



Subchondroplasty of the ankle: A novel technique

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Arthritis is a multifactorial process involving the joint articular surfaces, synovial fluid, supporting ligaments and musculature, anatomic alignment, and subchondral bone and bone marrow. Recent literature has shown a safe and efficacious procedure of symptomatic bone marrow lesions in the knee with an injectable calcium phosphate bone substitute, known as Subchondroplasty[®] (SCP[®]). The authors present the first usage of the procedure in the ankle and report on two cases with promising results.

Keywords: Arthritis, bone marrow edema, surgery, arthroscopy , percutaneous, microfracture

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Osteoarthritis affects approximately 15% of the world's adult population, with 1% of those suffering from osteoarthritis in the ankle [1]. In comparison of arthritis in other joints in the body, the most common cause of ankle arthritis is posttraumatic, and less often the result of primary/senile osteoarthritis. Consequently, a diverse age spectrum with a relatively young average age of presentation is encountered in the treatment of ankle arthritis [2]. Elderly and less active people are typically treated surgically with joint destructive procedures in mid- and end-stage arthritis, either by arthrodesis or total ankle replacement. Younger and more active people with symptomatic arthritis have been treated with the above mentioned procedures with less favorable results and need for repeat surgery [3]. Other joint sparing procedures have also been advocated in the younger population, with mixed short-term and long-term results [4].

The ankle joint has a substantially smaller contact area than the hip or knee. As a result, the ankle experiences more force per square centimeter than the knee or hip throughout weightbearing [5]. Unique to the ankle is a thinner (1-2mm), stiffer cartilage, which is known to be more resilient than the cartilage seen in the hip and knee [6]. Arthritis is a multifactorial process, where the articular cartilage is often seen at the center of the pathology, but other influences such as synovium, supporting ligaments and musculature, anatomic malalignment, and subchondral bone and bone marrow play an important role in the disease process.

The subchondral bone layer supports the overlying articular cartilage, where it absorbs most of the mechanical forces and helps evenly distribute joint stress. Subchondral bone is a dynamic structure, where it can normally respond to increased demands or loads across the joint by increasing its bony density and mineralization. As seen in knee osteoarthritis, repetitive stress and/or reduced healing abilities can form abnormalities within the subchondral bone. Histologic and magnetic resonance imaging (MRI) analysis of these "bone marrow lesions" (BMLs) has identified areas with less mineralization, increased fibrosis, necrosis, and microfractures [7,8]. BMLs have been identified as structural changes of the subchondral bone, where these lesions signify a precursor of advancing cartilage

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destruction, subchondral bone attrition, and acceleration of joint deterioration by joint collapse [9,10]. Further, the presence of BMLs has been strongly correlated to increased pain in patients suffering from arthritis [11].

Subchondroplasty® (SCP®) (Zimmer Holdings, Inc.; Warsaw, IN) is a proprietary term referring to the procedure of injecting a flowable nanocrystalline calcium phosphate (CaP) synthetic bone graft into the subchondral portion of bone. Current applications in the literature have been concentrated solely to the knee joint. The flowable CaP utilized, AccuFill (Knee Creations, LLC; West Chester, PA), has been developed to enable injecting the CaP between the subchondral cancellous trabeculae without damaging the existing bone scaffold. Once the CaP has been injected, an endothermic reaction crystallizes the CaP to mimic the properties of healthy cancellous bone. The host is then able to resorb the osteoconductive CaP over the next several weeks, and replace with its native cancellous bone.

Surgical Technique

Subchondroplasty can be considered in patients with symptomatic, arthritic ankle joints. A thorough history should be obtained, identifying any past history of injury, and previously attempted treatment. A comprehensive physical examination is then performed, placing the ankle through a range of motion, and palpating all important anatomic features of the joint. Further, joint stability should be evaluated for with stress tests to assess for any medial or lateral ligamentous insufficiency. Standard weightbearing radiographs (anteroposterior, medial-oblique, lateral) are obtained to rule out fractures or dislocation, neoplasms, assess for any joint malalignment, and to carefully scrutinize the articular surfaces of the tibia and talus. Conservative measures should be recommended to the patient, including non-steroidal anti-inflammatory medications, injections, activity modification, or bracing.

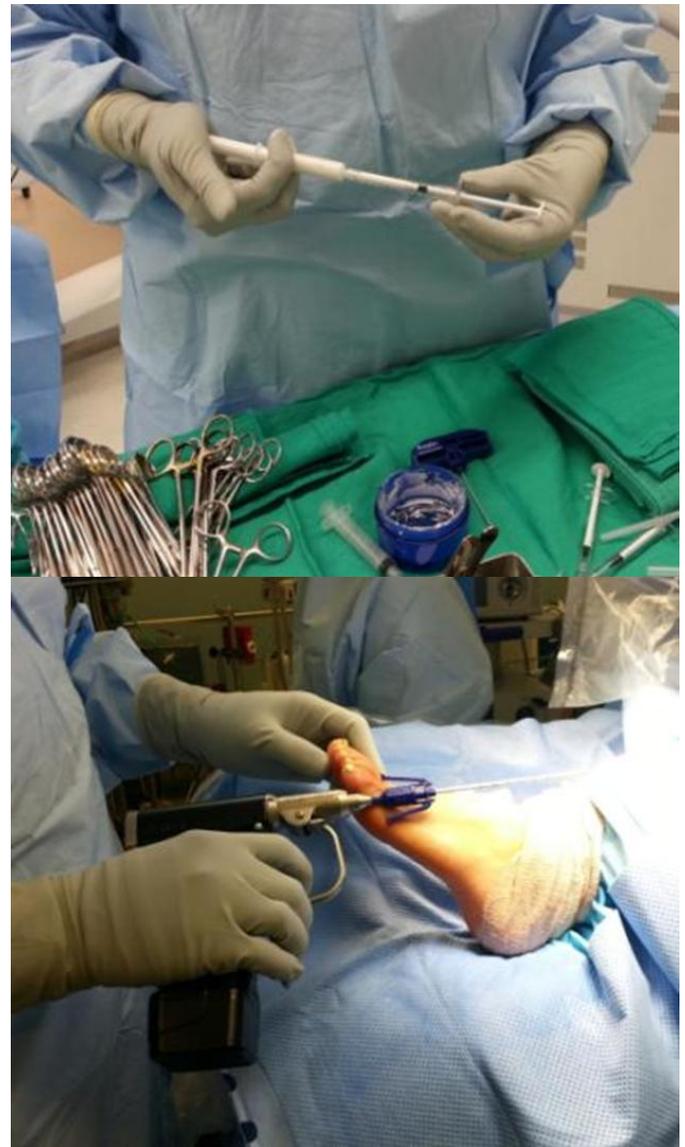


Figure 1 & 2 Intraoperative photographs; CaP mixed and loaded in to a 5cc syringe (top), drill bit and cannula loaded on power instrumentation (bottom).

In surgical candidates, an MRI is obtained within 3 months of surgery to assess the presence of BMLs. BMLs can be identified on T2 fat-saturated, proton density fat-saturated, or short T1 inversion recovery MR imaging. Utilizing axial, coronal, and sagittal imaging, a BML can be accurately triangulated. Clinical examination should correlate with MRI findings. The entire joint and surrounding soft tissues should be further examined for any pathology, which may or may not be addressed at the time of the Subchondroplasty procedure. Subchondroplasty is contraindicated if severe cartilage loss or collapse of the subchondral plate is seen.

The Subchondroplasty procedure is performed with the patient in the supine position. After general or spinal anesthesia, a well-padded thigh tourniquet is placed. In most cases, ankle arthroscopy should be performed first to evaluate the integrity of the articular surfaces, and to address intra-articular pathology. Other adjunct procedures (tibial osteotomies, ligamentous repairs, etc.) may be performed before or after the Subchondroplasty procedure.

Once arthroscopy and/or other procedures are completed, the ankle should be positioned to allow for a true anteroposterior and lateral views. With the previous MRI as reference, the drill bit and cannula is triangulated into the BML, confirmed with AP, oblique, and lateral views (Figure 1 & 2). Multiple drill attempts, or drill exit past the subchondral plate is to be avoided, as this may lead to extravasation of the CaP. With the injection cannula maintained in the proper position, a syringe filled with the CaP bone substitute is luer-locked and injected into the defect under fluoroscopic imaging. The surgeon should continue to inject the bone substitute until a darkened blush is visualized which should mimic the size and shape as the BML on the MRI. Multiple CaP-filled syringes may be required based on the size of the BML. Care should be taken to not over pressurize the bone with the injection. Once completed, fluoroscopy or arthroscopy can be utilized to ensure no intra-articular bone graft extravasation. Following a time lapse of 4-5 minutes after the CaP injection, the trocar should be reinserted into the injection cannula before all instrumentation can be safely removed.

Case 1

A 48 year old male presented to our clinic with complaints of chronic left ankle pain and instability. The patient suffered a significant ankle sprain four years prior, where he was treated with a fixed walking boot. The patient states after four weeks, he was transitioned to a lace-up ankle brace. He admitted to continued minor sprains when he was active or walks on uneven ground without his brace. The patient failed further conservative management with corticosteroid intraarticular injections.

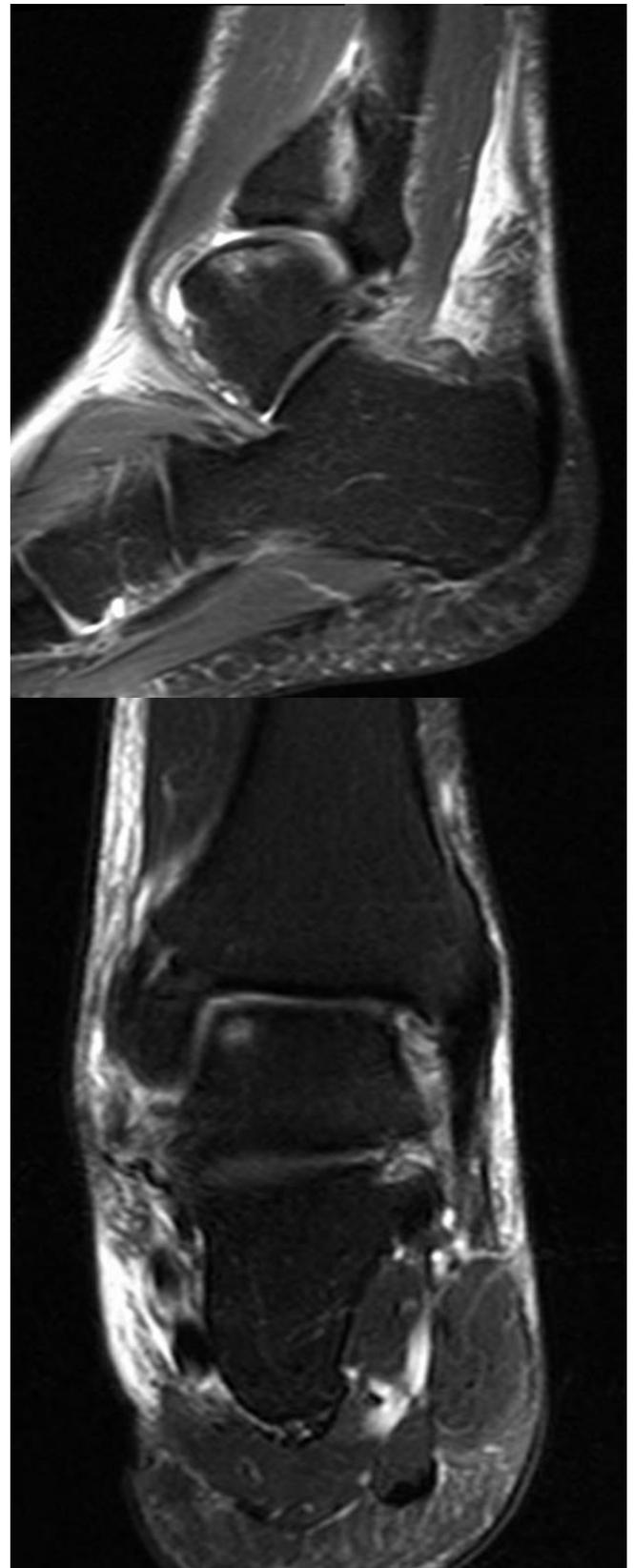


Figure 3 & 4 Patient one; Preoperative MRI T2 fat-saturated images with localized subchondral edema to the central-medial talar dome.

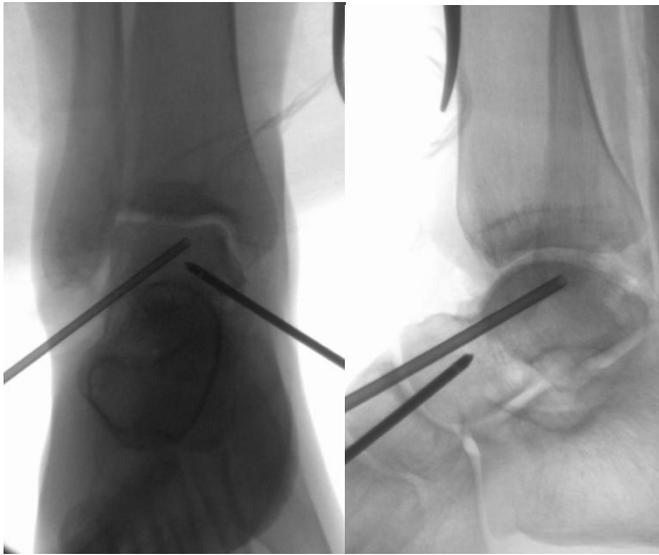


Figure 5 & 6 Patient one; Intraoperative triangulation of the cannula (left), and injection of CaP bone substitute (right).

An MRI was subsequently ordered (Figures 3 and 4), which displayed chronic tearing of the anterior talofibular ligament, significant anterior tibial joint spurring, and subchondral bone marrow edema to the medial aspect of the talar dome.

The patient elected for surgical management of his ankle joint. The Subchondroplasty procedure was performed first. Utilizing the recent MRI, the drill and cannula were triangulated into their proper position from a lateral talar process approach. After verification of proper positioning, the CaP was injected into the medial aspect of the talar dome (Figures 5 and 6). Subsequent procedures included ankle arthroscopy, anterior ankle arthrotomy, and a modified-Brostrom procedure.

Case 2

A 28 year old male presented to our clinic as a second opinion for continued ankle pain after suffering a previously treated fibular non-union. The patient was previously treated nonoperatively with an external bone stimulator and cast immobilization until fracture consolidation was confirmed with serial radiographs. Although the patient underwent physical therapy for eight weeks, he complained of continued pain and swelling. An MRI was performed (Figures 7 and 8), which displayed a large osteochondral lesion of the

talus (OLT) to the anterior-lateral aspect of the talar dome, significant subchondral talar edema, and chronic tearing of the anterior talofibular ligament. After explaining the results of the MRI in detail, the patient elected for surgical management.

The Subchondroplasty procedure was first performed to the ankle joint. After successful triangulation of the drill and cannula, the CaP was injected into the large area of persistent bone marrow edema within the lateral talus (Figures 9 and 10). An ankle arthroscope was utilized, to visualize the significant OLT and to ensure lack of CaP extravasation within the joint. The OLT was microfractured and juvenile articular cartilage allograft was delivered to the defect. The patient then underwent a modified-Brostrom procedure.



Figure 7 Patient two; preoperative MRI T2 fat-saturated images displaying diffuse lateral talus bone marrow edema.



Figure 8 Patient two; preoperative MRI T2 fat-saturated images displaying diffuse lateral talus bone marrow edema.



Figure 9 & 10 Patient two; intraoperative triangulation of the drill/cannula (top) and injection of CaP bone substitute (bottom).

Recovery and Follow-up

Following surgery, both patients were maintained nonweightbearing for a total of six weeks. The patients were then transitioned in to a supportive ankle brace and underwent functional rehabilitation for an additional six weeks.

Patient one progressed through his postoperative period without complications and was able to resume full activities 12 weeks after surgery.

Patient two endured a syncopal episode in the shower 13 weeks after surgery, fell, and suffered a mid-diaphyseal tibial fracture. Subsequently, an intramedullary rod was placed and was again placed nonweightbearing for an additional three weeks. He was then able to slowly transition to protected partial-weightbearing and was allowed to bear weight without assistance at eight weeks.

At 10 month follow-up, both patients admitted to minimal pain in the ankle joint. Patient one reported mild discomfort while golfing, in which the pain is controlled with non-steroidal anti-inflammatories. Patient two has returned to full activities without bracing or restrictions. Upon retrospective review, both patients state they would elect to have their procedures performed again.

Discussion

Operative treatment of ankle arthritis can be classified as either joint-sparing or joint-destructive. Previous treatments of either category up to this point have not directly addressed pathologic subchondral bone or symptomatic BMLs. As first described in the knee joint, Subchondroplasty offers the benefit of a relatively simplistic and safe minimally-invasive procedure, with prompt return to weightbearing, while restoring pathologic subchondral bone to healthy cancellous native bone. The future of the procedure may involve expanding its usage across any bone or joint in the lower extremity, where a symptomatic bone marrow lesion has been identified. The authors encourage further investigation of the Subchondroplasty procedure in the ankle and foot for similar type subchondral bone restoration cases.

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None reported.

Conflict of Interest

Dr. Miller is a consultant for Zimmer Holdings, Inc. Zimmer Holdings, Inc. had no knowledge or influence in study design, protocol, or data collection related to this report.

References

1. Valderrabano V, Horisberger M, Russell I, et al. Etiology of ankle osteoarthritis. *Clin Orthop Relat Res* 2009;467:1800–6. [Pubmed](#)
2. Saltzmann CL, Salamon ML, Blanchard GM, et al. Epidemiology of ankle arthritis: report of a consecutive series of 639 patients from a tertiary orthopedic center. *Iowa Orthop J* 25:44-46;2005. [Pubmed](#)
3. Fuchs S, Sandmann C, Skwara A, Chylarecki C. Quality of life 20 years after arthrodesis of the ankle. A study of adjacent joints. *J Bone Joint Surg Br*. 2003;85(7):994-998. [Pubmed](#)
4. Kluesner AJ, Wukich DK. Ankle arthrodiastasis. *Clin Podiatr Med Surg*. 2009;26(2):227-244.
5. Stauffer RN, Chao EY, Brewster RC. Force and motion analysis of the normal, diseased, and prosthetic ankle joint. *Clin Orthop Relat Res*. 1977;127:189–196. [Pubmed](#)
6. Treppo S, Koepp H, Quan EC, Cole AA, Kuettner KE, Grodzinsky AJ. Comparison of biomechanical and biochemical properties of cartilage from human knee and ankle pairs. *J Orthop Res*. 2000;18:739–748. [Pubmed](#)
7. Hunter DJ, Gerstenfeld L, Bishop G, et al. Bone marrow lesions from osteoarthritis knees are characterized by sclerotic bone that is less well mineralized. *Arthritis Res Ther* 11:R11, 2009. [Pubmed](#)
8. Taljanovic MS, Graham AR, Benjamin JB, et al. Bone marrow edema pattern in advanced hip osteoarthritis: quantitative assessment with magnetic resonance imaging and correlation with clinical examination, radiographic findings, and histopathology. *Skeletal Radiol* 37:423-431, 2008. [Pubmed](#)

9. Wluka AE, Wang Y, Davies-Tuck M, et al. Bone marrow lesions predict progression of cartilage defects and loss of cartilage volume in healthy middle-aged adults without knee pain over 2 years. Rheumatology 2008;47:1392-1396.

10. Roemer FW, Neogi T, Nevitt MC, et al. Subchondral bone marrow lesions are highly

associated with, and predict subchondral bone attrition longitudinally: the MOST study. Osteoarthritis Cartilage 2010;18:47-53. [Pubmed](#)

11. Felson DT, Chaisson CE, Hill CL, et al. The association of bone marrow lesions with pain in knee osteoarthritis. Ann Intern Med 2001;134:541-549.

[Pubmed](#)