IN VITRO EVALUATION OF INTERVERTEBRAL DISC ELASTIC MODULUS BY ELASTOGRAPHY

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Introduction

Simulation of the human spine mechanical behavior allows insights on several subjects of study, both in research and clinical application, but it needs information on the subject-dependent spine geometry and on the tissues mechanical properties. Thanks to recent technological and technical advances, the former can be easily and precisely obtained [Humbert, 2009]. *In vivo* personalization of the mechanical properties, however, remains a challenge; the intervertebral disc (IVD), in particular, plays an important role in the spine mechanics, especially in presence of scoliosis which is often accompanied by joint laxity [Binns, 1988].

This preliminary study aims to determine if intervertebral disc apparent elastic modulus can be measured by elastography, a relatively recent technique which has been applied to noninvasively assess several tissues, such as muscles, prostate, liver and breasts [Fink, 2010].

Methods

Six oxtails were prepared by isolating the first or second caudal segment (two vertebras and the IVD). Stereoradiographic images of each sample were acquired in order to measure the IVD thickness (L_0) and cross-section area (A_0) at rest. Each segment was tested in compression up to 400 N (20 N preload, 3 conditioning cycles, 0.5 mm/min displacement speed) while recording force (F) and displacement (ΔL) through the testing machine (Instron 5566, Instron, Massachusetts, USA) The slope of the stress (F/A_0) versus strain ($\Delta L/L_0$) curve was used to evaluate the elastic modulus of the IVD at 400 N. The sample was then compressed again to 400 N and the position was held. Ten elastographic images (Aixplorer, SuperSonic Imagine, France) of the IVD were acquired and averaged to determine the average shear wave speed. The whole protocol (mechanical test and elastography) was repeated 6 times. Correlations and repeatability were analysed with Spearman's rank correlation coefficient and Kruskal-Wallis one-way analysis of variance, respectively; significance was set at 0.01.

Results

Average IVD elastic modulus was 17.8 ± 3.9 MPa, while average shear wave speed was 5.1 ± 0.8 m/s. Elastographic measurements were repeatable ($p > 0.01$, Kruskal-Wallis test). Pooled data ($n = 36$) showed a significant correlation between IVD elastic modulus and shear wave speed (Spearman's rho = 0.62, $p < 0.01$, Figure 1). A tendency, although not significant, was also observed for average values (Figure 1).

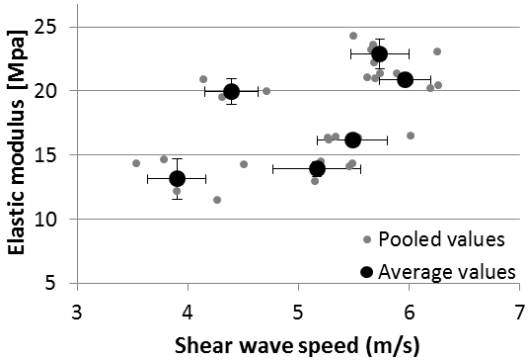

Figure 1: Intervertebral disc elastic modulus versus shear wave speed (pooled and average values).

Discussion

In this preliminary study, a correlation was observed between IVD elastic modulus and the shear wave speed measured by elastography; the poor correlation of average values probably depends on the low number of tested specimens. These results thus have to be confirmed on more specimens, but they are encouraging on the feasibility of non-invasive intervertebral disc mechanical assessment by elastography.

References

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