Ankle Arthrodesis Basics
- Fusion of the Tibia, Talus, and Calcaneus
- Needed when severe ankle degeneration or traumatic injury has occurred
- Use of an Intramedullary (IM) nail
- The IM nail provides compression & stability to promote fusion of the joint

Patient-Specific Model Creation
- ScanIP software segments CT image to computer model
- Model consists of ~750,000 individual elements
- Bone density will convert into mechanical properties of bone
Can simulate performance of IM nails in same patient model
- CT of Ankle
- Combined Model
- CAD Model of Nail

IM Nails Studied
- Titanium Nail
  - Modeled after 12 mm VersaNail (Zimmer Biomet)
  - Assigned TiAlV properties

Pseudoelastic Nail
- Modeled after 12 mm DynaNail (MedShape)
- Nickel Titanium (NiTi) rod modeled and experimentally validated with previous study
- Assigned CFRP properties

Titanium & CRFP nails showed near identical performance with only 17-22% of force going through the bone

Research Questions
1. How does material influence load sharing during gait?
2. How does IM Nail material maintain compression during resorption?

Model Properties
- Assume linear elastic properties
- Linear thermal behavior
- Contact properties between nail & bone
- Fatigue crack propagation behavior

Material Properties
- Titanium = 110 GPa
- CFRP = 75 GPa
- NiTi Custom UMAT

Titanium, CRFP, and Pseudoelastic nail material were modeled and simulated with the DynaNail to assess their compression during resorption.

Titanium
- Maintained compression during simulated resorption
- CFPR & Titanium showed near identical performance with 78 and 83% of the GRF going through the nails, respectively.

Pseudoelastic Nail
- Maintained compression during simulated resorption
- CFPR material does not dramatically alter load sharing compared to titanium nails, with 78 and 83% of the GRF going through the nails, respectively.
- The pseudoelastic nail showed 67% of force going through bone

Force through nail and bone (tibia) were monitored for two gait cycles

Both titanium and CFRP nails lost over 80% of their compression in < 0.1 mm of resorption

The pseudoelastic nail showed 67% of force going through bone

Conclusions
- CFRP material does not dramatically alter load sharing compared to titanium nails, with 78 and 83% of the GRF going through the nails, respectively.
- The pseudoelastic nail shares 67% of the GF with bone.
- Both CFRP and Titanium nails lost over 80% of initial compression w/ resorption (< 0.1mm)
- The Pseudoelastic nail maintained compression with simulated resorption