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Bone Marrow Concentrate Enriched in Platelet Growth Factors Combined With De-mineralized Bone Matrix for Complex Revision and Complex Lower Limb Arthrodesis

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Abstract

Complex arthrodesis procedures in the lower limb present a challenging model for successful outcomes, especially in the face of multiple co-morbidities [1]. Not only is this patient population at risk for delayed union and nonunion, the potential for infection and delay in soft tissue healing is also of great concern [2]. Autolo-gous fusion solutions have been used for decades in bone repair procedures in the form of bone grafts (iliac or rib) or bone marrow (Figure 2) aspirate harvested from the marrow cavities with good results. Bone graft harvest comes with inherent challenges, often resulting in do-nor site morbidity [3]. Bone marrow aspirate (BMA) har-vested from the marrow cavities is a mixture of stromal and peripheral blood and has less inherent risk and still provides a potent osteogenic stimulus. Unfortunately, pure BMA has relatively few osteoprogenitor cells per volume and contains a high proportion of red blood cells that can interfere with bone healing [4] (Figure 1a). Recently, advances in the use of bedside devices have given physicians the option of an autologous concen-trate of therapeutic cells such as white blood cells and platelets as well as adult stem cells known to be instru-mental in osteogenesis, while removing the majority of the red cell fraction (Figure 1b). Additionally, platelet-rich plasma (PRP), which is produced from peripheral blood, contains concentrated growth factors that play a role in the proliferation and differentiation of adult stem cells and the enhancement of tissue healing [5,6]. Both human bone marrow derived mesenchymal stem cells (hMSCs) and platelets have been shown to possess antimicrobial characteristics [7,8].

Design

The aim of this retrospective case series is to report on the effectiveness of growth factor enriched cBMA combined with demineralized bone matrix (DBM) for adequate bone fusion rates and soft tissue healing in complex arthrodesis procedures.

Patients

This case series includes 42 patients, 28 males and 14 females with a mean age of 51 years. Co-morbidities include diabetes mellitus, obesity, abnormal bone met-abolic panel (BMP) being low vitamin D, calcium, zinc, and smoking (Figure 1).

Procedure

Complex Lower Limb Arthrodesis: 15 primary; 27revision.

Methods

Peripheral blood (30 ml) was drawn into an ACD-A primed 60 ml syringe prior to incision. After prepping and draping, 30 ml of bone marrow was aspirated using an 11 gauge, multi-port aspiration needle from the proximal tibia 4 cm distal from the tibial plateau at the center of the medial face of the tibia. This was

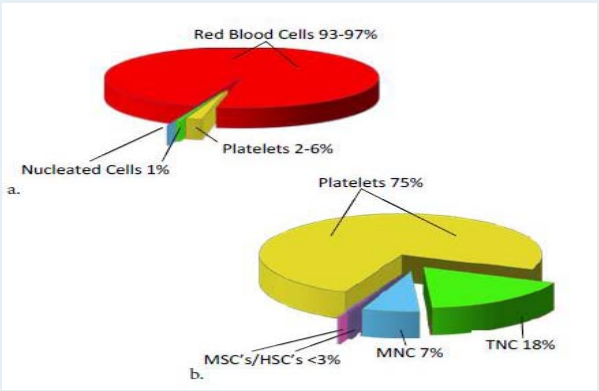

Figure 1: (a) Cellular content of bone marrow. (b) Cellular component of bone marrow with RBC fraction removed.

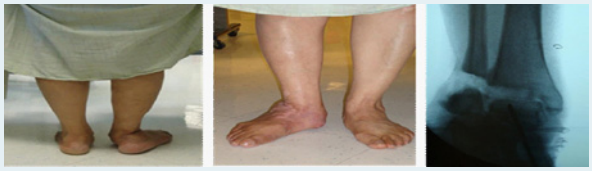

Figure 2: Example patient: 68 y/o with subtalar midtarsal joint malunion. Diabetic, morbidly obese with poor BMP. Two failed prior surgeries.

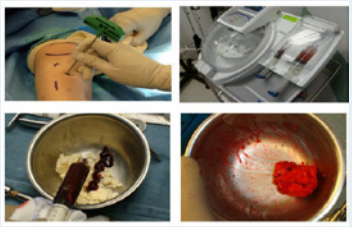

Figure 3: (a) Bone marrow aspiration from proximal tibia, (b) BMA processing in Magellan® System (c) addition of cBMA to DBM powder product (d) final implantable graft.

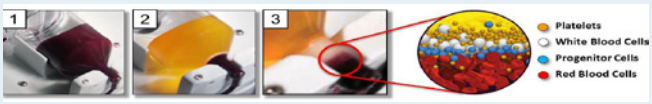

Figure 4: Representative still images of the centrifugation process on the Magellan® System (bottom); (1) Bone Marrow Aspirate in the chamber just prior to entering into the soft spin (2800 RPM), (2) beginning of hard spin (3800 RPM) following removal of pRBC fraction, and (3) formation of the buffy coat and identification of the cellular separation of at the end of the hard spin.

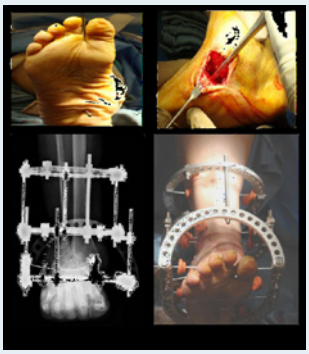

Figure 5: Placement of bone graft and external fixator.

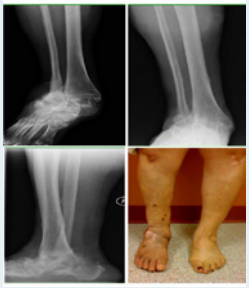

Figure 6: (a) Pre-op subtalar midtarsal join malunion (b) & (c) Con-firmed solid pantalar fusion at 27 weeks post-op. (d) Post-op.

done bilaterally for a total of 60 ml of BMA. The bone marrow was filtered, then processed in the Arteriocyte Magel-lan® system which enables the rapid bedside processing of a "closed-system" concentration of bone marrow aspirate and whole blood. (Arteriocyte Medical Systems, Inc., Hopkinton, MA). Figure 3a & 3b The Magellan® was programmed to deliver 3 ml of cBMA from 60 ml of processed bone marrow. The 30 ml of whole blood was then processed in the Magellan® to yield 3 ml of PRP, delivering a platelet concentration of 6-7X base-line, and was then added to the cBMA. The final 6 ml cBMA/PRP cocktail was mixed with a DBM graft and placed at the defect site (Figure 3c, 3d & 4). (Note: the volume of cBMA needed is dependent on the saturation instructions for the DBM being used.) All patients under-went the Ilizarov method of external fixation [9] (Figure 5).

Results

After 26 months of follow-up, 35 of the 42 patients (83%) obtained solid arthrodesis as confirmed by CT scan, were stable, without infection, and pain free. Average time to fusion in healed patients was 22 weeks. (Representative patient - Figure 6) Of the remaining seven patients, 3 were mobile with painful non-unions that were braceable and 4 were non-mobile with non-unions requiring additional surgery, but were pain free.

Summary

It is the opinion of the author that saturating DBM graft material with a bedside processed autologous cBMA has increased fusion rates and decreased potential complications in these complex arthrodesis procedures.

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