ACCURATE ANKLE FOOT ORTHOTICS THROUGH ADDITIVE MANUFACTURING

Luiza Muraru[1,2] , Veerle Creylman[1,2] , Louis Peeraer [1,3]

[1] *MOBILAB, Thomas More University College, Geel, Belgium*

[2] *Biomechanics Section, KU Leuven, Leuven, Belgium*

[3] *Faculty of Kinesiology and Rehabilitation Sciences, KU Leuven, Leuven, Belgium*

Introduction

Ankle foot orthoses (AFO) are prescribed for orthotic management of patients with different gait abnormalities. AFO rigidity is one of the most important mechanical characteristics that determines the function of the orthotic aid. Depending on patients' pathology and anatomy, rigidity is adjusted by customizing several AFO design parameters: wall thickness, trim-line parameters, neutral angle, material, etc. Nowadays this process is performed manually which can introduce undesired manufacturing variability in the quality and/or effectiveness of hand-made orthoses. Additive manufacturing (in particular selective laser sintering – SLS) has proved to be a feasible [Telfer, 2012] and clinically effective [Creylman, 2012] alternative engineering technique for manufacturing of orthotic appliances.

The objective of this study was to quantify the effect of several design parameters on SLS manufactured AFO rigidity and to find a relationship between patients specific parameters and AFO function.

Methods

For this study a CAD model of a leaf spring type AFO was designed for a healthy person based on anatomical landmark points identified on the leg scan of the patient. Further, the initial design was altered by changing two main parameters: the overall shell thickness and the ankle clearance (defined as the distance from the malleoli to the AFO rim and controlled by malleoli radius). These parameters were assigned ranges of values between a minimum and a maximum limit.

Material properties of SLS-Nylon 12 were implemented in the numerical model and a static load that induces bending equivalent to dorsiflexion was applied. AFO rigidity was expressed as rotational stiffness (N*mm/°) or as overall AFO deflection (mm).

Results and discussion

The effect of wall thickness and ankle clearance on AFO rigidity is depicted in the graphs from Fig. 1. These relationships allow accurate and optimal determination of AFO parameters for predetermined AFO rigidity which should be optimal for patient treatment.

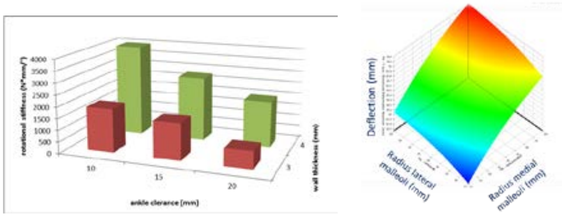

Figure 1: the effect of ankle clearance and wall thickness on AFO rotational stiffness (left); the relationship between malleoli radius and overall AFO deflection (right).

Further, a relationship between patient parameters (expressed as applied flexion moment) and AFO function (expressed as flexion angle) could be simulated by applying different loading regimes that mimic patient activity (Fig. 2).

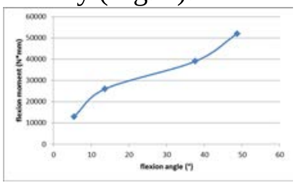

Figure 2: flexion moment vs. flexion angle for specified design parameters (thickness = 3mm; ankle clearance = 10).

Well-defined AFO designs can be defined based on relations described above. Once established, the model file can be transferred to the additive manufacturing machine for immediate printing. This workflow guarantees fabrication of customised orthotics with accurate and predetermined characteristics.

References

Telfer *et al*, BMC Musculoskeletal Disorders 13-84, 2012.

Creylman *et al*, Prosthet Orthot Int, 2012.

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