Autogenous and Allogenic Stem Cell Usage in Foot and Ankle Fusions

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Disclosure

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Our disclosures are in the Final AOFAS Program Book. There are no potential conflicts with this presentation.
Introduction

• Intimate details of pathways for fracture healing and bone fusion at forefront of research

• Achieving bone fusion is multifactorial:
  • Surgical technique/fixation
  • Patient physiology/co-morbidities
  • Effect of drugs and toxins (smoking)
  • Weight-bearing forces
Introduction

- Patient innate healing response or capacity cannot be underestimated.

- Many studies have demonstrated negative healing effects of\(^1-^6\):
  - Poorly controlled diabetes
  - Malnutrition
  - Vitamin D/calcium deficiency
  - Smoking
Mesenchymal Stem Cells (MSCs)

- Originate in many tissues, including fat and bone marrow
- Differentiate into osteoprogenitor cells
  - Contains the three entities that necessitate bone healing: osteoconduction, osteoinduction and osteogenic cells
- No recipient rejection; perfect compatibility

Negatives:
- Limited volume available
- Harvest site morbidity (particularly from crest)
Exogenous Grafts

• May be able to attain autograft equivalency when osteogenic cells and inductive proteins are combined

• May be preferable over autograft due to:
  • Harvest site morbidity
  • Inadequate volume/quantity
  • Increased costs via increased procedure codes and operating time
  • Treatment of complications from harvest site including fracture, hemorrhage, pain, nerve or arterial injury, or cosmetic disturbance\textsuperscript{8-11}
Indications and Contraindications

Treatment algorithm calls for BMA supplementation for all foot and ankle fusions deemed ‘at risk’ for nonunion:

- **Patient specific**
  - Tobacco history
  - Obesity
  - Diabetes
  - Immunosuppressed
  - History of prior nonunion

- **Surgery specific**
  - Fusion of tarsometatarsal, naviculocuneiform, subtalar, talonavicular or ankle joints
Allograft & BMA

- Two commercial off-the-shelf allografts available:
  - Osteocel-Plus® (NuVasive, San Diego, CA)
  - Trinity Evolution® (Orthofix, Lewisville, TX)
- Both offer an osteoconductive, osteoinductive, and osteogenic option reported to supply MSCs in a concentrated dose.
Technique

- BMA harvest performed prior to tourniquet inflation
- 12-gauge Jamshidi needle inserted into lateral wall of calcaneus or medial distal tibia using a reported technique\(^\text{15}\)
- 5-20 mL aspirate is withdrawn
- Reorienting the needle for every 2-5 mL of aspirate is recommended to enhance the quality\(^\text{16}\)
- Senior authors’ method is to soak the allograft in BMA prior to implantation
- The BMA can be spun in a centrifuge to concentrate the osteoblastic potential of the aspirate, or used as a straight aspirate

Bone marrow aspirate harvest is performed using an aspirate needle inserted into the lateral wall of the calcaneus
Complications

• BMA harvest for use in lower extremity has been demonstrated to be safe and minimally invasive\(^\text{17}\)

• Multicenter, multi-surgeon retrospective study
  • 548 patients in 5 anatomic locations:
    • Proximal and distal medial tibial metaphysis
    • Medial malleolus
    • Medial and lateral calcaneus
Discussion

• Study by Hernigou et al.\textsuperscript{18}
  • 60 noninfected atrophic tibial nonunions
  • 20 ML of concentrated BMA aided in healing 53 of 60
  • 7 failures had significantly fewer osteoprogenitor cells
  • Positive correlation between number of fibroblast colony-forming units and volume of mineralized callus at 4 months
  • Negative correlation between time needed to obtain union and concentration of fibroblast colony-forming units injected
Discussion

- Study by Connolly et al.\textsuperscript{19}
  - BMA injected directly into 20 tibial nonunions
  - 18 of 20 healed at an average of 6 months
- Healy showed clinical effectiveness when treating nonunions with BMA in cancer patients\textsuperscript{20}
- Hernigou and Connolly studies show that BMA can be useful in tibial nonunions and appears to be dose-dependent with a minimal number of cells present to show effects
Discussion

- No level 1 studies of BMA and/or MSC products to augment bone fusion currently exist.
- Benefits are based on educated theory combined with limited clinical usage and lower levels of evidence studies.
- Utilization of these products does not guarantee fusion.
- MSCs do not replace proper surgical technique but offer potential enhancement of the technique success.

Nonunion STJ

Revision STJ fusion with stem cell allograft and BMA
References

THANK YOU