The effect of thickness variation on the rigidity of ankle foot orthoses: A case for the need for quality control

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Introduction

Rigid Ankle-foot orthoses (AFOs) are typically prescribed in cases where movement around the ankle needs to be fully restricted [1,2]. Traditional drape-forming is a widely used, cost-effective technique for producing custom rigid ankle-foot orthoses (AFOs). The process involves heating a polymer sheet and draping it over a positive cast of the user's limb. The manual nature of this method leads to a lack of uniformity in material thickness across the AFO and can result in structures that are inadequately rigid. Considering the critical role that thickness plays in determining AFO rigidity, this uncertainty regarding the thickness of the final structure can translate into substantial differences in mechanical behaviour with significant implications for AFO effectiveness.

Method

A clinically relevant method to measure AFO thickness as part of the manufacturing process was developed and validated. Three major UK orthotic manufacturers took part in this study, using the measurement method for all custom rigid AFOs they manufactured between March and April 2024. A validated finite element model was used to estimate the impact of the observed difference between prescribed and final thickness on AFO stiffness.

Aim

This study assesses the difference between the prescribed and the final thickness of AFOs and estimates its potential impact on AFO rigidity.

Results

86 AFOs were assessed in total. Copolymer polypropylene was the most commonly used material and 4.7 mm was the most commonly used material thickness. Final thickness was between 4.0% and 35.5% lower than the prescribed one (median thickness reduction= 17.4%). This discrepancy in thickness led to a relative reduction in AFO stiffness ranging between 7.0% and 80.0% (median stiffness reduction= 30.7%).

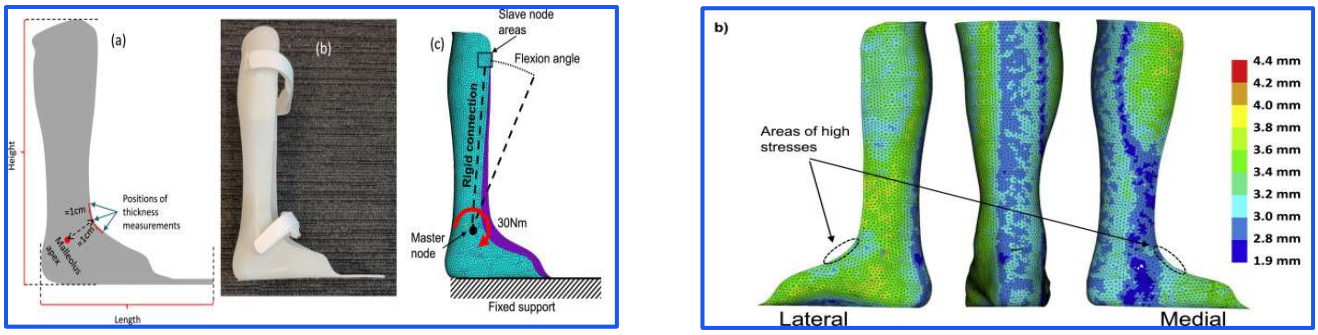

Fig. 1. (a) Schematic of the measurements of AFO dimensions and trimline thickness. (b) The bespoke AFO used in this study for the mapping of thickness distribution and (c) the produced FE model for the simulation of dorsiflexion. Fig 2. (b) A contour plot of thickness values across the surface of the AFO. Warmer colours correspond to greater thickness.

Discussion

The results presented here indicated that AFOs produced using the drape-forming tend to be thinner that the prescribed thickness. The median relative reduction in thickness was 17.4%, this reduction in thickness would lead to a structure that is 30.7% less stiff than the prescribed thickness. The adequacy of AFO thickness cannot be judged based on prescription thickness. Measurements of final thickness as part of standard practice should be considered to enhance the provision of bespoke AFOs. Further research is needed to establish thresholds of acceptable manufacturing-induced deviation from the prescribed AFO thickness.

References

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