Characterization of Ink for 3D Printing of Bone Scaffolds

Arielle Pfeil[1], Ashley Armstrong[2], Amy Jaye Wagoner Johnson[3]

Research Sponsors: Shell, Illinois Scholars in Undergraduate Research Program, National Science Foundation: Civil, Mechanical, and Manufacturing Innovation (NSF CMMI Grant No 1727381)

1. Undergraduate Scholar, Department of Mechanical Science and Engineering
2. Graduate Mentor, Department of Mechanical Science and Engineering
3. Faculty Sponsor, Department of Mechanical Science and Engineering

Bone grafting procedures replace damaged tissue in the human body with healthy bone tissue from other sources, including from elsewhere in the body (autografts) and from donors (allografts). Standard bone repair can be challenging due to risk of infection, biological rejection, shortage of donor supply, and wound complications. 3D printing of bone scaffolds provides synthetic material for implantation in place of standard bone grafting procedures.

Research in bone scaffolds lies at a diverse intersection of biology, mechanical and materials engineering, and manufacturing. Here, custom biocompatible ink composed of hydroxyapatite is deposited via extrusion-based 3D printing. In order to achieve optimal scaffolds, the hydroxyapatite ink must have specific material properties for structural integrity and *in vivo* biocompatibility. Deviations from ideal conditions can result in ink which does not retain desirable geometry. Difficulties with ink extrusion may also arise due to high viscosity or inhomogeneous ink. To formulate optimal ink, systematic studies of particle size and phase composition of the powders used in the ink, dicalcium phosphate ($CaHPO_4$) and calcium carbonate ($CaCO_3$), must be performed. Improvements to manufacturing methods such as ball milling and calcining produce more favorable ink rheology in shorter process time and at a lower cost. Our investigation has determined powder manufacturing sequences to produce printable ink with consistent powder particle size and phase composition. Characterization of ink produced by outdated protocols is expected to reduce processing times by nearly 50%. This ink will be used to fabricate advanced curvilinear bone scaffolds to investigate the optimization of bone growth.