BSBME SENIOR CAPSTONE PROJECT

Patient-tailored orthotics treating asymmetrical brachiocephali and scoliosis and patient-tailored lower limb prosthetics treating above and below knee amputations and hip distarticulations

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**ABSTRACT**

There are many children suffering from neurodegenerative diseases and traumatic injuries, which then lead to issues in the legs and feet that then require orthotic corrective or preventative assistance. These diseases include but are not limited to brachiosephali, scoliosis, spinibifida, multiple sclerosis, lyme disease, connective tissue disorder, cerebal palsy, trisomy 12. In addition to diseases, strokes, trauma and anything leading to a loss of oxygen in the brain cause issues often in the leg and foot area, requiring orthotic treatment. Orthotics are often thought to be preventative, but due to the fact that I will be working in pediatric orthotics, these braces can also be corrective. Orthotics that have to ability to decrease the negative effects of these diseases and can significantly increase quality of life for these children and decrease the negative future possibilities if their diseases are left untreated. Orthotics are a non-invasive, non-surgical, topical means of gradually treating the problems that result from these diseases/trauma. Current treatments involve physical therapy, chiropracters, and along with other methods. The long term goal for this project is to develop orthotics that treat the patient, i.e. reshape the head in the case of brachiosephali or lessen the planter-flex of an ankle of a patient suffering from spinibifida. The proposed study will create several different types of orthotics: helmets or AFOs that significantly decrease the effects of the given disease. I plan to test the success of my devices by utilizing the normal measurement ranges dictated by the charts attached at the end of this paper as well as durability of materials, and comfort of orthotic.

Currently there are 1.25 million amputees living in the United States, with 135,000 new amputations performed every year1. This has created a large need for prosthetics. Today there are varying levels of function, comfort and aesthetics in prosthetics, correlating to price and availability. The simplest consist of a rubber or metal hand/arm that merely satisfies an aesthetic need for anatomical normalcy while other more complex options involve running blades and electrical joints. Currently, the market includes low to medium function lower limb prosthetics when fitting patients. In this paper, we will discuss the numerous options for patients in the field of prosthetics in relation to non-functional replacements, mechanically controlled and bionic lower limb replacements, touch on the drawbacks of each method and speculate on how to improve and advance current technology. Unfortunately, while there has been significant progress in relation to the complexity of these prostheses, there are downfalls such as the impracticality in translation of some current designs to out-of-lab products. I will give some possible solutions to the accessibility and cost-effective dilemmas. The impact of this work is immeasurable; we are bringing quality of life up exponentially, function of limbs and self-sufficiency to a populous who so desperately desires a strong, fully functioning body.

ELEMENTS OF ENGINEERING DESIGN

*What was designed:*

Patient-tailored orthotic helmets and lower limb prosthetics treating above/ below knee amputations and hip distarticulations

*The objectives are as follows:*

1. Achieve a tailored orthotic that will treat a patient suffering from brachiocephalic/scoliosis by specifically applying pressure to certain points on their spine/skull (specific to patient). We chose this objective –that a device could specifically apply pressure because clinical research has shown at a young age a child’s skull is very malleable and can be manipulated to the correct shape with constant pressure/alignment techniques.
2. Achieve values in the range of normal, symmetrical skull range after typically around 9-12 months depending on the patient and compliance using the orthotic. If this objective is not met, then we will return to objective 1. Often times, if there is too much room in the helmet, it’s too tight, it rubs in the wrong way, certain parts need to be shaved down, etc. it needs to be adjusted and refit.
3. Explore new polymer systems, including co-polymer and polyethylene. This is because each polymer offers its own pros and cons and I want to focus on finding the best fit for certain orthotics.
4. Achieve a tailored prosthetic that will treat a patient post amputation/congenital limb loss by creating a socket that is comfortable, does not cause soft tissue damage and can handle body weight applied.
5. Achieve a hip/knee/ankle prosthetic that allows a normal gate, prevents whip, is durable, water proof, and serves as a functioning replacement of the limb lost.
6. Explore new materials used in the creation of the prosthetics such as different carbon fibers. Certain materials are common place but we want to focus on new innovative materials to decrease weight of the socket, increase durability, make it more cost effective.

*Basic science, math and/or engineering sciences applied:*

Force balancing to reshape the skull and enable regular patient gaot, materials science to construct the orthotics and prosthetics of the correct material (i.e. durable but not stiff such as copolymer), anatomy (in order to be able to diagnose the patient properly and be able to treat specific diseases) and lastly CAD was utilized to visualize the head shape after scanning it in to base the helmet off of.

*How objectives were tested:*

Bi-weekly assessments of the patient’s skull with measurement checks in relation to the plagio/brachicephali charts. If the measurements of certain cross-sections of the skull begin to decrease and become more symmetrical, the helmet is successful in treating these diseases.

*Constraints considered:*

Cost, comfort, durability, weight of orthotic and prosthetic, design/aesthetic of product.

*Alternative solutions considered:*

Different materials were looked into such as moleskin or foam for the inside of helmet, doc bands (less bulky but need to be cast), torticollis collar (very invasive). For the prosthetics, different types of carbon fiber, foam and resin were researched. Different styles of lower limb prosthetic design were tested.

*The extent to which the final result met the set objectives:*

The results were very positive, asymmetry in the skull was decreased greatly by our helmet and measurements went into the normal ranges according to brachycephali charts. The prosthetics designed produced little to no irritation, provided stability and normal gait and encapsulated soft tissue with little to no discomfort.

DESGIN FLOW CHART

Orthotic Design:

Prosthetic Design:

INTRODUCTION

Brachycephali- shortened front-to-back diameter of the skull

Plagiocephali- flattening of one side of the head, resulting in asymmetry and sometimes bulging of the forehead on the flat side of the skull.

These are very common diseases in infants, quantified as about 1 in 5 babies.2

Works Cited

1. James, Roshan, and Cato T. Laurencin. “Regenerative Engineering and Bionic Limbs.” *Rare Metals*, vol. 34, no. 3, 2015, pp. 143–155., doi:10.1007/s12598-015-0446-0.
2. Parsons, F. G. “The Brachycephalic Skull.” *The Journal of the Royal Anthropological Institute of Great Britain and Ireland*, vol. 54, 1924, p. 166., doi:10.2307/2843666.