Mechanical Behavior of Additively Manufactured Open-Porous Scaffold Structures for Bone Tissue Engineering

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Introduction
- Critical-sized bone defects represent a significant challenge in the orthopedic field.
- Limitations on autograft and allograft as repair techniques led researchers to explore the implantation of artificial bone tissue scaffolds.

Research Hypothesis
- The main hypothesis in this research is stress shielding being the main cause of bone resorption (loss) that leads to eventual failures of bone implants.
- The goal is to design a scaffold structure that is osteoconductive, biocompatible with elastic modulus that matches the structural modulus of cortical bone (15 GPa) to minimize stress shielding.

Research Methodology
- Scaffold structure is designed using numerical optimization tool through finite element analysis.
- Cell size (c) and strut diameter of the diagonal unit cell are optimized to achieve elastic modulus of 15 GPa while fixing the poor size (a) to 800 microns to enable cell ingrowth.

Results
- SEM imaging showed minimal variations in cell and strut sizes.
- SS316L powder particles have been well sintered as minimal porosity was found in struts.

Conclusion
- Literature show application of bone scaffolds in clinical field have great ability to facilitate bone tissue regeneration and repair.
- Numerical optimization using FEA is a powerful tool for generating optimized scaffold designs.
- Additive manufacturing enables the fabrication of scaffolds with accurate and controlled mechanical properties.
- Tested scaffold showed to exhibit the stiffness of cortical bone and the behavior of cancellous bone which mimics the bone behavior under loading.

Bibliography

Future Work
- Explore other unit cell shapes and fabricate scaffolds with multiple unit cells.
- Evaluate other mechanical properties such as bending, torsion and fatigue.
- Conduct non-linear FEA to study the stress distribution of a scaffold implanted in a femur bone.
- Develop a bone growth model to evaluate the osteointegration properties of scaffolds with various porosities.