Evaluation of Stress Fracture or Osteochondral Insufficiency Repair with Injectable Graft

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Statement of Purpose

As noted in the knee, repetitive stress and microtrauma can form abnormalities within the subchondral bone. Histological and MRI analysis of these "bone marrow lesions" (BMLs) has identified areas with less mineralization, increased fibrosis, necrosis and microfractures.[1] Consequently, this correlates to increased pain in patients suffering from arthritis. Similarly, repetitive stress and/or reduced healing abilities can form abnormalities within the bone marrow in stress fractures. The purpose of our study is to evaluate the efficacy and safety of an injectable calcium phosphate (CaP) bone substitute into symptomatic BMLS in the foot and ankle.

Methodology & Hypothesis

A retrospective review of 24 consecutive patients undergoing injection of CaP into a BML from two institutions are included in this study from the patient population of the senior author from 9/30/16 to 8/28/17. To be included in the study, patients had to present with foot or ankle pain for at least 3 months, exhaust conservative options (immobilization, bracing, activity modification, non-steroidal anti-inflammatory medications) and have an MRI indicating increased bone marrow edema in T2-weighted fat suppression images (Figure 1). Patients were excluded if they had an autoimmune disease, renal disease requiring dialysis, severe cartilage loss or collapse of the subchondral plate. Postoperatively, the patients were evaluated clinically, and radiographs and/or MRI was obtained at 6 weeks and 3 months.

As patients included in this study have exhausted all other conservative options, we hypothesis that injectable CaP bone substitute can be an effective alternative procedure to alleviate pain and help return to activity.

Procedure

After a thorough history and physical examination is performed, standard weightbearing radiographs are obtained to rule out acute fracture or dislocations. Next, if all conservative options had failed, an MRI was obtained within 3 months of surgery to assess the presence of BMLs. BMLs can be identified on T2 fat-saturated or proton density fat-saturated MR imaging. Utilizing axial, coronal and sagittal imaging, a BML can be accurately triangulated. It is imperative that clinical examination correlates with MRI findings. If indicated, adjunct procedures such as ankle arthroscopy, plantar fasciotomy or cheilectomy was also performed. Moreover, in some cases, bone marrow aspirate from the distal tibia was obtained and mixed into the injectable CaP. With the previous MRI as reference, the drill bit and cannula was triangulated into the BML, and subsequently confirmed with AP, oblique and lateral views (Figure 2). With the injection cannula maintained in the proper position, a syringe filled with the CaP bone substitute is injected into the defect under fluoroscopic imaging. The bone substitute was injected until a darkened blush is visualized, which should mimic the size and shape of the BML noted on the MRI. Care is taken not to over pressurize the bone with the injection. Following a time lapse of approximately 4-5 minutes, the trocar is reinserted into the injection cannula before all instrumentation is safely removed.[2]

Results

The final study population consisted of 24 patients with 29 foot/ankle BMLs being injected with CaP bone substitute (13 left and 16 right). The average age was 46.2 years and the male:female ratio was 10:24. In regards to location, most lesions were noted in the talus (11), followed by the metatarsals (7), calcaneus (5) and tibia (4). The remaining 2 lesions were noted in the midfoot, specifically the navicular and intermediate cuneiform (Table 1).

Radiographically, increased bone density was visualized as early as 6 weeks and in certain cases, repeat MRI was obtained at 3 months verifying decreased bone marrow edema (Figure 3). Most (83%) of the patients were able to return to work/activity gradually within 8-12 weeks. No complications, wound problems or adverse reactions were noted from the injection. 4 patients had no pain relief and stated they would not have the procedure done again. The remaining patients would undergo the procedure again.

Table 1

Age	(n = 24)	
Average	46.2	
Male	47.4	(23 - 61)
Female	45.3	(19 - 67)
Sex	(n = 24)	
Male	10	41.7%
Female	14	58.3%
Laterality	(n = 29)	
Left	13	44.8%
Right	16	55.2%
Location	(n = 29)	
Tibia	3	10.3%
Talus	9	31.0%
Calcaneus	4	13.8%
Navicular	1	3.4%
Cuneiforms	1	3.4%
Metatarsals	7	24.1%

Figure 1

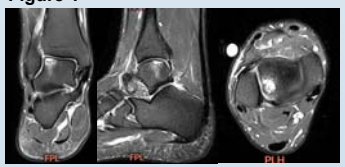


Figure 2

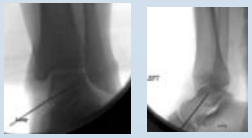
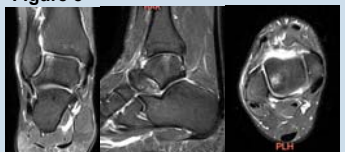


Figure 3



Discussion

Injectable CaP has been utilized in the orthopedic realm as a relatively simplistic and safe minimally invasive procedure with early return to weightbearing.[3] In the past, CaP-based bone substitute has been used primarily as a graft option in bone defects. Furthermore, biphasic CaP ceramics have shown good osteoinductive and osteoconductive results. These properties may contribute to the balance of the bone mineralization lost in the areas of BMLs. Unlike hydroxyapatite, the degradation of CaP substitutes is more similar to that of autologous bone.[4]

Numerous authors have reported satisfactory results and durable outcomes with CaP bone substitutes for knee osteoarthritis. Cohen et al observed significant improvements in both pain and function in 66 patients undergoing CaP bone substitute injection and arthroscopic debridement of the knee through 2 years postoperative follow-up.[5]

However, to our knowledge, not many studies evaluate this procedure for bone marrow lesions noted in the foot and ankle. The present study demonstrates a simple and reproducible surgical technique, which succeeded in its objective of injecting CaP bone substitute into BMLs. The small number of patients and the absence of control group are important limitations. A larger study with a long-term follow-up would be beneficial.

Nevertheless, we report our experience of the procedure in 24 patients with early osteoarthritis or stress fracture who were mostly satisfied with the procedure and were able to return to activity promptly. In the patients that were not satisfied, 3 of the injected BMLs were noted in the metatarsals, which are anatomically less cancellous than other pedal bones. For this reason, we believe that the CaP bone substitute may have caused a significant increase in the pressure of the metatarsal bone, likely causing more pain and leading to patient dissatisfaction.

In conclusion, the developed injectable CaP procedure may be a new treatment modality for early stage osteoarthritis or stress fracture when an associated BML is present in the foot and ankle.

References

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