

# Surgical Treatment of Insufficiency Fractures of the Knee



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**Abstract:** Bone marrow lesions (BMLs) in the knee represent focal edema caused by subchondral bone attrition and microfractures to the trabecular bone. These lesions are poor prognostic indicators for several orthopaedic procedures but also have been associated with the progression of osteoarthritis. Current research is aimed at treating BMLs with the intent to improve the overall structural integrity of the subchondral bone and delay the need for arthroplasty. The injection of calcium phosphate bone substitute has been proposed to treat BMLs because animal models have shown its potential to stimulate bone repair. This technical note describes the key steps involved in performing percutaneous fixation of BMLs with a hard-setting bone substitute, as well as associated pearls and pitfalls. Although continued research with prospective comparative cohorts and long-term follow-up is needed to determine the efficacy of this procedure, this intervention holds promise in delaying the need for total knee replacement in the arthritic patient with a focal lesion.

There is growing interest in the diagnosis and treatment of bone marrow lesions (BMLs) about the knee. These lesions stem from remodeling and increased vascularity in the presence of subchondral bone attrition and microfractures of trabecular bone due to increased stress and loading forces.<sup>1-3</sup> Often, they are represented on fluid-sensitive magnetic resonance imaging (MRI).<sup>4</sup> The causes of these lesions include contusions from trauma (with or without cruciate ligament injuries), insufficiency fractures, degenerative cartilage lesions, spontaneous osteonecrosis, avascular necrosis, bone erosions, or synovitis.<sup>5-8</sup> Bipolar “kissing lesions” may also occur from impaction of both the femur and tibia during trauma.<sup>4</sup>

Subchondral BMLs have mixed effects on clinical outcomes after several orthopaedic procedures<sup>8-13</sup>; however, there is considerable evidence of this finding being associated with the progression of osteoarthritis in the knee.<sup>14,15</sup>

There is growing interest in the use of orthobiologics as an intervention to stimulate bone repair and prevent overall joint deterioration.<sup>16</sup> The use of calcium phosphate bone substitute materials within BML sites has been proposed to treat these lesions.<sup>17,18</sup> Over time, autologous osteoclasts and osteoblasts will remodel around the injection sites to reconstitute the structural integrity of the subchondral bone.<sup>19,20</sup> A recent biomechanical study showed that AccuFill (Zimmer Knee Creations, Exton, PA) was the only bone substitute able to be injected into a high-pressure environment, like that of subchondral trabecular bone, at large enough volumes to be clinically useful.

Initial clinical series in patients receiving this injection have shown improvements in subjective outcome scores.<sup>17,18,21</sup> Rates of conversion to total knee arthroplasty have been reported as 8% and 30% with 14.6 months' and 2 years' follow-up, respectively.<sup>18,22,23</sup> As a preventive intervention, the injection of bone substitute holds promise to delay the knee for conversion to arthroplasty, particularly in patients in whom knee replacement is unsuitable. We describe a technique for accurate placement of bone substitute materials in patients with pain correlating to BMLs seen on MRI.

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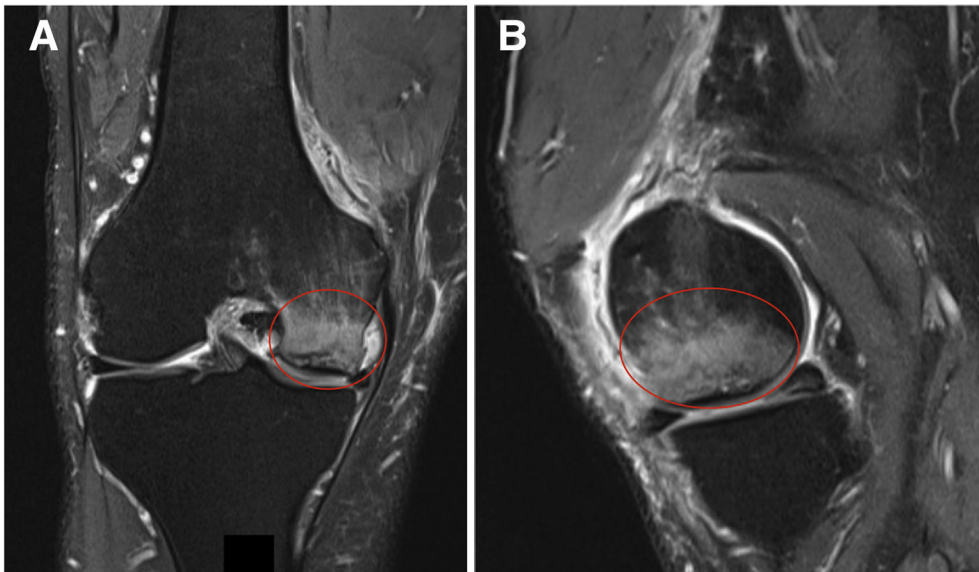
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**Fig 1.** Preoperative magnetic resonance imaging of the right knee in prone position: coronal slice (A) and sagittal slice (B) showing focal bone marrow lesion (ovals) in medial femoral condyle.

## Surgical Technique

### Preoperative Assessment

A thorough history should delineate the patient's mechanism of injury, provoking or inciting factors, and severity and duration of symptoms. In addition, the patient should be evaluated for any history of osteoarthritis, osteochondritis dissecans, and avascular necrosis. Previous failed therapies should be noted. A focused physical examination should evaluate range of motion and ligamentous stability, include palpation of bony protrusions, and particularly focus on the area of the suspected lesion. Standard weight-bearing anteroposterior (AP) radiographs at 0° and 30° of flexion, sunrise radiographs, and lateral radiographs of the knee should be ordered to evaluate the level of osteoarthritis or presence of osteochondritis dissecans lesions. MRI is used to confirm the presence of and evaluate subchondral signal (Fig 1).

### Indications for Intervention

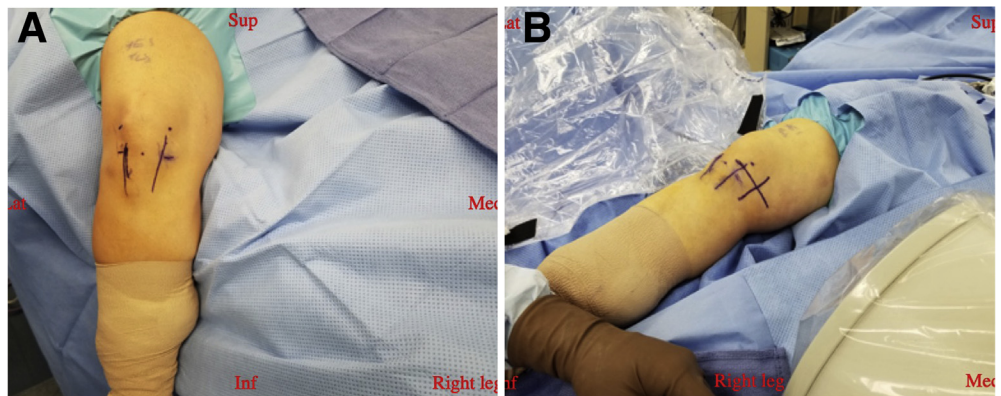
A conservative therapy trial with rest, oral nonsteroidal anti-inflammatory drugs, physical therapy, low-

impact activity, and weight loss should be initiated. Unloader bracing, to relieve load on the lesion side, may be used. Trials of corticosteroids or hyaluronic acid injections may be considered. Operative intervention should not be used for acute lesions (<3 months). Surgery may be indicated in patients with symptoms matching the lesion site and stable knees, intact subchondral bone, and osteoarthritis in whom conservative management has failed.

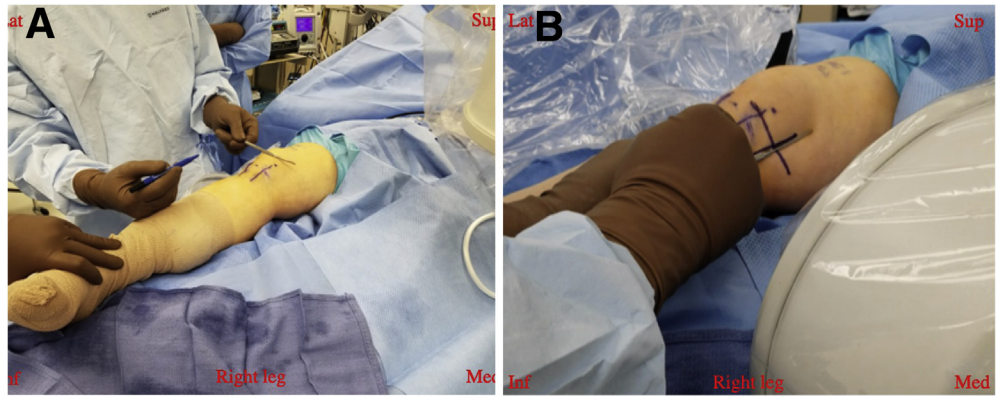
### Patient Positioning

A thorough examination under anesthesia should be performed to document range of motion and ligamentous stability. The patient is positioned supine on a radiolucent table either with the operative leg on a bone foam bump or with a towel under the knee to allow moderate flexion of the knee. A bump can be placed under the operative hip to help position the knee directly perpendicular to the floor, with the patella pointing straight toward the ceiling (Fig 2). Under lateral fluoroscopy, the distal and posterior femoral condyles should be collinear with one another, and the

**Fig 2.** (A, B) Patient draping and positioning for percutaneous fixation of bone marrow lesions with patella pointed straight toward ceiling. Patient positioning is confirmed with lateral fluoroscopy. The C-arm should be brought in from the side of the operative leg for medial-sided lesions. A right leg is shown. (Inf, inferior; Lat, lateral; Med, medial; Sup, superior.)



**Fig 3.** (A, B) A radiopaque freer elevator is used to localize the bone marrow lesion in the mediolateral and anteroposterior planes under fluoroscopic guidance. A right leg is shown. (Inf, inferior; Lat, lateral; Med, medial; Sup, superior.)



medial and lateral aspects of the tibial plateau should be aligned. The trochlear groove should be visible as a separate line from the medial and lateral facet margins. Attention should be paid to the nonoperative leg as well so that it does not interfere with the operative side.

### Navigation

When a medial-sided BML is being treated, the C-arm should be brought in from the side of the operative leg. For a lateral-sided lesion, the fluoroscopy machine should be brought in from the contralateral side. This positioning of the C-arm, depending on which side the BML is on, will allow for transition between AP and lateral views without the surgeon having to adjust his or her hand or the guide pin.

Next, by use of the sagittal cuts from the preoperative MRI scan as guidance, the location of the BML is correlated with its position on intraoperative lateral fluoroscopy of the knee. A radiopaque freer elevator (or a similar surgical instrument) is placed longitudinally until its position on the radiograph correlates with the sagittal position of the BML on MRI. After the position of the lesion is found in this plane, a line is drawn along the freer using a marking pen. This is then repeated using the coronal cuts of the MRI scan to correlate the positioning of the BML on the AP knee radiograph (Figs 3 and 4).

### Cannula Placement and Injection

The injection cannula with the inner stylus in place is inserted into the skin at the point at which the vertical and horizontal lines on the knee cross. The cannula is then drilled into the bone using a wire driver (Fig 4).

Fluoroscopy is used to confirm that the cannula is in the area of the BML on the AP and lateral radiographs (Fig 5). Final confirmation of localization is performed by correlating fluoroscopic images with that on preoperative images (Fig 6). Once the positioning is confirmed, the inner stylus is removed and the AccuFill bone substitute is injected. Final AP and lateral radiographs are taken to confirm that the bone substitute has filled the entire area of the BML. If the lesion is not completely filled by the bone substitute on radiography,

another cannula can be inserted into a different portion of the BML using the same technique and bone substitute can be injected.

After the bone substitute is injected, a knee arthroscopy is performed, and any intra-articular pathology is addressed. The patient is woken from general anesthesia and discharged home the same day as surgery.

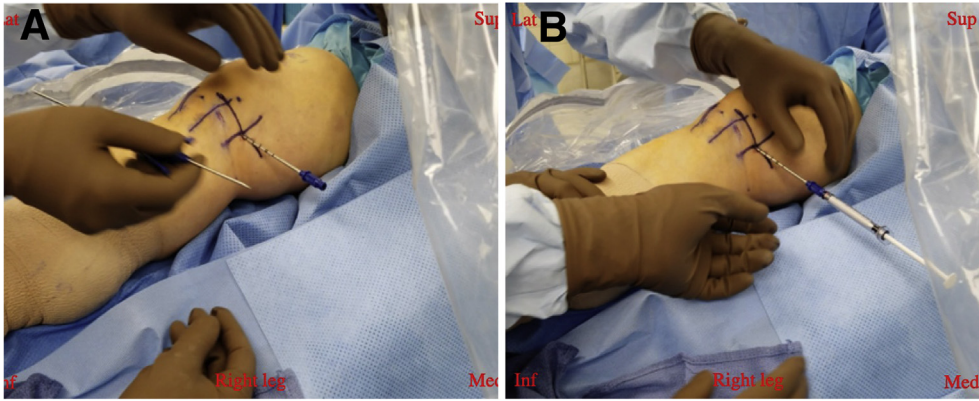
### Postoperative Protocol and Rehabilitation

This procedure is typically treated in an outpatient setting, pending pain control in the postoperative setting. Pain will be most significant between 48 and 72 hours after surgery. The patient is allowed weight bearing as tolerated with crutches for assistance during the first 1 to 2 weeks. Patients are followed up in the clinic within 7 to 10 days after surgery for surgical-site evaluation and removal of stitches. Formal physical therapy is initiated 2 weeks after surgery. Return to full and unrestricted activity is allowed between 4 and 8 weeks after surgery with consideration of patient symptoms (Video 1).



**Fig 4.** A wire driver is used to introduce the injection cannula into the bone marrow lesion based on previous localization steps under fluoroscopic guidance. A right leg is shown. (Inf, inferior; Lat, lateral; Med, medial; Sup, superior.)





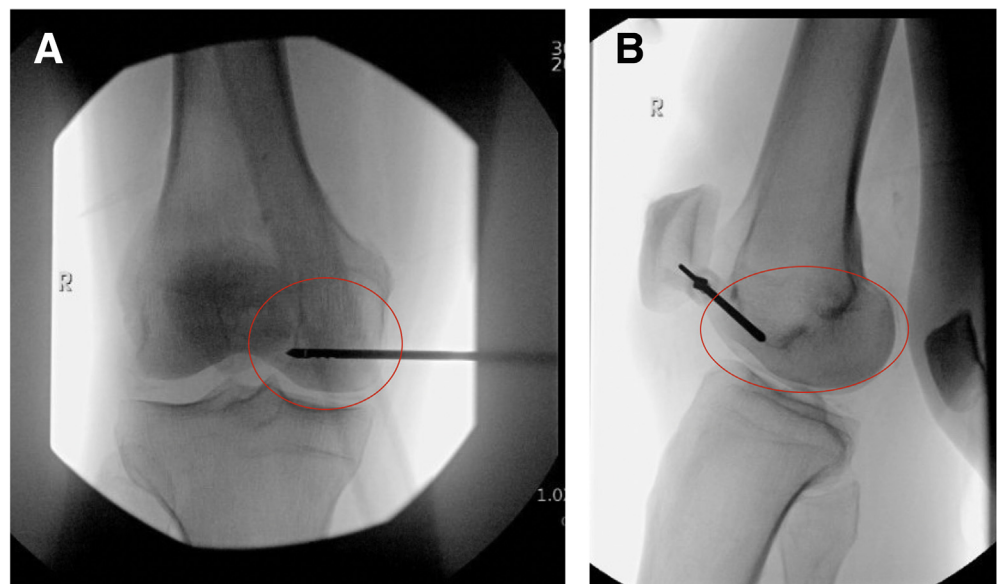
**Fig 5.** (A, B) Fluoroscopy is used to confirm cannula placement prior to injection of AccuFill into the bone marrow lesion. A right leg is shown. (Inf, inferior; Lat, lateral; Med, medial; Sup, superior.)

## Discussion

This technical note examines the steps in the fixation of BMLs using a hard-setting bone substitute. Bone cement injection offers an efficient method of treating symptomatic focal BMLs with the potential of delaying the progression of osteoarthritis (Table 1). The advantages of this intervention are that it is minimally invasive with a low operative time. The risks of this procedure are also minimal, but extravasation of the bone cement into the joint or nearby soft tissue is possible. Secondary viewing with arthroscopy is important to identify this before the cement hardens because this may cause pain for the patient. In addition, it is important to highlight that bone cement injection is a focal treatment option. As BMLs often stem from a systemic degenerative process, new lesions may occur in previously uninvolved compartments of the knee (Table 2). Although further clinical studies are required to prove the efficacy of this procedure, our technical

note contributes to the growing body of literature on how to accurately perform this procedure.

A comprehensive preclinical study was recently performed in canine models. Brimmo et al.<sup>20</sup> injected AccuFill substrate into BMLs created from an arthroscopic impact injury of 40 N to the medial femoral condyle. They had an interval of follow-up between 3 months and 2 years and examined differences between test and control groups with respect to radiographs, MRI pathology, histology, range of motion, pain on a visual analog scale, and micro-computed tomography. At final follow-up, no significant differences were found with respect to radiographic, arthroscopic, MRI, and histologic examination findings. However, micro-computed tomography showed greater bone volume fraction and trabecular thickness and nearly complete resorption of injectate at final follow-up. Of note, 2 canines in the treatment group also showed robust fibrocartilage repair tissue over the top of the



**Fig 6.** The fluoroscopic anteroposterior view (A) and lateral view (B) of the right knee bone marrow lesion are correlated with previously acquired magnetic resonance imaging to ensure that localization of the lesion (ovals) is appropriate.

**Table 1.** Pearls and Pitfalls of Treatment of Focal Bone Marrow Lesion in Osteoarthritic Knee With Hard-Setting Bone Substitute**Pearls**

The patient must be appropriately positioned with the knee perpendicular to the floor and an assistant to hold the knee steady during the procedure. Lateral fluoroscopic imaging should be performed to confirm alignment.

Intraoperative fluoroscopy should be correlated with preoperative MRI, which better characterizes the bone marrow lesion.

The level of subchondral bone is 5-10 mm below the articular surface of the knee.

Periodic fluoroscopy should be used while drilling to avoid entry into an unwarranted site within the knee.

Kissing lesions may be addressed simultaneously, during the same procedure.

**Pitfalls**

The C-arm should be positioned from the contralateral side to allow for sufficient space to perform the procedure.

Body habitus should be accounted for when creating surface landmarks.

Use of MRI images taken >3 mo prior to the procedure can affect proper cannula placement.

The injection cannula may move or rotate during swapping of injection syringes. Care must be taken to maintain the appropriate site.

Enough volume should be injected to completely fill the area of edema.

Multiple passes with a cannula can result in extravasation of bone cement.

MRI, magnetic resonance imaging.

**Table 2.** Advantages and Disadvantages of Use of Hard-Setting Bone Substitute in Treatment of Focal Bone Marrow Lesions in Osteoarthritic Knee**Advantages**

The surgical procedure is minimally invasive with a minimal risk and complication profile known.

The technique offers an efficient and cost-effective method of preventing progression of osteoarthritis.

Patients are treated on an outpatient basis and can expect pain relief within 48-72 h.

The rehabilitation time is short, with a return to full activity within 4-8 wk—preferable for active patients.

**Disadvantages**

There are specific indications for use, which include subacute focal lesions in the presence of mild to moderate osteoarthritis with intact subchondral bone.

Alternative compartments remain at risk of an insufficiency fracture of a focal lesion.

Correct cannula placement requires proficiency with fluoroscopy.

original defect. Furthermore, the treatment group was associated with less pain, less effusion, and better range of motion at 1 and 2 years after treatment.

The aforementioned study also highlighted that the treatment subjects were further impaired than the control subjects during the 3- and 6-month periods.<sup>20</sup> This finding is reflected by limited clinical series to date, which also showed greater pain within 6 months, and is likely the result of the initial osteogenic processes after injection.<sup>17,18,21</sup> Only Cohen and Sharkey<sup>18</sup> have followed up their patients to the 2-year time point; however, they still found significant improvements in pain and International Knee Documentation Committee scores. Smaller series with shorter follow-up periods were performed by Bonadio et al.<sup>17</sup> and Chatterjee et al.,<sup>21</sup> and both investigations still showed improvements in pain and knee function scores. However, despite reporting improvements in subjective outcomes, Chatterjee et al. also reported that 7 of 22 patients had poor clinical outcomes and found that postoperative outcome score was inversely related to preoperative Kellgren-Lawrence osteoarthritis classification. They concluded that injection of bone cement was ineffective, particularly in patients with advanced osteoarthritis.

There remains a high demand for prospective, comparative cohort studies with long-term follow-up to assess the true efficacy of the described procedure. A

combination of basic science literature and early clinical studies shows promise in the use of hard-setting bone substitutes to manage BMLs. In addition, future studies should account for the etiology of these lesions, degree of osteoarthritis, lesion location, and substrate composition.

Treatment of focal BMLs in the knee with hard-setting bone substitute holds promise in delaying the progression of knee osteoarthritis. This technical note offers a simple and reproducible set of steps to perform this operation successfully. Future studies should investigate the efficacy of this procedure.

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