Finite Element Analysis of Ankle Foot Orthoses

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INTRODUCTION
Nowadays Ankle Foot Orthoses (AFOs) are commonly used in clinical practice to normalize the gait of for example stroke patients with a drop foot. The flexibility of the AFO depends mainly on its design, material used, the location of the trim line, the thickness. The goal of this project is to investigate the influence of these parameters on the flexibility of the AFO and on the stress distribution in the AFO by the use of Finite Element Analysis (FEA).

METHODS
A patient-specific polypropylene AFO was designed for a healthy test subject (female, 24). The inner surface of the AFO was scanned to develop an STL-mesh of the AFO, to be imported into MSC Marc. The thickness of the model is set as an element-parameter. Changes were made to the STL-model to investigate the influence of the trim line-location on the stiffness of the orthosis and stress distribution in the orthosis. The influence of the AFO-thickness was investigated by adapting the element parameters.

To determine the boundary conditions for the model, the test subject walked with the AFO while measuring the pressure distribution between [1]
- AFO and the foot and calf
- AFO and the shoe.

An insole-measurement system of RsScan International was used.

To evaluate the FEA-models a test rig measuring the flexibility of the orthosis was developed. The results of the FEA-model were compared with the results of the test rig. A gait analysis of the test person with the different AFOs was performed as well.

RESULTS
The main stress occurred at the lower part of the calf shell of the AFO (the neck region) (figure 1). This is in accordance with practical experience.[2].

In the FEA-model a negative correlation was found between the flexibility of the orthosis, i.e. the flexion-angle, and the radius of the trim line as well as the wall thickness of the orthosis. These results also occurred in the test rig and the gait analysis.

The major goal of an AFO is to improve the gait of the patient, and therefore a certain amount of flexibility / stiffness is required. Other parameters than trim line and thickness need to be investigated to keep the flexibility / stiffness of the orthosis while improving the stress distribution to avoid breakdown.

CONCLUSION
The use of FEA-models of AFOs proves to be a valuable instrument to investigate the design options for an individually adapted AFO, and to investigate its flexibility and possible areas of breakdown. This study is a first step in the use of such models for a variety of pathological conditions of the ankle-foot complex.

REFERENCES

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