Clinical Impact of a Tunable Ankle Foot Orthosis on Hemiparetic Gait in Stroke: A Case Study

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INTRODUCTION
Clinicians have increasingly recognized the importance of optimizing mechanical characteristics of orthoses specific to each patient’s needs. Research has demonstrated that the optimization of AFO stiffness and alignment can impact the clinical outcome in the treatment of some neuromuscular conditions including stroke (Jagadamma, 2010; Kobayashi, 2015; Singer, 2014). This case study presents the clinical approach and outcome of the orthotic treatment of a chronic stroke subject using a novel ankle joint that facilitates the independent adjustment of various mechanical characteristics.

METHOD

**Subject:** The subject is a 76 year old male, 16 years post stroke presenting with left hemiparesis. There is profound involvement of the upper extremity, hypertonicity and spastic co-contraction of the left ankle and knee. The subject has a 5° knee flexion contracture, and his dorsiflexion range of motion is limited to -5° with the knee extended. The subject’s gait pattern is equinovarus with a pathologic extensor synergy. Gait deviations include foot drop, circumduction, forefoot first contact, limited tibial progression, and shortened contralateral step length.

**Apparatus:** A custom composite AFO was fabricated using Triple Action™ ankle joints and intrinsic support to resist equinovarus. The orthotic ankle joints allow for independent adjustment of ankle alignment, plantarflexion resistance, and dorsiflexion resistance. A Vicon motion capture system was used for data collection with the subject walking on a level treadmill at self-selected speed.

**Procedures:** The subject’s clinical presentation was fully qualified by manual muscle testing, range of motion, observational gait analysis, and other functional measures. The subject was fit with the AFO using customary orthotic practice. The AFO was kinematically optimized in the clinical setting using a standard adjustment procedure that defines specific events to be observed during gait. Ankle joint settings and postural support of the AFO were changed systematically during motion capture to determine the kinematic effects of each adjustable feature.

**Data Analysis:** Mean joint angle graphs over the entire gait cycle were generated to compare the effects of incrementally adjusting each setting.

RESULTS
Observational gait analysis, supported by kinematic data, revealed systematic changes in biomechanical variables with AFO mechanical characteristics. Lateral supramalleolar support was effective resisting varus at the ankle. The ankle alignment setting had arguably the greatest effect of all the controlled variables. While the alignment had a more measureable impact at the ankle, an indirect influence of the knee was also observed. In addition to closed chain effects during stance phase, ankle alignment also influenced knee flexion angle during terminal swing. This may have been due to biomechanical coupling secondary to the subject’s shortened gastrocnemius. The increase toward a dorsiflexed alignment coincided with a decrease in terminal swing knee extension.

The plantarflexion resistance was tuned to soften knee flexion during loading response as well as maintain clearance during swing. Also, when plantarflexion resistance was decreased, this allowed greater plantarflexion range of motion during preswing, and an increase in knee flexion during preswing and initial swing was observed. Overall the influence of the plantarflexion resistance was seen throughout gait, except during terminal stance, whereas the dorsiflexion resistance appeared to influence only terminal stance.

DISCUSSION
The purpose of this case study was to determine if a tunable ankle foot orthosis could be an effective means of orthotic treatment for a chronic stroke subject exhibiting lower extremity gait deficits secondary to weakness and spasticity. Each of the adjusted mechanical characteristics of the AFO impacted the subject’s gait in a particular way that was useful for optimizing his gait. By isolating these adjustments, the effects of each variable were observed more clearly during observational gait analysis. The ability to tune the custom AFO specific to this subject’s needs proved beneficial in improving his functional outcome.

CONCLUSION
The tunable AFO was effective in influencing lower extremity kinematics for this particular chronic stroke subject. Overall his clinical outcome was enhanced due to the ability of the orthosis to be optimized to compensate for his biomechanical deficits.

CLINICAL APPLICATIONS
This case study has demonstrated the importance of tuning custom AFOs specific to each patient. Understanding the effects of varying different mechanical properties of AFOs and having the ability to independently adjust these properties can improve patient outcomes.

REFERENCES
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