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Subchondroplasty of the Foot: Two Case Reports

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ABSTRACT

Early avascular necrosis of metatarsal heads and cuboid injuries are uncommon conditions encountered by foot and ankle specialists. Treatment options are limited and typically include long periods of offloading or non-weightbearing. There is limited published information on alternative treatment approaches for such pathologies when conservative therapies fail. Presented are 2 patient cases treated with a percutaneous calcium phosphate injection after failure of standard therapy, persistent pain, and bone marrow edema in the foot.

Early avascular necrosis of metatarsal heads and cuboid injuries are uncommon conditions encountered by foot and ankle specialists. Treatment options are limited and typically include long periods of offloading or non-weightbearing. There is a paucity of published information on alternative treatment approaches for these pathologies when conservative therapies fail.

Avascular necrosis of the metatarsal head, or Freiberg's disease, is an osteochondral infraction often described in younger individuals, with a peak onset between 11 and 17 years of age (1). Data have been suggestive of higher prevalence levels in females and patients commonly presenting with pain in the second or third metatarsal head, with a sensation of walking on something hard, increased swelling, and a worsening of symptoms when barefoot (2,3).

Although the pathophysiology of Freiberg's disease is unknown, it is suspected to be multifactorial, including components of repetitive trauma, vascular compromise, and complications related to systemic diseases. Multiple classifications have been developed to describe the progression of the disease based on radiographic findings, which begin with a fissure fracture in the epiphysis and develop into central bony absorption, medial and lateral projections, fracturing of the projections leading to loose bodies, and overall fattening of the metatarsal head, deformity, and arthrosis (4). Although multiple surgical techniques have been described in regard to its later stages, early-stage treatments are often limited to conservative care, such as offloading and decreased activity for prolonged periods (5).

Cuboid stress fractures, although also uncommon, are often treated in a similar manner as early-stage Freiberg's infraction. Patients are requested to be non-weightbearing for 4 to 6 weeks, followed by subsequent weightbearing in a controlled ankle movement (CAM) boot for an additional 2 weeks until transitioned into standard shoe gear. When this treatment fails, and the patient reports persistent pain during ambulation, additional treatment options are generally limited to prolonged non-weightbearing and eventual use of a bone-stimulating device to encourage healing. Although these strategies can be successful, many patients are not able to remain fully non-weightbearing for an extended period.

The presented case reports are based on 2 patients treated with percutaneous calcium phosphate injection into the affected bone after failure of standard therapy, persistent pain, and bone marrow edema (BME). Available treatment information related to subchondroplasty is nearly non-existent in the ankle and foot literature. Abrams et al (6) described a technique using a subchondral injection of calcium phosphate into the lateral tibial plateau in an area of BME, stating if there was edema to the bone marrow with subchondral bone intact, the technique may be appropriate. The authors also stated that the technique is thought to help stabilize the damaged bone and allow for pain relief during bone healing. Welch et al (7) used an experimental model in

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which a subchondral defect, including depression of the defect, was created in the tibial plateau of goats. These fractures were then either filled with calcium phosphate or cancellous autograft. The authors purported that over time, up to 18 months, the defects filled with calcium phosphate were more anatomically reduced than autografts. Chatterjee et al (8) described the lack of effectivity of subchondral calcium phosphate injections in areas of BME when advanced osteoarthritis was present.

Case Report 1

Mechanism of Injury

The patient was a 25-year-old white male. Prior history included no known injuries or deformities to the lower extremities and a reported high level of physical activity related to playing and coaching competitive tennis.

Initial Treatment

The patient presented to a foot and ankle clinic for a second opinion of longstanding second metatarsophalangeal joint (MTPJ) pain, which was previously diagnosed as predislocation syndrome and treated with conservative therapies. The patient reported worsening pain over time and rated it as 7/10 on the visual analog scale (VAS). Pain was also described as being aggravated with activity and significantly improved with rest. On examination, vascular and neurologic examinations were within normal limits and mild edema was noted around the second MTPJ. Pain was elicited with palpation of the second MTPJ. Plain radiographs were unremarkable (Fig. 1), and a further workup was requested by the patient.

Because of reported longstanding pain without improvement with conservative therapies, the decision was made to obtain a magnetic resonance imaging (MRI) scan of the patient's right foot (Fig. 2*A*–*C*). The MRI revealed BME and cortical disruption of the central aspect of the second metatarsal head consistent with avascular necrosis. After a discussion regarding treatment options, the patient opted to proceed with operative subchondroplasty.

Fig. 1. Case 1. Right foot with reported second metatarsophalangeal joint pain.

Operative Treatment

The patient was taken to the operating room, a high calf tourniquet was applied, and general anesthesia administered. The foot was prepped and draped in a sterile fashion. A stab incision was made over the second metatarsal head; blunt dissection was carried down to the bone. A trocar was inserted into the target site of the metatarsal head under live fluoroscopy (Fig. 3*A*). Using standard manufacturer guidelines of the Zimmer Subchondroplasty® (Zimmer Holdings Inc., Warsaw, IN) set, a cannula replaced the trochar and 1 mL of Zimmer AccuFill® Bone Substitute Matrix (Zimmer Holdings Inc.) was injected into the metatarsal head under live fluoroscopy with visualized dispersion throughout the metatarsal head (Fig. 3*B*). No extravasation of the calcium phosphate was noted, and a plunger was used to push remaining substance through the cannula; it was then allowed to harden for 8 minutes before the removal of the cannula. The incision was closed with a single horizontal mattress suture, and a dry sterile dressing was applied over the operative extremity.

Postoperative Course

Postoperatively, the patient was requested to remain non-weightbearing for 1 week. At the 1-week follow-up visit, the patient reported pain was well controlled and improving daily. Patient was icing and elevating the foot daily, and rated pain 3/10 on VAS. The patient was allowed limited ambulation in a postoperative shoe. At the 2-week follow-up visit, the suture was removed and Steri-Strips (3M, St. Paul, MN) applied. He rated pain 1/10 on VAS and was encouraged to be weightbearing as tolerated in a postoperative shoe. At week 4, the patient was transitioned to full weightbearing in a supportive shoe. Pain was reported as completely resolved at that time. Radiographic images were taken at 10 weeks from subchondroplasty (Fig. 4*A* and *B*) and as of 1 year, there have been no documented issues or concerns. The patient reported return to playing tennis without pain or complication.

Case Report 2

Mechanism of Injury

The patient was a 53-year-old white female with controlled hypertension and hypothyroidism, both non-contributories to injury. The patient reported walking on a treadmill and felt a pop in her left foot. There was no known prior injury to any area of the left foot.

Initial Treatment

The patient presented to the foot and ankle surgery clinic 10 days after sustaining injury with complaints of pain to the dorsal aspect of the affected foot. She reported increased pain with a 9/10 on VAS, which worsened while weightbearing and decreased with rest. On examination, vascular and neurologic examinations were within normal limits. There was mild edema in the dorsal mid-foot without erythema or ecchymosis. Pain was elicited with palpation at the base of the fourth metatarsal. Radiographs indicated a transverse fracture of the fourth metatarsal base; no acute fracture or dislocation of the cuboid was noted at that time. Patient was placed in a CAM boot and allowed weightbearing as tolerated.

At the 4-week follow-up visit, the patient complained of minimal pain. Foot radiographs indicated excellent healing across the fracture site. At that time, she was allowed to transition from the CAM boot to supportive shoe with a physical therapy evaluation. The patient was

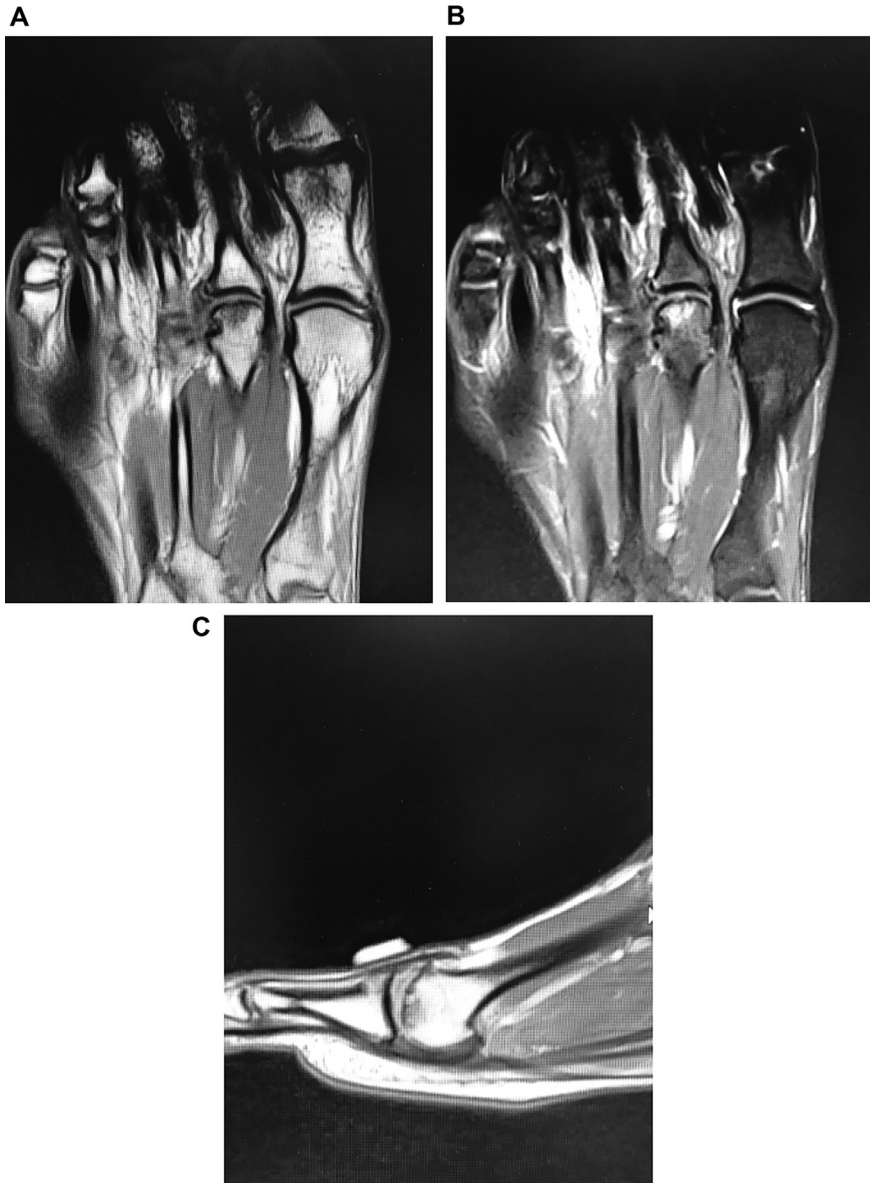

Fig. 2. Case 1. *(A)* Right foot showing central defect of second metatarsal head. *(B)* Right foot showing central cortical defect with associated bone marrow edema of the second metatarsal head. *(C)* Right second metatarsal head showing central depression with associated bone marrow edema.

then seen approximately 3 months after initial injury and rated pain at 6/10 on VAS at the plantar lateral aspect of the left foot during typical walking exercises. An MRI was ordered during the visit to evaluate for non-union; a non-displaced fracture of the cuboid and BME was reported (Fig. 5). A CAM boot was again used to immobilize the foot, and the patient was requested to be minimally weightbearing. At the patient's 1-month follow-up visit from discovery of the cuboidal fracture, she reported no pain in the CAM boot but stated she had walked a few times barefoot and had pain of 3/10 on VAS. The CAM boot was continued and the patient was referred for surgical evaluation.

The patient presented for evaluation at 9 weeks after initial discovery of the cuboidal fracture. After a discussion with the patient about her injury, experienced pain after physical therapy, and continued use of immobilization, presented treatment options included continued immobilization and operative subchondroplasty. The patient opted to proceed with operative subchondroplasty.

Operative Treatment

The patient was taken to the operating room and positioned supine on the table, a high calf tourniquet at 250 mmHg was applied, and general anesthesia administered. After the foot was prepped and draped, a stab incision was made over the cuboid and a trocar was inserted into the target site of the left cuboid under live fluoroscopy. Using standard manufacturer guidelines for the Zimmer Subchondroplasty® (Zimmer Holdings Inc.) set, a cannula replaced the trochar and approximately 2 mL of Zimmer AccuFill® Bone Substitute Matrix (Zimmer Holdings Inc.) was inserted into the cuboid bone under live fluoroscopy with visualization of the calcium phospate dispersion throughout the cuboid bone (Fig. 6). When dispersal was noted as adequate, the cannula was removed from the operative site and a single stitch was placed across the stab incision. A standard sterile dressing was applied over the operative foot.

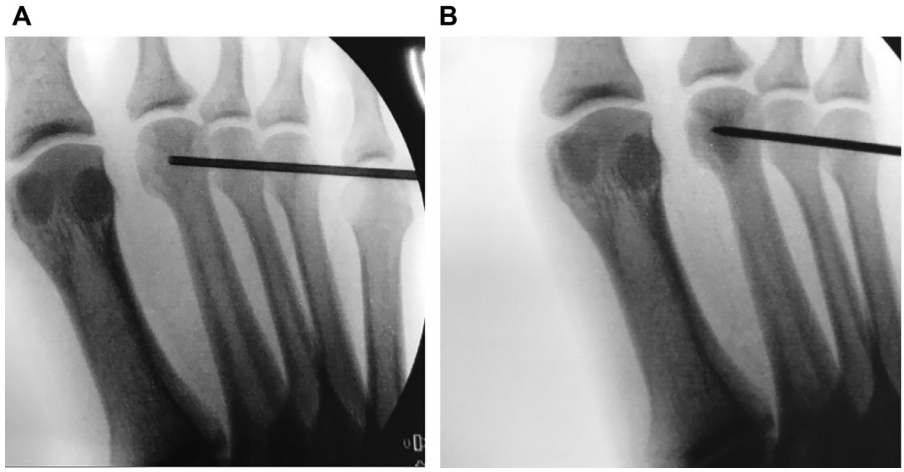

Fig. 3. Case 1. *(A)* Trochar placed in second metatarsal head. *(B)* Dispersion of calcium phosphate without extravasation.

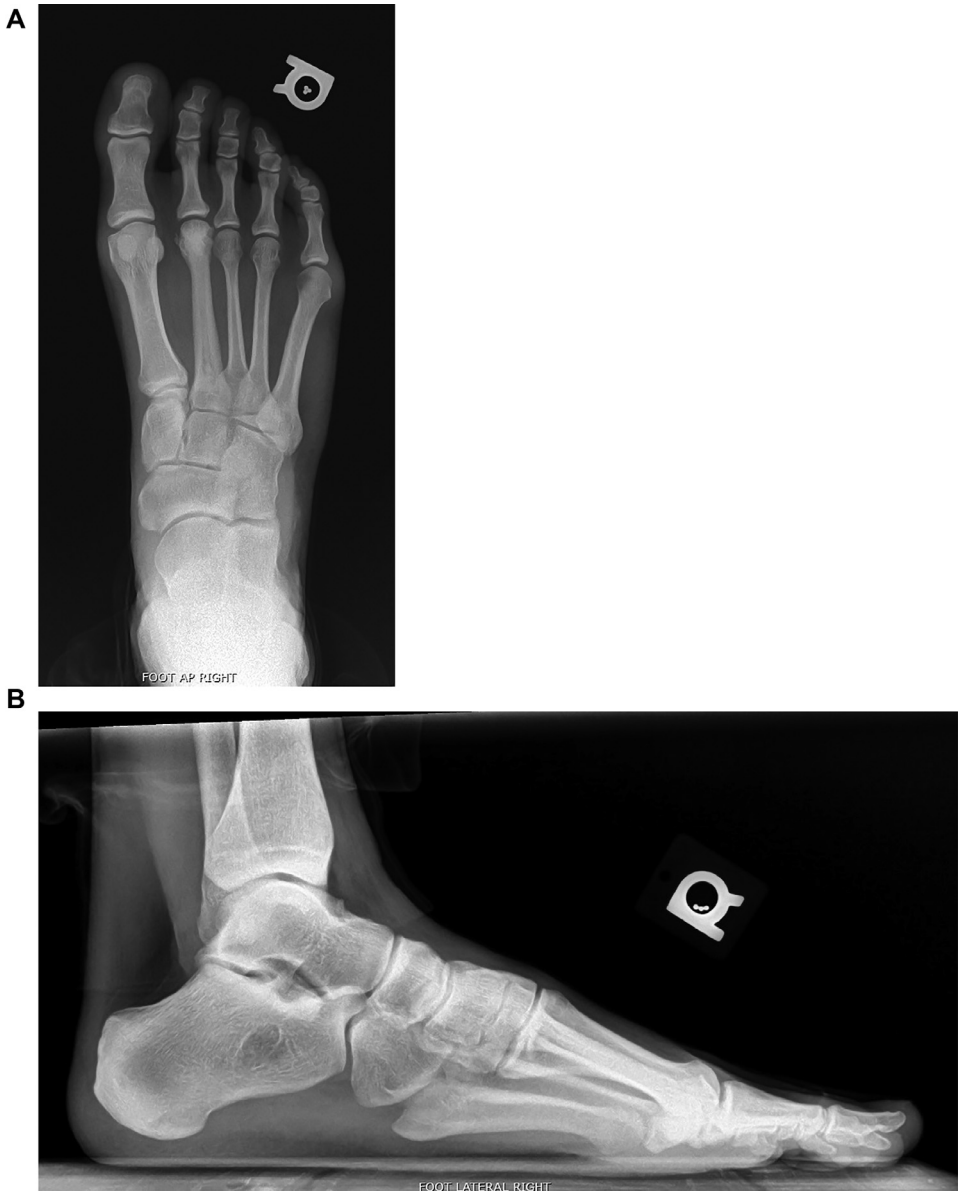

Fig. 4. Case 1. *(A)* Anteroposterior view of the right foot at 10-week follow-up. *(B)* Lateral view of the right foot at 10-week follow-up.

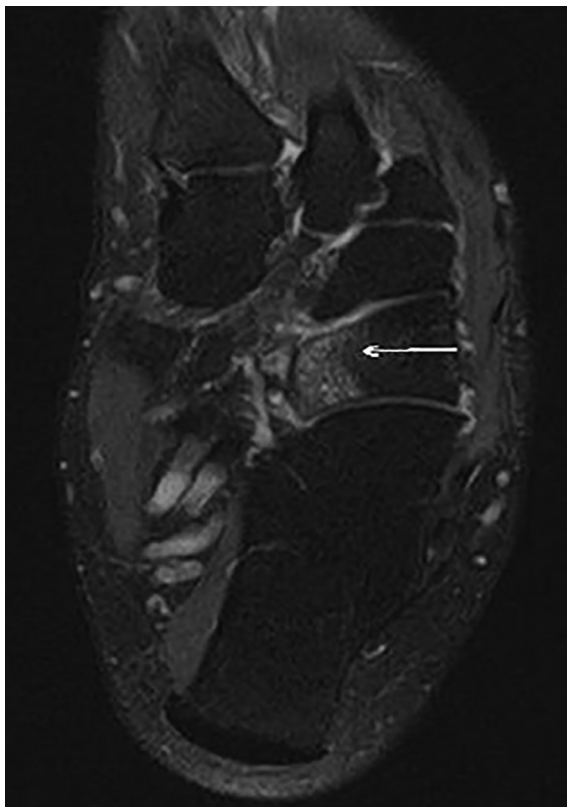

Fig. 5. Case 2. Left foot showing bone marrow edema of the cuboid.

Fig. 6. Case 2. Density change after calcium phosphate injection.

Postoperative Course

Postoperatively, the patient was requested to remain non-weightbearing on the left foot. At the 1-week follow-up visit, pain was rated 2/10 on VAS. Patient was advised to remain in CAM boot with weightbearing as tolerated. At the 2-week follow-up visit, pain was rated at 1/10 on VAS. Sutures were removed, and she was advised to transition out of the CAM boot and into a standard shoe with an elastic bandage wrap to control swelling. During her 1-month follow-up visit, the patient reported no pain and was fully transitioned into a supportive tennis shoe and resumed walking without pain in the foot. The patient returned to the clinic for a final surgical follow-up visit at approximately 3 months after subchondroplasty. Foot radiographs were taken and indicated no further concern for cuboidal injury. The patient reported no pain with palpation over the cuboid and 0/10 on VAS when distance walking in tennis shoes. A follow-up MRI scan was not indicated with her absence of pain at the final visit. Patient is approximately 3 years from subchondroplasty with no reported or documented issues or concerns.

Discussion

Early-stage avascular necrosis or stress fractures of the foot typically require a long course of non- or partial-weightbearing. If standard treatments fail, there are few adjunct therapies available to facilitate adequate healing. In the case of Freiberg's disease, surgical options are often invasive and require osteotomies or, in severe cases, arthroplasty. In the setting of a stress fracture, surgical options are limited because screws or plates are not indicated without cortical disruption. A possible option in both of these cases may be the use of subchondroplasty.

The injected substance used in the presented cases is a United States Food and Drug Administration regulated and approved injectable bone substitute consisting of calcium phosphate. The product quickly hardens and provides a macroporous scaffold thought to provide secondary stability and, over time, is absorbed and replaced with autogenous bony ingrowth.

There have been very few reports of subchondroplasty available in the literature, with most involving orthopedic surgeries of the knee. The substance used in the presented cases has been reportedly used by orthopedic surgeons for femoral and tibial plateau injuries with chronic BME. Bonadio et al (9) reported significant improvements in 5 patients undergoing subchondroplasty of the medial femoral condyle and medial tibial plateau. Cohen and Sharkey (10) described injectable bone substitute use in 66 patients as being promising for pain treatment related to bone marrow lesions in the knee. They reported no significant complications at their 2-year follow-up mark, and noted a quick return to activity with postoperative management recommendations including 1 to 2 weeks of weightbearing as tolerated with crutches and use of physical therapy. Miller and Dunn (11) reported use of injectable bone substitute on 2 patients with chronic BME of the talus. In their study, patients were kept non-weightbearing for 6 weeks postoperatively before transitioning into a standard shoe. It was reported that patients had satisfactory results with the procedure. Of note, the 2 patient cases reported in this article were able to safely attain full weightbearing status earlier than 6 weeks because of their decreased loadbearing position. However, weightbearing status should be independently considered for each injury and patient.

In conclusion, with the time lengths associated with failed conservative treatments in the reported cases, injectable bone substitute was thought to be an appropriate treatment modality. It included a minimally invasive surgical procedure that allowed patients to return to activity while providing a supportive structure within the bone until stability could be achieved. Both patients reported a relatively quick cessation of pain and were able to return to preinjury activity by

3 months after surgical intervention. With limited literature available on this treatment modality, subchondroplasty should be considered a possible alternative approach in the field of foot and ankle surgery and further studied.

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