Development of a Custom 3D Printed Plantarflexion Stop for Foot Drop

(Technical Report)

A Patient Centered Approach to Orthotic Design: An Actor-Network Theory Perspective

(STS Research Paper)

An Undergraduate Thesis Portfolio

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

This thesis portfolio connects two projects: a technical Capstone Project focused on the iterative design of an innovative ankle-foot orthosis (AFO) with dorsiflexion assist and plantarflexion stops for individuals with foot drop, and an STS Research Paper examining the sociotechnical networks influencing orthotic device development through Actor-Network Theory (ANT). Both projects center around improving the quality of life for patients facing mobility challenges, but approach the issue from differing perspectives. The Capstone Project directly addresses a tangible clinical need through engineering innovation, enhancing patient mobility and independence through user-centered design principles. In contrast, the STS paper investigates the broader network of social, technical, and institutional actors that shape the design, adoption, and efficacy of orthotic devices. By integrating the technical insights from practical device creation with the sociotechnical insights from ANT analysis, the portfolio offers a broader understanding of the barriers and facilitators to successful orthotic innovation. This approach illustrates the importance of accounting for sociocultural contexts in the development and implementation of engineering solutions aimed at improving patient quality of life.

Capstone Project Summary

The Capstone Project develops a novel adjustable ankle-foot orthosis (AFO) featuring an integrated plantarflexion stop mechanism to enhance user comfort, adjustability, and functional mobility for patients with foot drop. The addition of a plantarflexion stop was the main deliverable of the project, and was made to offer patients increased stability and adjustability options in their brace. Current orthotic solutions generally suffer from either insufficient support or excessive rigidity, causing discomfort and reduced compliance among users. To address these issues, 3D modeling techniques were employed in Autodesk Fusion 360 and iterative

prototyping with feedback from the Icarus Medical Innovations team. The final prototype incorporated the existing adjustable quick-release button mechanism enabling precise control of dorsiflexion assistance and the additional plantarflexion stop to restrict the angle of the ankle during the swing phase of gait, allowing customization to individual user needs. Yield strength testing and torque measurements demonstrated improved stability, establishing the groundwork for future patient testing on usability compared to existing commercial products. By placing user needs at the core of the design process, this project successfully delivered a socially acceptable, economically viable, and clinically effective orthotic solution.

STS Research Paper Summary

The STS Research Paper analyzes the sociotechnical relationships influencing the design and implementation of AFOs. ANT provided a framework for mapping the interactions between human and non-human actors, including patients, clinicians, device manufacturers, insurance policies, and orthotic technologies, that collectively shape orthotic device design. Documentary research and discourse analysis revealed that user experience and clinical efficacy are heavily influenced by economic constraints, insurance reimbursement policies, social stigma associated with visible disabilities, and technological accessibility. The study identifies key actor-networks that have the ability to either facilitate and hinder the adoption of innovative AFO technologies. By examining these sociotechnical networks, the paper suggests strategies for more inclusive and patient-centered orthotic design practices that have the potential to lead to enhanced acceptance, reduced stigma, and improved patient outcomes.

Concluding Reflection

Simultaneously undertaking the technical Capstone Project and the STS Research Paper provided insights that would not have emerged from either project individually. Integrating the sociotechnical perspective of the STS research into the engineering design process highlighted critical human factors, such as patient preferences and the economic realities of insurance coverage, that influenced design decisions. Conversely, the practical constraints encountered during the Capstone Project emphasized the importance of considering sociotechnical networks early in the design phase. By involving local prosthetists, patient needs were incorporated in the beginning stages of the project streamlining the design process. This dual approach supported the creation of unique designs that are technically sound, socially acceptable, and economically feasible. Additionally, this integrated experience reinforced skills in interdisciplinary collaboration, critical analysis, and user-centered design, preparing me to contribute in real-world healthcare contexts.