

Development of a multi-layered polyurethane phantom model to mimic the thoracolumbar layers

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BACKGROUND Lumbopelvic pain is one of the most prevalent musculoskeletal disorders. Tissue stiffness measurement techniques can help in evaluation [1]. In order to compare the precision of these tools, there is a need of building a phantom mimicking the different layers of the thoracolumbar tissue. In the literature, phantoms made in polyvinyl alcohol, gelatin, agar, etc. have been made to imitate the stiffness of healthy and fibrotic tissue. However, there is a lack of phantoms that can represent layers of differing tissue. Thus, the purpose of this study was to develop and to define the characteristics of a phantom mimicking layered thoracolumbar tissues.

METHODS A phantom made of four individual layers has been developed to reproduce the four layers of the thoracolumbar tissue which are the cutis (epidermis and dermis), the subcutaneous connective tissue, the fascia profunda and the muscle (erector spinae). These layers (300 x 210 mm) were manufactured with polyurethane-based gel from Technogel[®]. The gel is homogeneous and shows memory foam behaviour, demonstrating viscoelastic properties. Each layer has a specific thickness [1-3] and stiffness [4-5], to mimic the real morphological and mechanical properties of the tissue. The choices of these characteristics were taken from a literature review. Mechanical, ultrasound, and elastography techniques were used to evaluate the stiffness of each layer.

RESULTS A thickness of 3 mm, 6 mm, 1 mm and 10 mm was chosen for the cutis, the subcutaneous connective tissue, the fascia profunda and the muscle, respectively (Figure 1A). Gel pads with several stiffness values were manufactured in the range from 38 to 118 kPa to take potential alterations of the tissue into account. Among the different tools ultrasound elastography shows no propagation of the wave due to the homogeneity of the gel while MR elastography was able to measure surface waves (Figure 1B).

CONCLUSION The multi-layered phantom could possibly be improved by adding diffusers inside the gel or by using other gel such as gelatin. This tissue-mimicking phantom for the thoracolumbar layers is a first step allowing the comparison of the performances of stiffness measurement apparatus in the context of evaluation of low back pain.

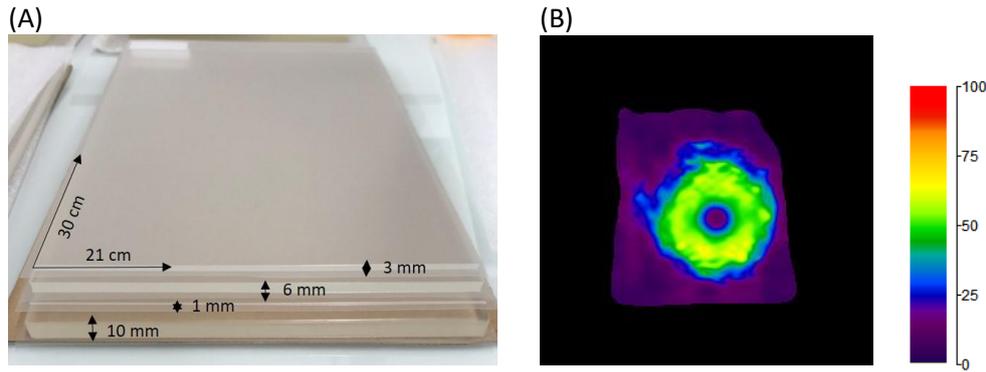


Figure 1. (A) Pads of the four polyurethane layers for the cutis, subcutaneous connective tissue, fascia profunda and muscle (erector spinae). (B) Cartography of stiffness in kPa obtained with magnetic resonance elastography technique on a phantom with a thickness of 10 mm.

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