# Bone Marrow Aspirate Concentrate and Its Uses in the Foot and Ankle

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**KEYWORDS**

• BMAC • Regenerative medicine • Bone marrow aspirate • Tendon • Ligament • Joint • Foot • Ankle

**KEY POINTS**

- Improving patient outcomes and returning them to their preinjury state is of utmost importance for all foot and ankle surgeons.
- The use of bone marrow aspirate concentrate (BMAC) for augmentation in bone, soft tissue, and chondral repair shows promising results.
- There is a great need for high-level research to further analyze the positive efficacy BMAC on improved outcomes in healing pathologic conditions in the foot and ankle.
- There is little argument that harvesting bone marrow aspirate in the lower extremity is safe and cost-effective with no major complications reported.

## INTRODUCTION

Foot and ankle surgeons diagnose and treat a plethora of ailments that can be addressed both conservatively and surgically. Many times, patients wish to avoid the operating room at all costs, whereas others must undergo a surgical procedure to ensure the best prognosis. Because the health care system in the United States continues to evolve and quality measures are driving reimbursement, improving patient outcomes are what every foot and ankle surgeon strives to accomplish. Numerous orthobiologics have been advocated in the orthopedic literature as an adjunct to routine healing to increase the success of a particular treatment regimen. Bone marrow aspirate concentrate (BMAC) has gained popularity, particularly in the foot and ankle subspecialty arena, as an augmentation to healing in and out of the operating room. Unfortunately, patients are often compromised with multiple comorbidities, including diabetes, smoking, compromised immunity, and avascular

The authors have nothing to disclose.
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Clin Podiatr Med Surg ■ (2017) ■–■
http://dx.doi.org/10.1016/j.cpm.2017.08.006 **podiatric.theclinics.com**

necrosis, which may make healing difficult. BMAC use has been widespread and particularly positive results have been seen in bone and soft-tissue healing.[1–5]

BMAC has been used for the adjunctive treatment of numerous pathologic conditions in orthopedics.[6] Viable cells are found in aspiration from many different anatomic regions of the body.[7] Concentration of these cells has been shown to improve healing due to the increased number of certain important cells.[8] There is known benefit from autologous bone marrow concentrate. It has been shown that there is wide variety of live cells, including endothelial progenitor cells, mesenchymal stem cells (MSCs), hematopoietic stem cells (HSCs), and other progenitor cells. There are also many growth factors, including platelet-derived growth factor, bone morphogenic protein, transforming growth factor-B, vascular endothelial growth factor, interleukin (IL)-8, and IL-1 receptor antagonist.[9–14] Bone marrow is the primary site of MSCs, which are multipotent and aid in soft tissue and bone healing.[15–18] MSCs have the innate ability to differentiate into cell types based on the environment. These cellular transitions include fibroblasts, chondrocytes, osteoblasts, and myogenic cells.

The safety of harvesting BMAC has been reported on.[19,20] A complication rate of 0% to 12% has been documented in the harvesting of BMAC in the lower extremity. Bone marrow aspiration from the calcaneus can be performed with ease (**Fig. 1**). Roukis and colleagues[21] performed a multicenter, retrospective, observational cohort study looking at 530 subjects. All subjects underwent harvest of bone marrow aspiration from various sites in the lower extremity. All procedures were determined to be successful with no infection, nerve injury, wound healing, or iatrogenic fractures.

Theoretic evidence of the utility of BMAC to aid in healing has been reported. The authors reviewed the orthopedic and foot and ankle literature to review the uses of BMAC in healing common foot and ankle conditions.

## MECHANISM

Recently, there has been a spike in interest in the use of BMAC in the foot and ankle literature. This is because it is a cost-effective way to deliver a conglomerate of stem cells and growth factors to a particular area. Much of the focus on the benefit of BMAC in foot and ankle surgery is on the potential for MSCs to differentiate into different tissue derived from mesenchymal cells. Numerous tissues have been found to contain MSCs, including bone, adipose tissue, synovium, and blood.[22,23] A multitude of

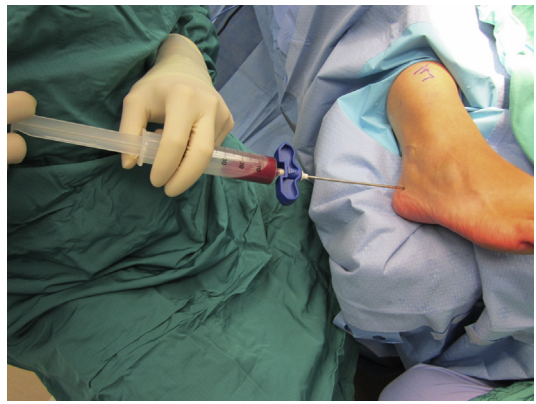

**Fig. 1.** Intraoperative harvesting of bone marrow aspirate from the calcaneus.