Abstract: Imitating Human Soft Tissue with Dual-Daterial 3D Printing

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Currently, it is common practice to use three-dimensional (3D) printers not only for rapid prototyping in the industry, but also in the medical area to create medical applications for training inexperienced surgeons. In a clinical training simulator for minimally invasive bone drilling to fix hand fractures with Kirschner-wires (K-wires), a 3D printed hand phantom must not only be geometrically but also haptically correct. Due to a limited view during an operation, surgeons need to perfectly localize underlying risk structures only by feeling of specific bony protrusions of the human hand.

The goal of this experiment is to imitate human soft tissue with its haptic and elasticity for a realistic hand phantom fabrication, using only a dual-material 3D printer and support-material-filled metamaterial between skin and bone. We present our workflow to generate lattice structures between hard bone and soft skin with iterative cube edge (CE) or cube face (CF) unit cells. Cuboid and finger shaped sample prints with and without inner hard bone in different lattice thickness are constructed and 3D printed.

The most elastic available rubber-like material is too firm to imitate soft tissue. By reducing the amount of rubber in the inner volume through support material (SUP), objects become significantly softer. This was confirmed by an expert surgeon evaluation. Subjects adjudged 3D printed finger samples in CF design as realistic compared to the haptic of human tissue with a good palpable bone structure. Blowy SUP is trapped within a lattice structure to soften rubber-like 3D print material, which makes it possible to reproduce a realistic replica of human hand soft tissue [1].

References

1. Maier J, Weiherer M, Huber M, et al. Imitating human suft tissue on basis of a dual-material 3D print using a support-filled metamaterial to provide bimanual haptic for a hand surgery training system. Quant Imaging Med Surg. 2018;in press.