Novel 3-D Printed Digit Osseo-integration 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.

Fig 1. X-ray of Human Hand (Right), Fox Hound paw (Left)

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 3-D print various implant prototypes.

Table 1. Paw Measurements of American Fox Hounds

	Mean Bone Length (mm)	Cortical Thickness (mm)	Intramedullary Space (mm)
Proximal Phalanx (3)	35.2 +/- 0.42	2.01 +/- 0.38	2.60 +/- 0.91
Metatarsal (3)	74.1 +/- 0.67	1.80 +/- 0.47	3.34 +/- 0.77

Figure 2. 3-D Printed Digit OI Prototypes

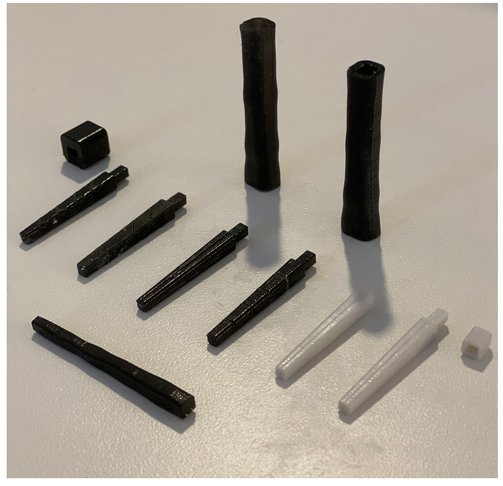

Fig 2. 6 OI Digit OI prototypes (Center), 3-D representation of intramedullary space (Bottom Left), 3-D Phalanx representation for fit testing (Top Right)

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 +/- SD 0.67 mm, 1.80 mm +/- SD 0.47 mm, and 3.34 mm +/- SD 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 +/- SD 0.42 mm, 2.01 mm +/- SD 0.38 mm, and 2.60 mm +/- SD 0.91 mm respectively.

Fig 3. 3 mm bone sections (Center), Metatarsal/Proximal Phalanx coronal section)

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 amputees, 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.

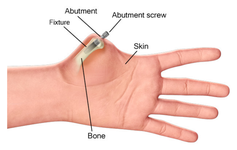

Fig 4. Example of OI thumb implant

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