Technical Note

Intraosseous Bioplasty for a Chondral Cyst in the Lateral Tibial Plateau

Nicholas Elena, M.D., Brittany M. Woodall, D.O., Katie Lee, B.A., Patrick J. McGahan, M.D., Neil P. Pathare, M.D., Edward C. Shin, M.D., and James L. Chen, M.D., M.P.H.

Abstract: Subchondral lesions are the result of osseous modifications seen in a different array of pathologies such as osteoarthritis, rheumatoid arthritis, calcium pyrophosphate deposition, and osteonecrosis. The physiopathologic changes in all of the aforementioned pathologies are not clear yet. What is clear is that the development of a cystic change in the subchondral bone can cause pain and can lead to modification of the activity of daily life. To provide relief and treatment for such a condition, there are different options with joint replacement as last resort when the cyst develops in communication with the joint; if the cyst is not in communication with the joint, it is possible to perform a bioplasty as we present in this technical report. It is crucial to assess the bone continuity, especially when traumas are reported in the patient history. In our case, the tibial plateau did not have signs of collapse. The technique here presented is a minimally invasive technique that can be reproduced for focal and localized subchondral cysts.

Subchondral cystic changes are considered common findings related to different pathologies. They can present in conditions such as osteoarthritis, rheumatoid arthritis, calcium pyrophosphate deposition disease, and osteonecrosis, but still the physiopathologic process is unclear.[1] Two theories have been postulated: the synovial intrusion theory and the bony contusion theory. The first suggests a connection between the articular and cystic cavities that allows the synovium to enter and enlarge the defect. The latter instead suggests no connection between cavities but that an impact between opposing bones, both with and without any cartilage defect, may result in microfractures and necrotic bone. The necrotic area is further remodeled with bone fragments phagocytosed by osteoclasts, creating a subchondral cystic cavity.[1-3]

In 1983, Lotke et al.[4] described osteonecrosis-like syndrome as tibial plateau osteonecrosis, with following cystic change, to establish this diagnosis as a separate entity from distal femur or meniscus pathologies. All patients reported progressive pain, especially with weight bearing and a history of a minor trauma (e.g., a misstep on the curb or increase in physical activity). This may be secondary to the fact that the highest shear stresses applied to the tibial plateau occur at the outer boundaries of the contact region.

An important factor to consider, before possible treatment, is the integrity of the tibial plateau without communication between the knee joint and the pathologic cavity. In a younger population, it is emphasized to preserve the articular surface over the area of the arthroplasty; therefore, it is necessary to assess early arthritic changes or tibial plateau depression[5] that would prevent conservative treatment options such as core decompression or bone grafting.

Bone grafting with autologous bone marrow cells, isolated and concentrated from the iliac crest, has been studied for early stages of osteonecrosis in the femoral head with reliable and positive results.[6] The procedure here described is applied to an uncommonly injured area such as the lateral tibial plateau. Moreover, harvesting of cells from a bone marrow aspirate is performed in a healthy part of the tibia; the aspirate is centrifuged to collect platelet-rich plasma (PRP) and mixed with

From the Advanced Orthopaedics & Sports Medicine, San Francisco, California, U.S.A.

The authors report the following potential conflicts of interest or sources of funding: J.L.C. receives personal fees from Arthrex, outside the submitted work. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

The investigation was performed at Advanced Orthopaedics & Sports Medicine, San Francisco, California, U.S.A.

Received May 30, 2018; accepted July 30, 2018.

Address correspondence to Nicholas Elena, M.D., Advanced Orthopaedics & Sports Medicine, 450 Sutter St, Ste 400, San Francisco, CA 94108, U.S.A. E-mail: nicholas.elena1990@gmail.com

2212-6287/18661

https://doi.org/10.1016/j.eats.2018.07.011

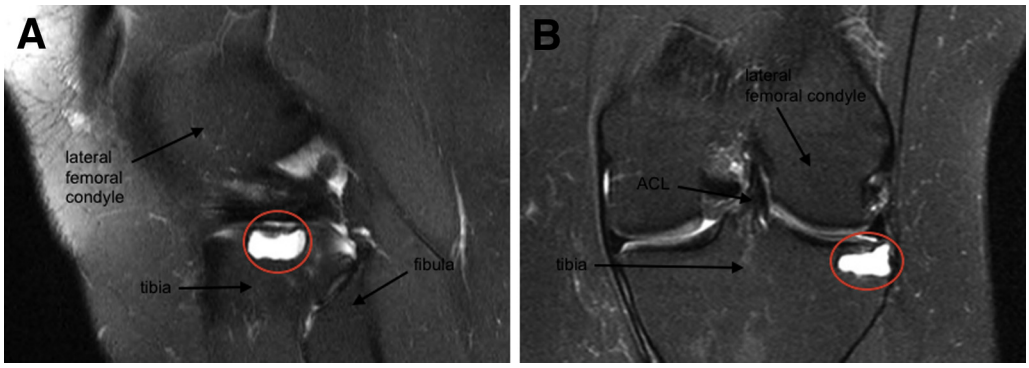

Fig 1. Left knee magnetic resonance image, fat-saturated T2. (A) Sagittal plane shows a hyperintense lesion on the proximal lateral tibial (red circle), described as a cystic change by the radiology report. (B) Coronal view of the lesion (red circle) shows the vicinity to the tibial plateau with concern of its integrity. The arthroscopic view can properly evaluate whether the plateau is collapsed or not, and based on this the surgical procedure can be changed.

demineralized bone matrix (DBM). This mixture is then injected after core decompression of the lesion.

Surgical Technique

Indications/Contraindications

First of all, this procedure is indicated in a young population of patients; the lesion has to be circumscribed, localized, and symptomatic. Swelling, painful range of motion, stiffness, and poor function are indications for this procedure. In case a patient is asymptomatic with a subchondral cyst, it is not necessary to perform any procedure.

Patients must be compliant with the postoperative protocol to avoid possible relapses. Every condition in which it is possible to preserve the integrity of the joint, without any other intra-articular pathology, and grant full recovery is viable for the intraosseous bioplasty (styled as the proprietary IntraOsseous BioPlasty technique when performed with the Angel System [Arthrex, Naples, FL], a bone marrow processing system that prepares customized PRP concentrate).

The main contraindication is the collapse or depression of the tibial plateau. In patients with more extensive lesions, preservation of the joint is not possible; therefore, there is an indication to undergo more invasive techniques, including a knee arthroplasty in extreme cases. In addition, communication of the intra-articular space with the cyst is a contraindication because a collapse of the tibial surface could develop with further traumas. Patients with early arthritic changes are not suitable for the bioplasty because this procedure would be just temporarily palliative for their progressive condition.

Imaging Assessment

The patient is first evaluated with a set of left knee radiographs. In this case, the radiographs taken just a few days after the injury show a subchondral cyst. The patient is then further evaluated with left-knee

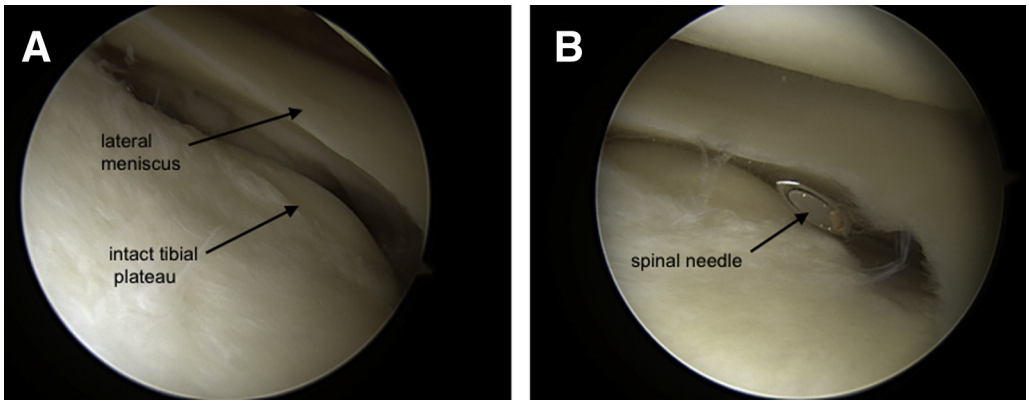

Fig 2. Arthroscopic pictures of the left knee from the anterolateral portal. (A) By stressing the knee joint with a so-called figure-4 position, it is possible to create space between the lateral meniscus and the tibial plateau. This position allows us to examine the lateral aspect of the tibial plateau, where the cystic lesion is supposed to be, and be sure of its integrity. (B) A spinal needle has been inserted in between the meniscus and the tibial plateau to create a joint landmark for the following bone decompression. The drill will be placed distal to that location to avoid breaching the cortex.

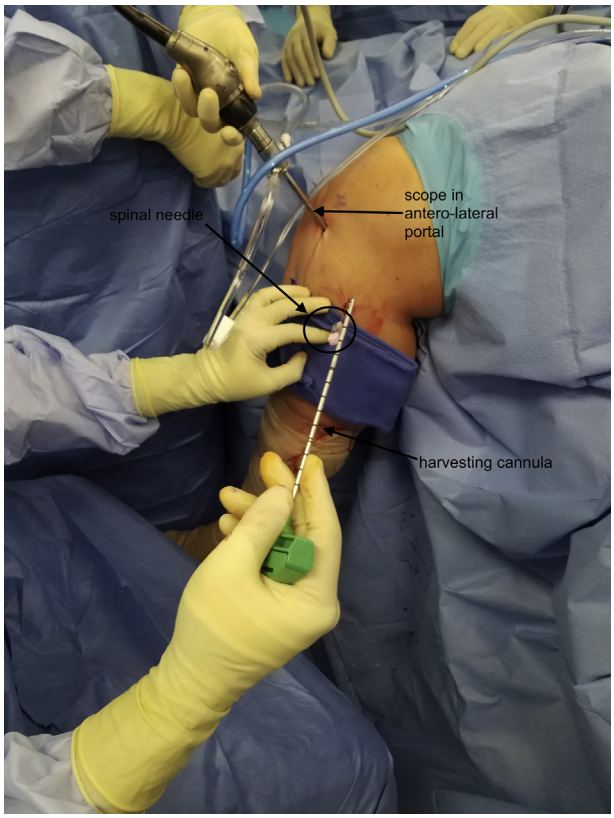

Fig 3. A harvesting cannula is being inserted, in the left knee, to perform a bone marrow aspirate with a trajectory angled away from the lesion. The cannula has an inner stylus that will be removed after the harvesting location has been properly reached. Then the cannula will be connected to a syringe to proceed with the bone marrow aspiration.

1.5-Tesla magnetic resonance imaging. The images for our patient reveal a hyperintense lesion on a T2 fat-saturated scan (Fig 1), and it is described as follows: "a peripheral proximal lateral tibial cystic change measures up to 1.7 cm mediolaterally × 1.1 cm superoinferiorly × 1.7 cm anteroposteriorly."

Patient Setting

The patient is placed supine on a standard operative table with a padded tourniquet placed proximally on the surgical limb that was previously marked. A lateral stress post at the same height of the tourniquet is used to give support to the limb and to be able to stress the limb adequately during the arthroscopic part of the procedure. The surgical site is then prepped and draped in the usual sterile fashion. A fluoroscope, covered with a sterile drape, is also requested to check the position of the lesion throughout the case.

Diagnostic Arthroscopy

The integrity of the lateral tibial plateau is assessed through a diagnostic arthroscopy using a 30° 4.0-mm arthroscope. A classic anterolateral portal is made, and a sheath with scope is inserted into the joint. An anteromedial portal is made via needle localization to test the stability of the tibial plateau with a probe. A spinal needle is then used to localize the cystic lesion on the lateral aspect of the tibial plateau (Fig 2).

Bone Marrow Harvest and Preparation

The adequate position of the needle is assessed with the help of fluoroscopy, which confirms the location of the cyst. A small percutaneous incision is created on the lateral aspect of the tibia where the lesion has been localized. A harvesting cannula is then inserted in the incision and redirected with an angled trajectory to avoid the lesion and aspirate the bone marrow (Fig 3). A decision to use the nearby healthy area for the harvest is made to avoid the creation of another incision. The harvesting cannula is impacted into the bone, and the inner stylus of the cannula is removed. Two 30-mL syringes, pretreated with 5 mL of acid-citrate-dextrose formula A, are secured to the cannula, and bone marrow harvest aspiration is performed to fill both syringes (Fig 4).

Once the harvest is complete, both syringes are connected to the Angel System (Fig 5). The processing time to obtain the concentrate from 60 mL of aspirate is approximately 17 minutes.

Once the PRP is ready, it is mixed with DBM (Arthrex) until the mixture has the consistency of a thick paste (Fig 6). A syringe is then loaded with the mixture of DBM and PRP, ready to be injected.

Bone Decompression

A bone decompression is performed with a 2.4-mm wire pin drilled in the location of the cyst. The spinal needle and the fluoroscope are useful to localize the lesion (Fig 7). In cases where the cyst is far enough from the joint, it is possible to carefully ream over the wire pin and decompress the lesion even further (Fig 8). With the help of the intraoperative radiographs to check the distance from the tibial plateau, a 5.5-mm reamer is used (Video 1). In addition, arthroscopic visualization is necessary to monitor the integrity of the articular surface of the tibia during the reaming process. Once the reaming process is complete, the arthroscope sheath can be placed over the pin placed in the tibia; then the pin can be removed and the arthroscope inserted in the decompressed area. This allows to arthroscopically assess the decompression (Fig 9).

PRP Inoculation

An open-ended delivery cannula has an inner stylus that can be removed, and its inner diameter is wide enough to allow us to insert the cannula over the previously positioned 2.4-mm pin (Fig 10). The pin is

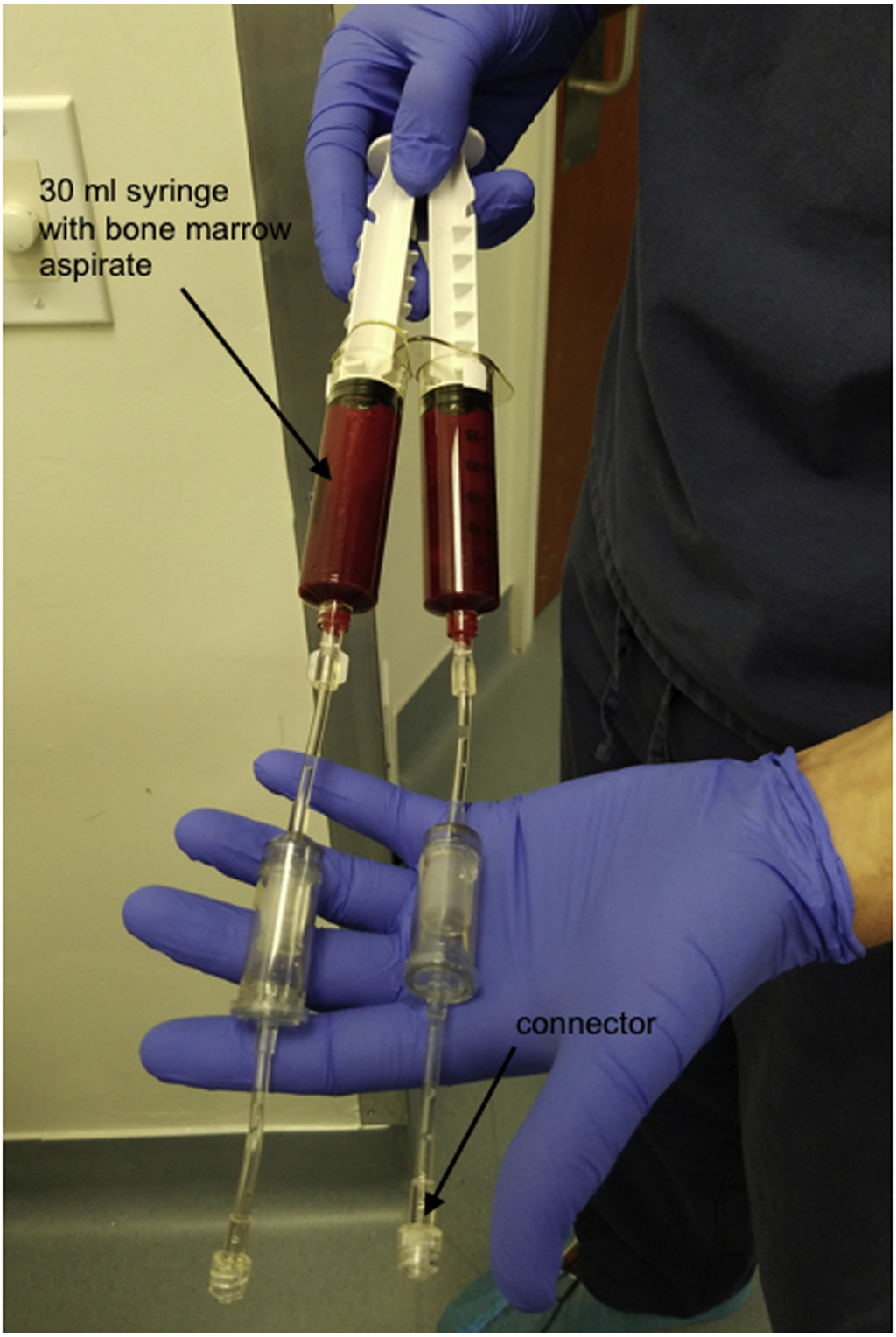

Fig 4. Two 30-mL syringes are shown, pretreated before the surgery with 5 mL of acid-citrate-dextrose formula A (ACD-A). At the tip of each syringe, there is a connector that connects to the Angel System.

then removed with the cannula in place; a syringe with the concentrated PRP-DBM is secured to the delivery cannula and then injected. Injection proceeds from the deepest part of the lesion to superficial, slowly withdrawing the delivery cannula out while injecting and periodically taking an intraoperative radiograph to document the cannula tip placement to ensure the void in the tibia is filled.

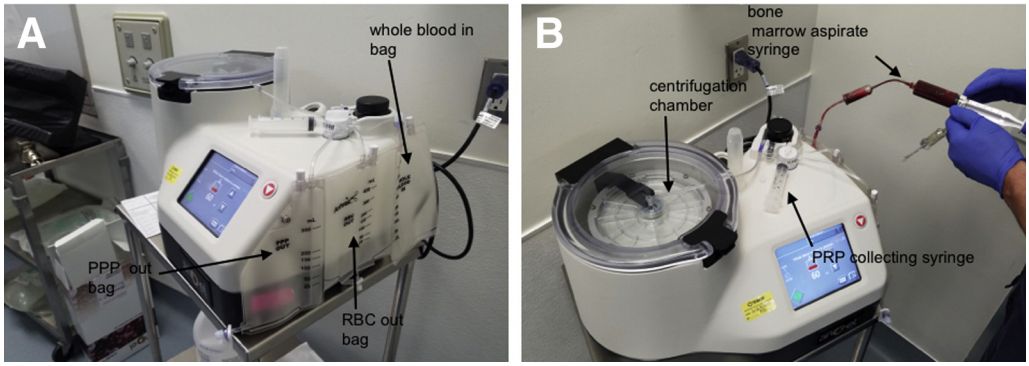

Fig 5. The Angel System (Arthrex). (A) The bone marrow aspirate will be injected in the rightmost bag (whole blood in), and the automated process will start dividing the different blood components. First, the platelet-poor plasma (PPP) will be discarded in the leftmost bag (PPP out). Then the platelet-rich plasma (PRP) will be collected in the syringe on top of the system, and finally the red blood cells (RBCs) will be collected in the bag in the middle. The length of this process depends on the quantity of bone marrow aspirate used. In this case, it was approximately 17 minutes for 60 mL of aspirate. (B) The syringe with the harvested bone marrow is screwed in, the bone aspirate is injected in the rightmost bag, and the centrifugation process is about to start.

Postoperative Protocol

The first postoperative encounter is set after 10 days to remove stitches and take a first set of radiographs of the operative site. Note that radiographs are required every postoperative appointment to assess the filling of the cyst. The patient has to be non-weight bearing for the first month and then can gradually start to be partial weight bearing.

At 1.5 months after the procedure, the patient can start formal physical therapy with passive and active range-of-motion exercises. At the 2-month mark, the patient is supposed to be partially weight bearing with crutches. In addition, the physical therapy exercises have to follow the weight-bearing restrictions. At 3 months, only 1 crutch can be used for 1 more week and then transition to full weight bearing. Physical therapy is recommended to be continued to build strength and help patients return to their preferred activities.

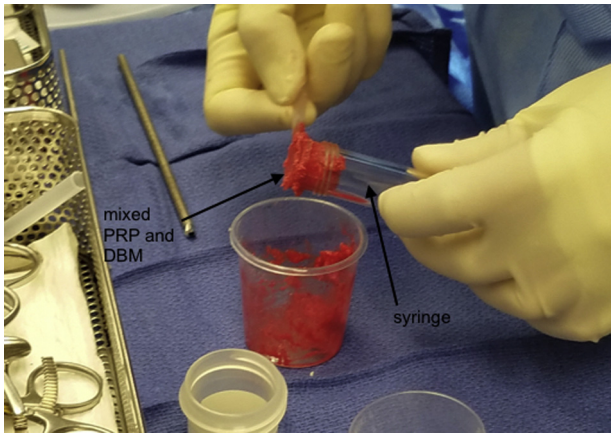

Fig 6. The platelet-rich plasma (PRP) obtained from the Angel System is mixed with demineralized bone matrix (DBM), taken from a donor cadaver, until the result is a thick paste inserted in a syringe.

Discussion

This Technical Note describes a percutaneous decompression of a subchondral cyst of the lateral tibial plateau with application of autologous PRP mixed with DBM for the treatment of a subchondral cyst. Several studies have compared the outcome of isolated decompression versus decompression coupled with bone marrow grafting.[7-10] Not only does the postoperative imaging show improvement but also the pain reported greatly decreases with decompression and grafting.[7]

Core decompression grants a more permanent solution, destroying the inner wall of the subchondral cyst, whereas the PRP-DBM injection has osteogenic potential to promote bone production and fill the void left from decompression.[8] Additionally, the PRP-DBM mixture carries a very low risk of side effects because it is harvested from the patient; the only downside is the preparation time required for this process. The Angel System allows the preparation of the PRP intraoperatively but requires time, and in our case, where we harvested 60 mL of bone marrow, the processing period was approximately 17 minutes. While waiting for the PRP-DBM to be ready, it is possible to focus attention on bone decompression. The bone decompression is usually performed with a pin drilled inside the lesion location,[5] but considering that there was enough space between the subchondral cyst location and the articular space, we decided to ream with a 5.5-mm reamer and decompress even more (Table 1). This last step has to be performed very carefully with support of both arthroscopy and fluoroscopy to assess the integrity of the joint and avoid breaching the articular

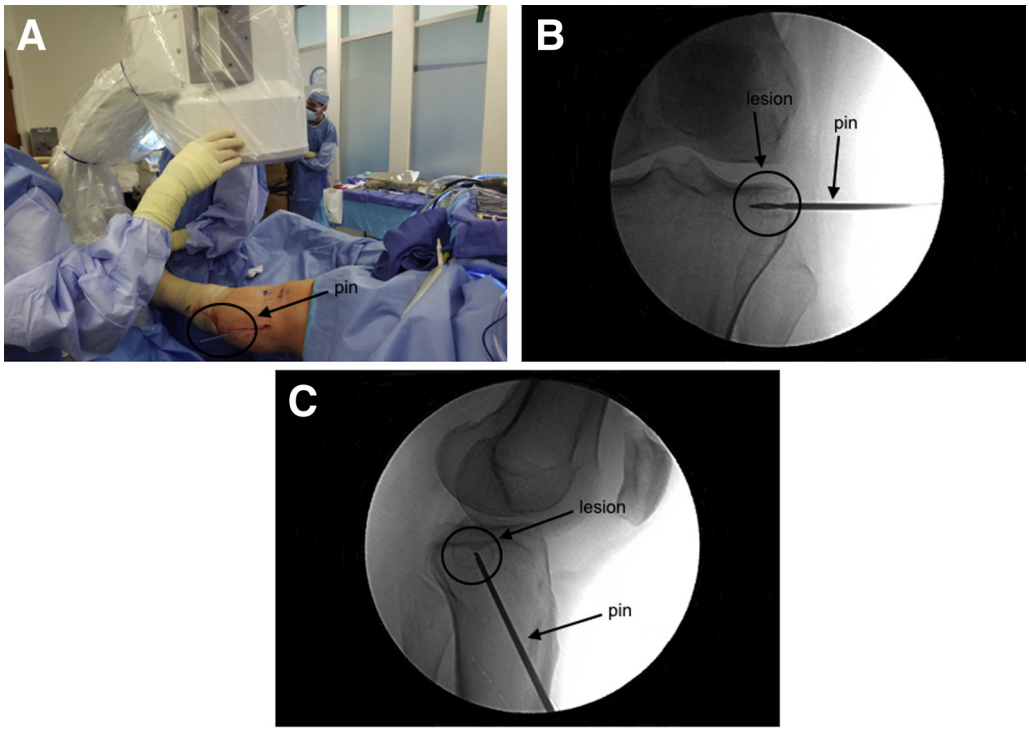

Fig 7. (A) A fluoroscope is in place to check the positioning of the pin for the bone decompression of the left knee tibial plateau. As shown in panels (B) and (C), we took both anteroposterior and laterolateral shots to confirm the exact location of the lesion and relative pin placement.

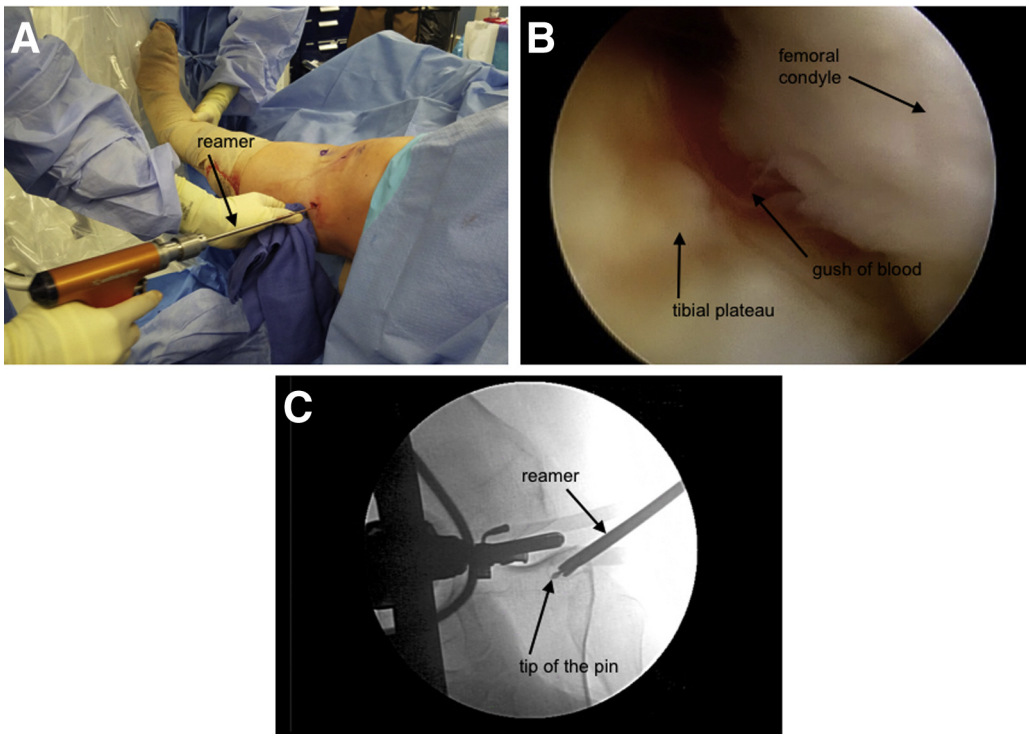

Fig 8. (A) A 5.5-mm reamer is about to ream the lesion and decompress the cystic area even further. It is necessary to avoid tibial plateau disruption during this step. If the lesion is located too close to the joint, this step must be skipped. (B) Arthroscopic picture of the left knee from the anterolateral portal. During the reaming process, it is advised to check the tibial plateau and ensure not to violate the cortex. The blood coming out of the reaming creates a bleeding bed that will trigger the healing process. (C) Radiograph of the left knee. It is possible to see both the pin the reamer on top. Fluoroscopic guidance will help avoid over-reaming the area.

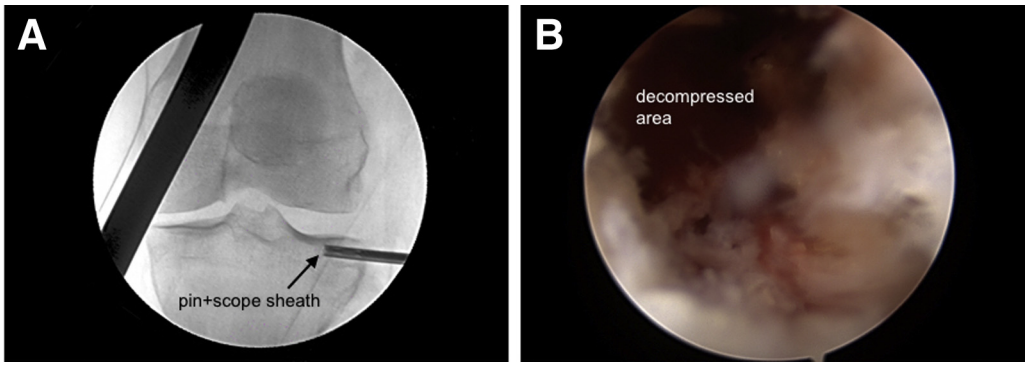

Fig 9. (A) After the reaming is complete, the pin is left in place to maintain the location of the decompressed lesion. A scope sheath is placed over the pin, and once the scope sheath is in place the pin can be removed. The camera is then inserted to evaluate the area. (B) The scope is in place inside the decompressed area in the lateral tibial plateau of the left knee.

surface of the joint. A breached articular surface does not allow for a successful intraosseous bioplasty because of damage to the joint and extravasation of bone graft into the joint. A more invasive procedure is demanded when a breach occurs, and this can be considered the main risk of this technique.[5]

Relapse is another risk to consider, especially in case of a nonadequately reamed subchondral cyst. Therefore, a failed conservative procedure such as this one might lead to a more invasive one in the future carrying a harder postoperative course and rehabilitation protocol.

Arthroscopic evaluation could be a disadvantage because of suboptimal visualization of larger or multiple lesions. Open techniques are preferred because they are time saving and the lesions can be easily assessed.[11]

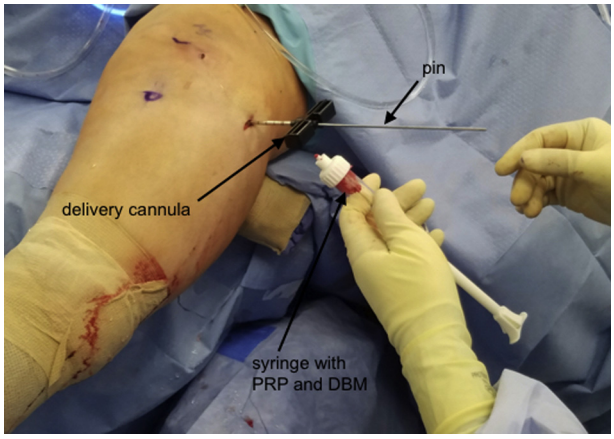

Fig 10. The left knee. An open-ended delivery cannula is placed over the same pin used for the bone decompression; this way, we are sure to be in the exact location. The pin can now be removed and the syringe, previously loaded with the PRP-DBM mix, is screwed in on the top of the cannula, ready to inject. (PRP-DBM, platelet-rich plasma–demineralized bone matrix.)

The minimal invasiveness aspect of this procedure is a clear advantage (Table 2) because the only other incision besides the arthroscopic portals is the percutaneous incision over the lesion. This additional portal allows us to decompress the cyst and even harvest the bone marrow aspirate as long as the cannula is redirected away from the lesion. Once a path with the subchondral cyst is established, it is important to maintain a guide pin in place to easily slide the cannula over the pin to avoid needing to relocate the lesion. Another advantage of the intraosseous bioplasty is joint preservation to prevent articular cartilage erosion. Joint preservation is the primary goal of treatment, especially in young patients with cystic changes[12]; therefore, a more conservative treatment is warranted when possible. It is contraindicated to perform a bioplasty in cases where there is already a communication between the joint and the cyst or in cases of collapse of the tibial plateau. As supported by Zhao et al.,[11] the rationale for decompression and PRP-DBM injection is not only to provide a structural support to the injured area but also to restore the bone mass previously lost.

IntraOsseous BioPlasty of the lateral tibial plateau is only an example of application of this technique; the

Table 1. Pearls and Pitfalls of IntraOsseous BioPlasty

Pearls
Assess the lesion both with radiography and arthroscopy.
Aspirate more bone marrow than needed.
Decompress the lesion with a pin and reamer.
If possible, directly scope the decompressed area.
Keep the guide pin inserted and slide cannulas/tools over top of it to maintain an exact location.
Pitfalls
Breach of the cortex during decompression or inadequate decompression
Inadequate consistency of platelet-rich plasma–demineralized bone matrix mix
Failure to use frequent radiographic imaging
Premature removal of the guiding pin

Table 2. Advantages and Disadvantages of IntraOsseous BioPlasty

Advantages
Minimally invasive technique
Joint preservation, therefore avoiding joint replacement
Few contraindications
Autologous platelet-rich plasma prepared
Delivery cannula to inject in the precise cyst location
Disadvantages
Intraoperative platelet-rich plasma time preparation
Impossible to perform the technique with collapsed tibial plateau
Possible additional incision to harvest the bone marrow aspirate

purpose of this article is to describe an easy procedure that can be reproduced in most cases of subchondral cysts.

References

1. Audrey HX, Abd Razak HR, Andrew TH. The truth behind subchondral cysts in osteoarthritis of the knee. *Open Orthop J* 2014;8:7-10.
2. Chen Y, Wang T, Guan M, et al. Bone turnover and articular cartilage differences localized to subchondral cysts in knees with advanced osteoarthritis. *Osteoarthritis Cartilage* 2015;23:2174-2183.
3. Rajani AM, Kumar R, Shyam A. Huge subchondral cyst communicating with medullary canal of femur in OA knee-treated by extension stem and bone grafting. *J Orthop Case Rep* 2014;4:81-84.
4. Lotke PA, Ecker ML. Osteonecrosis-like syndrome of the medial tibial plateau. *Clin Orthop Relat Res* 1983;176:148-153.
5. Goodman SB, Hwang KL. Treatment of secondary osteonecrosis of the knee with local debridement and osteoprogenitor cell grafting. *J Arthroplasty* 2015;30:1892-1896.
6. Zhao D, Cui D, Wang B, et al. Treatment of early stage osteonecrosis of the femoral head with autologous implantation of bone marrow-derived and cultured mesenchymal stem cells. *Bone* 2012;50:325-330.
7. Arbeloa-Gutierrez L, Dean CS, Chahla J, Pascual-Garrido C. Core decompression augmented with autologous bone marrow aspiration concentrate for early avascular necrosis of the femoral head. *Arthrosc Tech* 2016;5:e615-e620.
8. Erol B, Onay T, Çalışkan E, Aydemir AN, Topkar OM. Treatment of pathological fractures due to simple bone cysts by extended curettage grafting and intramedullary decompression. *Acta Orthop Traumatol Turc* 2015;49:288-296.
9. Lee SY, Chung CY, Lee KM, et al. Determining the best treatment for simple bone cyst: A decision analysis. *Clin Orthop Surg* 2014;6:62-71.
10. Gundle KR, Bhatt EM, Punt SE, Bompadre V, Conrad EU. Injection of unicameral bone cysts with bone marrow aspirate and demineralized bone matrix avoids open curettage and bone grafting in a retrospective cohort. *Open Orthop J* 2017;11:486-492.
11. Sadlik B, Gobbi A, Puszkarz M, Klon W, Whyte GP. Biologic inlay osteochondral reconstruction: Arthroscopic one-step osteochondral lesion repair in the knee using morselized bone grafting and hyaluronic acid-based scaffold embedded with bone marrow aspirate concentrate. *Arthrosc Tech* 2017;6:e383-e389.
12. Zhao D, Liu B, Wang B, et al. Autologous bone marrow mesenchymal stem cells associated with tantalum rod implantation and vascularized iliac grafting for the treatment of end-stage osteonecrosis of the femoral head. *Biomed Res Int* 2015;2015:240506.