Bone marrow augmentation of a first metatarsal opening wedge osteotomy to correct hallux valgus

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My disclosure is in the Final AOFAS Mobile App.

I have a potential conflict with this presentation due to:
Sheldon S. Lin - AOFAS Board Member and Associate Editor of Foot & Ankle International
Introduction - What is hallux valgus?

• Most common pathology affecting the great toe, occurring in 2-4% of the population.\textsuperscript{1}

• Onset occurs over time as metatarsal head drifts medially from the sesamoid apparatus, causing laxity in the supporting tendons and thickening of the medial eminence at the proximal phalanx.\textsuperscript{2}

• Progression of deformity is associated with family history, improper footwear, and anatomical metatarsal variants.\textsuperscript{2,3}
Introduction - First metatarsal opening wedge osteotomy

• An effective treatment for correction of hallux valgus deformity.

• More than 10% of patients experience failure of fusion and recurrent deformity following surgery.\(^4\)

• Poor clinical outcomes in part due to delayed osseous healing. By enhancing local osteogenic growth, we may improve functional outcomes.
Bone marrow aspirate concentrate (BMAC) is bone marrow that contains mesenchymal stem cells capable of differentiating and proliferating into connective tissue such as bone, ligaments, tendon, and cartilage.\(^5\)\(^-\)\(^7\)

Animal studies have shown that bone marrow promotes quicker and stronger healing in a grafted segmented defect model with regards to mechanical strength and callus volume.\(^8\),\(^9\)

Often incorporated with bone grafts (BG) to promote local healing.

Use in humans does not require approval by the US Food and Drug Administration (FDA). Previous clinical data is therefore limited.
Methods

Two Groups:
1. **BG+BMAC Group** - patients received 3 cc bone marrow concentrate in addition to the standard local bone graft of medial eminence
2. **BG Group** - patients received standard local bone graft of medial eminence alone

• Retrospectively evaluated seventeen patients with moderate to severe hallux valgus from March 2008 to June 2013.

• Surgeries were performed by a single orthopaedic surgeon specializing in foot and ankle surgery. All patients underwent a proximal first metatarsal opening wedge osteotomy using a low profile wedge plate and screw system and distal bunionectomy.
Methods (cont.)

• Autologous bone harvested from the medial eminence was inserted into the osteotomy site in all seventeen patients.

• For the group also receiving BMAC, sixty cc of bone marrow was harvested from the proximal tibia and concentrated down to 3 cc to be injected into the osteotomy site after placement of graft and closure of skin.

• Postoperatively, patients were evaluated by standard radiographic technique every 2-4 weeks. Union was defined as complete bone bridging across the defect as assessed by two blinded independent observers.

• Nonunion was defined as no evidence of progression towards healing or stagnation after 90 days following surgery.
Results

- 5 patients in the BG+BMAC group (mean age, 57.1; range, 49.6 to 67.1) received the additional BMAC, while 12 patients in the BG group (mean age, 53.7; range, 20.1 to 75.8) did not.

**BG+BMAC group**
- Radiographic union was achieved at a mean time of 50.5 days (range, 40 to 61) following surgery. Three out of five patients in the BG+BMAC group were considered a nonunion at last follow-up (minimum of 120 days), one of which required further corrective surgery.

**BG Group**
- Union in the BG group was achieved at a mean time of 59.1 days (range, 26 to 108). One patient out of 12 in the BG group failed to achieve union.
Clinical Example: Patient LF

48 years old. Female. Right hallux valgus deformity. BG+BMAC Group: Received 3 cc of autologous BMAC in addition to local bone graft of medial eminence.

Pre-operative AP radiograph  
6 weeks post operative  
26 weeks post operative

NO COMPLETE UNION EVIDENT!!
Clinical Example: Patient JH

42 years old. Female. Left hallux valgus deformity. BG Group: Standard local bone graft of medial eminence only. No BMAC received.

Pre-operative AP radiograph

2 weeks post operative

4 weeks post operative

SUCCESSFUL UNION
Conclusion

• Frequency of nonunion was higher in the BG+BMAC group that had bone marrow concentrate added to the local bone graft. We cannot draw any definitive conclusions due to the small sample size.

• There was no significant difference in time to union between the two cohorts. The use of BMAC was discontinued at the surgeon’s discretion as it appeared that the BMAC did not provide any additional benefits to promote union.
Potential downfall of BMAC

• Bone marrow concentrate contains immune cells in addition to stem cells.

• At high concentrations, immune cells may inhibit local bone growth. The expression of γ/δ T cells and their associated cytokines (IFNγ and IL-6) in response to injury or hazardous environments is detrimental to bone healing. Compared with control animals, γ/δ T cell-deficient animals show overall improved biomechanical strength and stability.\(^\text{10}\)

• Vangsness et al. found that intra-articular injection of BMAC to the knee following partial medial meniscectomy increased meniscus regeneration at a low dose but had no effect at a high dose.\(^\text{11}\)

• Additional research is necessary to determine if there is a dose-dependent effect of BMAC.
References

7. Pittenger MF; Mackay AM; Beck SC; Jaiswal RK; Douglas R; Mosca JD et al. Multilineage potential of adult human mesenchymal stem cells. Science. 1999 Apr 2;284(5411):143-7.