Thesis Project Portfolio

Finite Element Analysis of Icarus Knee Brace Under Tensile Stress to Investigate Structural Integrity

How do Social Disparities Affect Individuals with Prosthetics and Implants

An Undergraduate Thesis

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Executive Summary

Exploring the intricate mechanics of orthotic durability and the societal challenges in accessing prosthetic care, my thesis merges technical expertise with awareness of real-world implications. My technical research consists of performing finite element analysis and utilizing Autodesk software on an over-the-shelf orthotic device. This is to assess the Icarus Medical brace's durability, particularly whether integrating extension stops contributes to greater mechanical failure when the brace is subjected to medial-lateral patellar loads. My STS research paper tackles how socioeconomic factors play a part in people's ability to receive the prosthetic and implant care they need. This is to shed light on the potential lack of accessibility for individuals who may not be able to receive proper treatment for their ailments. Both my technical report and STS report involve investigating prosthetics/orthotics. In my technical report, I am looking into how a company's design change can affect the amount of load their knee brace can absorb. My STS report then investigates how socioeconomic status affects the accessibility and use of similar devices, encompassing a prosthetic and implant framework.

Patellofemoral knee osteoarthritis is a degenerative condition characterized by the erosion of articular cartilage along the trochlear groove and beneath the patella, resulting in inflammation and discomfort. This deterioration causes the cartilage to become rough, potentially exposing the underlying bone and causing pain during movement. Non-invasive treatment modalities include physical therapy, weight management, cold therapy, taping, bracing, and orthotic use. My capstone project focuses on evaluating the durability of braces, specifically investigating whether incorporating extension stops leads to increased mechanical failure when exposed to medial-lateral patellar loads.

The safety factor analysis results indicate that all three scenarios display similar potential areas of failure, particularly within the hole of the brace's hinge. There was also a greater surface area exhibiting a decreased safety factor in the "OTS Orthotic w/o Extension Stops" scenario. However, a noted decrease in maximum stress coupled with the greater surface area of high safety factors suggests that incorporating extension stops may enhance the brace's ability to absorb peak reaction forces exerted by the patellofemoral joint. There was a challenge in converting the brace's mesh for use in fatigue element analysis software. This limitation hindered the ability to develop a predictive model for long-term brace usage based on the structural differences observed in the three investigated scenarios. The findings contribute valuable data on the durability of off-the-shelf knee braces, which could inform future studies on their efficacy.

The social aspect of my research focuses on how economic factors impact access to implants and prosthetics across different socioeconomic groups, potentially affecting future generations and prompting discussions about regulatory measures. As advancements in medical technology increase, so do the costs of these aids, creating disparities that primarily affect lower-income individuals. The life-changing potential of these devices contrasts with the financial burdens they can impose, with estimates ranging from hundreds of thousands to over a million dollars in lifetime costs depending on the age of implantation and the rate of maintenance repairs. This trend of rising costs underscores the urgency of addressing healthcare inequalities to prevent

widening wealth gaps. Methodologically, my approach Integrates literature reviews and case studies. I analyze the complex interplay between socioeconomic factors and access to care, recognizing these technologies not just as medical tools but as embedded within social contexts. By emphasizing empathy and ethical considerations, I aim to uncover nuanced insights into the challenges faced by different socioeconomic groups, contributing to more compassionate and equitable healthcare practices.

The research highlights significant disparities in access to and outcomes of prosthetic and dental implant care, particularly influenced by socioeconomic status and insurance coverage. In the developing world, only a small fraction of amputees have access to prosthetic care, emphasizing the urgent need for robust systems to bridge this gap. Challenges in delivering prosthetic devices in developing regions stem from funding limitations, as recipients often lack the financial means to afford these aids. Financial constraints and lack of insurance coverage also impact access to dental implants and orthopedic procedures, leading to delayed interventions and poorer outcomes among disadvantaged groups. These disparities extend beyond immediate postoperative care, highlighting systemic issues in healthcare access and quality. Collaborative efforts among stakeholders, policymakers, and healthcare providers are crucial to establishing sustainable solutions and ensuring equitable access to quality care across diverse populations. By addressing socioeconomic and insurance-related barriers, healthcare systems can work towards achieving more inclusive and effective implant care for all individuals.