

BIOMECHANICAL STUDY OF PRESSURE APPLIED ON THE LOWER LEG BY ELASTIC COMPRESSION BANDAGES

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Introduction

Compression bandages are a common treatment for some lymphatics or venous pathologies. The treatment success directly depends on the pressure which is applied on the external surface of the leg and which is then transmitted to the internal tissues. This interface pressure (between the limb and the bandage) depends mainly on the following parameters:

- the bandage components (padding layers, ...)
- their mechanical properties
- the bandage stretch
- the application technique (spiral, ...) and number of layers (overlap)
- patient's leg morphology
- other parameters such as friction between the different bandage layers.

Though the efficacy of this treatment is admitted [1], its action mechanism and the pressure it applies on the leg remain poorly understood [2].

For now, the reference method for the computation of interface pressure applied by compression bandage is Laplace's Law:

$$P = n T / r \quad (1)$$

with P the local pressure, n the number of layers of the bandage, T the bandage tension (i.e. force to stretch the bandage), r the local radius of curvature of the limb. However, this law, which only considers the non-deformed state of the limb, is unable to accurately predict interface pressures [3].

The aim of this communication is to present a combined experimental and numerical approach for the assessment of interface pressure applied by compression bandages.

Methods

Bandages used in this study are Biflex[®] 16 (B16) and Biflex[®] 17 (B17) (manufactured by Thuasne), which differ in their elastic moduli (respectively 0.232 and 0.444 N.mm⁻¹) but have a similar structure.

Measurements of interface pressure applied by 4 bandages (B16 and B17 applied in a spiral pattern with 2 or 3 layers (respectively 50% and 66% overlap)) were performed, thanks to pressure sensor Picopress[®] (Microlab Elettronica, Nicolò PD, Italy), on 30 healthy subjects. These bandages were applied on the leg with a 1.3 stretch (following the manufacturer's recommendations).

On the other hand, the subject-specific numerical simulation of the application of these 4 bandages was

built for 5 female subjects, using the software Abaqus[®]. The leg geometry was obtained with a 3D optical scanner (Artec 3D[®] scanner) and the bandage geometry was built in Matlab[®], in order to fulfil the 1.3 stretch requirement. Bandage model was inflated then relaxed around the subject's leg model. Interface pressure given by the simulation was then confronted to the experiments and to the one computed with Laplace's law.

Results

Interface pressure measurements showed a very strong correlation between the interface pressure and the bandage elastic moduli and number of layers ($p < 0.0001$). Moreover, pressure varied with subjects' morphology. Nevertheless, the tendencies observed in the experiments cannot be explained by Laplace's law, hence the need to develop a numerical simulation of bandage application.

Although the results from the simulation (Figure 1) differ from the experiments and Laplace's Law, it is the first model to consider the geometry changes due to bandage application.

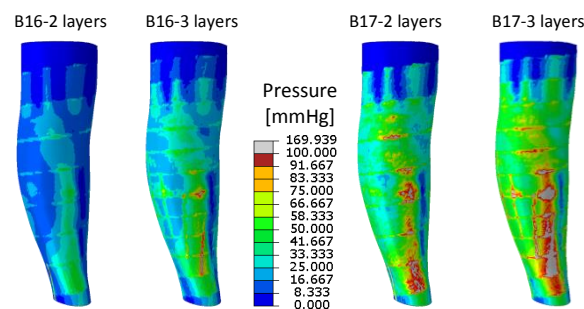


Figure 1: Pressure distribution over a leg for 4 different bandages

Discussion

Pressure measurements showed, once more, the limitations of Laplace's law in predicting pressure applied by compression bandages. This simulation is a first step toward a more complex model considering bandage-to-bandage interactions or patient-specific soft tissue mechanical properties.

References

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