Novel 3-D Printed Digit Osseointegration Prosthetic Designs Based on Fox Hound Metacarpal and Proximal Phalanx Measurements

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Background

- Digital amputation is the most common upper extremity amputation in the world.
- This can cause significant impairment in hand function, as well as psychosocial stigma.
- Currently, the gold standard for the reconstruction of digit amputations involves revision amputations, autologous reconstruction, or socket-based prosthetics.
- However, if autologous options are not feasible, we believe that an osseo-integrated prosthetic reconstruction could provide a functionally and aesthetically superior alternative.

*Osseo-Integration (OI)* is the method by which a titanium implant is directly embedded into the bone shaft and allowed to heal. A titanium abutment is positioned at the distal end of the implant and a skin aperture is fashioned around the abutment for external attachment.

**Research Objectives**

- Since there are limited to no practical (OI) finger prosthetics in wide scale use, the goal of this project was to create a novel digit OI implant using measurements of a fox hound’s metacarpal and proximal phalanges.
- We hypothesize that the fox hound would be a suitable animal model given the metacarpal and proximal phalanx lengths which are similar to humans.

**Methods**

- 3 amputated cadaveric fox hound paws were obtained for dissection. The metatarsals and proximal phalanges were dissected. Each bone was then sectioned.
- 16 measurements were taken for each cross-sectional piece to determine mean length of the bone piece, cortical bone thickness, and intramedullary space dimensions.
- These measurements were then used to design and 3D print various implant prototypes.

**Results**

- 3 metatarsal bones were sectioned into 14 separate 3 mm pieces. The mean bone length, cortical thickness, and intramedullary width for the 3 metatarsals was 74.1 mm +/- 0.67 mm, 1.80 mm +/- 0.47 mm, and 3.34 mm +/- 0.77 mm respectively.
- 3 proximal phalanges were sectioned into 6 separate 3 mm pieces. The mean bone length, cortical thickness, and intramedullary width for the 3 proximal phalanges was 35.2 mm +/- 0.42 mm, 2.01 mm +/- 0.47 mm, and 2.60 mm +/- 0.91 mm respectively.

**Limitations**

- The use of an American fox hound as an animal model may prove to be difficult given its active nature in the post-operative period which may affect secondary stability of the implant and infection risk.
- Although digit OI is rare, prior OI designs are already in use in Europe which potentially limits our ability for patenting in the future.
- Use of an already established European OI design would limit our ability to change any aspects of the implant for implant optimization.

**Conclusions**

- The OI method is gaining traction as a feasible technique to treat large extremity amputations, although there are limited examples of digit OI.
- Given that there is a large population that could benefit from such a simple yet elegant potential design, we believe that these novel designs ideas may be the stepping stone to create a functional experimental implant.

References: