondral bone to the cartilage and thus disturb natural healing. Although the mechanisms are still debated, pain may be a result of impaired venous drainage as the response to repetitive microtrauma.[14,15] In a recent study, MacKay et al.[16] showed that subchondral bone texture is associated with radiographic knee OA progression. In addition, several studies have correlated outcomes with known subchondral BMLs prior to cartilage restoration procedures. Severe subchondral bone marrow edema was associated with poor knee function in patients with

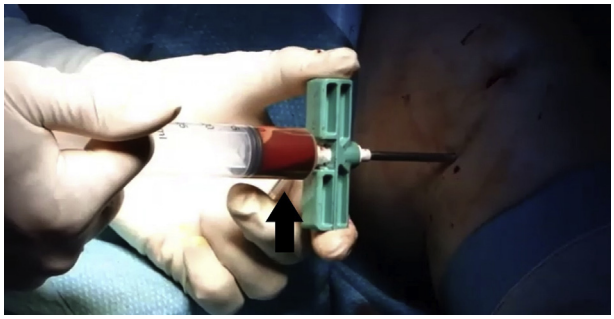


Fig 10. High-quality bone marrow (arrow) is inserted through the cannula into the treated area.



Fig 11. A final arthroscopic look is taken to confirm lack of intra-articular leakage.

chondral lesions and was a reliable prognostic factor in the first year after autologous chondrocyte implantation.[17] Additionally, the persistence of edema-like signs in the subchondral bone is a predictor of poor clinical outcome after microfracture surgery.[18]

Biological adjuncts to cartilage injuries are becoming increasingly researched and may prove to be beneficial in addressing common concerns. High-quality bone marrow is an easily available source of mesenchymal stem cells and growth factors including platelet-derived growth factor, transforming growth factor β, and bone morphogenetic proteins 2 and 7, which have anabolic and anti-inflammatory effects.[19] Although high-quality bone marrow is one of the most attractive sources of mesenchymal stem cells, several aspects, such as the amount of aspirate, need further exploration. Bone autograft augmentation can deliver additional supportive and biologically active tissue to the subchondral lesion.

Osteo-core plasty is a minimally invasive procedure with reported efficacy in the treatment of painful bone marrow edema associated with knee OA. It may be particularly important for younger, active patients who wish to reduce pain and avoid or delay total knee arthroplasty. Although different treatment modalities have been tested in the hope that they might reduce

Table 1. Advantages and Limitations

Advantages
Minimally invasive technique with early postoperative mobilization
Does not burn any bridges—revision option
Joint-preserving technique, therefore avoiding joint replacement
Augmentation with high-quality bone marrow increases healing potential of affected subchondral bone
Limitations
Lack of clinical trials with long-term outcomes and strong evidence that technique can prevent OA progression
More expensive and invasive than simple core decompression or platelet-rich plasma
Possible additional incision to harvest bone marrow aspirate and donor-site morbidity

OA, osteoarthritis.

Table 2. Technical Pearls and Pitfalls

Pearls
During bone marrow aspiration, change the trocar direction to obtain bone marrow from different places.
Assess the lesion with both MRI and radiography.
Use AP and lateral fluoroscopic images to determine the application site precisely.
Decompress the lesion with a cannula.
Perform arthroscopy to confirm lack of intra-articular leakage.
Pitfalls
Breach of cortex during decompression
Imprecise BMAC application and intra-articular leakage
Premature removal of trocar and cannula
Other intra-articular pathologies being left untreated

AP, anteroposterior; BMAC, bone marrow aspirate concentrate; MRI, magnetic resonance imaging.

pain and stop the progression of the disease, there is still a need for high-quality randomized controlled studies in the future to further improve treatment strategies in preventing or treating BMLs associated with OA.

Our technique has some limitations (Table 1). It is important to note the osteo-core plasty is a recently developed technique and long-term follow-up is needed. The major pitfall of this technique is the risk of cortex perforation during trocar insertion into the subchondral bone (Table 2).

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