# Computational Investigation of Material Selection and Interface Layer Height within Multi-layered Ostochondral Scaffolds

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**Statement of Purpose:** Osteochondral defects are common in all age groups due to trauma or pathology, and they result in more than 200,000 surgical procedures a year.[1] While autografts and allografts have been used to treat critical osteochondral defects with some success, there is no perfect clinical remedy to treat critical injuries to the osteochondral unit to date. Articular cartilage experiences increased shear upon degeneration and diminished lubrication under function.[2] While autografts and allografts have been implanted with some success, delamination of grafts has compromised the outcome of the defect site repair on numerous occasions.[3] As the integration between the osteal and chondral layers of a scaffold has been shown to be a critical aspect for treatment success, tissue engineers have explored various fabrication strategies to improve the interfacial shear strength within engineered osteochondral scaffolds.[3] In this work, we attempt to elucidate the factors involved in fabricating a multi-layered osteochondral scaffold with enhanced load-bearing properties. We generated a computational model of a multi-layered osteochondral scaffold under load-bearing forces and evaluated the effect of material selection and interface height.

**Materials and Methods:** To determine the effect of load-bearing forces within the interface scaffolds, a 3D stationary solid mechanics models was developed using COMSOL Multiphysics Version 5.6 (COMSOL, Burlington, MA). The geometry of the scaffold model was generated as a set of two simple rectangular prisms on top of one another with 18 extensions each that allow for a mechanically interlocked interface layer (FIG. 1A). Two custom materials per scaffold (Poisson's ratio $\nu$, density $\rho$, and modulus $E$ based on the scaffold composition) were generated and applied to their respective domains in the model. The COMSOL model simulated the effect of lateral shear and compression during articulation under physiological conditions.[2] Linear elastic material behavior was assumed across the entire domain. The bottom surface boundaries were set as fixed constraints, while a horizontal stress of 0.1 MPa and a vertical stress of 3.0 MPa were applied to the top surface boundaries of the model. The results were used to map the first and third principal stresses (P1 and P3), von Mises stress, and displacement experienced within the scaffolds

**Results and Discussion:** Simulations demonstrated that both the material selection and interface height influence the scaffold deformation within the multi-layered interface scaffolds (FIG. 1B). Our future efforts will be directed towards fabricating scaffolds with a mechanically robust interface via a combination of SLA printing of the bone layer and subsequent casting of the cartilage layer. These

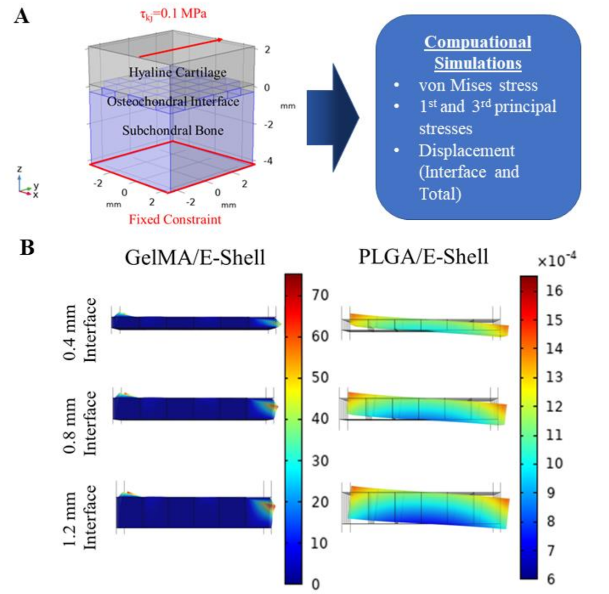


**Figure 1**. Solid mechanics model of osteochondral interface scaffolds. (**A**) COMSOL model of the 0.4 mm interface scaffold design with hard material (E-Shell 300) replicating bone in blue and soft material (GelMA, PEGDA, or PLGA) in grey. Shearing stress of 0.1 MPa was applied to the face perpendicular to the z-axis in the positive y direction. (**B**) Diplacement within the interface layer of GelMA/E-Shell and PLGA/E-Shell scaffolds possessing different heights at the interface.

constructs will be tested to evaluate their mechanical properties.

**Conclusions:** This project seeks to utilize the insights gained from computational modeling to develop a fabrication strategy that can improve the bond between the bone and cartilage layers of an osteochondral scaffold. The long-term goal of this work is to improve the clinical outcomes of patients receiving tissue engineered osteochondral scaffolds for large defect site repair. Future studies will focus on the development of a tri-phasic osteochondral scaffold using this fabrication strategy.

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**References:**

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