CUNNINGHAM CLUBFOOT BRACE

SCHOOL OF SCIENCE, ENGINEERING, AND HEALTH SYMPOSIUM 2017

Rebekah Forshey, Vy Ho, Paul Stoltzfus

Introduction

Figure 1: Clubfoot versus Normal foot

Clubfoot is a type of foot abnormality usually present at birth in which the baby's foot is twisted out of shape/position because the tendons are shorter than usual. This type of foot defect is fairly common (Mayo Clinic).

The current treatment for this condition is the Ponseti casting method of 5 different casting phases followed by a maintenance phase to keep the foot in the correct position.

Figure 2: Ponseti Method

Figure 3: A child using the Boots-and-Bar

The current method for maintenance is the Boots-and-Bar method. This method has several disadvantages including a very long treatment period (4 to 6 years), limitation of the child's mobility which prevents muscle strengthening, and discomfort. It has a success rate of about 75%. The Cunningham Maintenance Brace is a design that replaces this method and reports a high success rate (90%). The goal of our project is to improve the manufacturing process by exploring the possibilities of 3D printing and redesigning to improve production efficiency and simplicity.

Cunningham Maintenance Brace

Components:

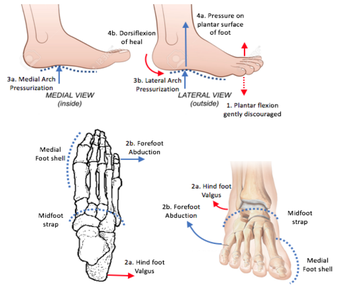
- Polypropylene components: thigh cuff, descending spiral, and foot hinge
- Velcro and Velcro strapping
- Foam padding
- Machine screws
- Spring steel

Figure 4: Cunningham Maintenance Brace

Strengths:

- Promote comfort
- Allow mobility and muscle growth
- Shorten the treatment time by two thirds of the Boots-and-Bar method
- Capable of correcting each foot independently

Figure 5: Anatomical placement of the forces by the maintenance brace



Testing

1.Physical Testing

Axial forces do not show a clear correlation with rotational angles.

Rotational forces display a strong linear relation with the angle of brace rotation. Therefore, the new 3D printable materials and design can then be compared with the current brace using this developed slope.

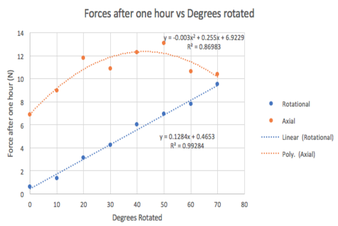
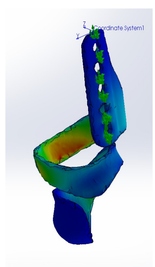
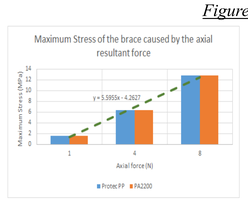


Figure 6: Axial and Rotational forces after one hour of rotation for varied rotation





2. Finite Element Analysis

The maximum amount of stress after the force was applied is on the first curve from the thigh. However, the amount of stress is still lower than the yield strength of the brace for polypropylene and a testing material (PA2200). Therefore, the brace will not be plastically deformed after usage.

Manufacturing Processes

Figure 8: Jerald Cunningham cutting out polypropylene brace

Current method

The entire process will take around 5-6 hours to produce 1 brace → labor intensive, significant material waste, and requires expert skill and/or training.

3D printing

3D printing currently takes over 20 hours, but does not require a person to be present the entire time → cuts down on material waste, helps standardize the dimensions, and minimizes necessary training for production.

Figure 9: Prototype prints for clubfoot brace

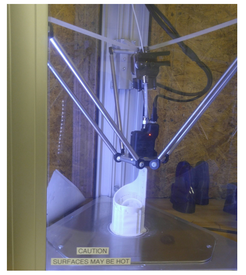


Figure 10: 3D Print with polypropylene using Delta Wasp

Conclusion

In the efforts to replicate the Cunningham Clubfoot brace via 3D-printing and in seeking to provide a quality clubfoot brace alternative to CURE International, we have already made significant progress in manufacturing research as well as characterization of the biomechanics. We believe that as we gather additional data and conduct additional analysis, testing, and research, we will be able to create a brace design that replicates Cunningham's current design while being compatible with the priorities of CURE International (in-country manufacturing, minimization of parts, and validation of efficacy).

Future directions

- Kenya trip to learn about the material availability and needs
- Retrospective study of clients who have utilized the Cunningham brace
- Exploration of different manufacturing processes and research on hygiene of the brace

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