Effect of X-ray contrast-enhancing staining agents on the mechanical properties of blood vessels.

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Introduction

Imaging soft biological tissues, such as blood vessels, with X-ray microfocus computed tomography (microCT) is challenging. However, staining tissues with X-ray contrast-enhancing staining agents (CESAs) allows to enhance the X-ray attenuation of the tissue constituents (such as collagen, elastin, etc.) and to distinguish different constituents within the soft tissue. We refer to this as contrast-enhanced microCT (CECT). When CECT is combined with in-situ mechanical testing, i.e. 4D-CECT, microstructural changes of the tissue constituents can be assessed during mechanical loading, allowing to link microstructure with functional behavior. However, for this purpose, a CESA is needed that gives the best contrast properties for the tissue constituents, while preserving the tissue integrity and mechanical properties. Therefore, we investigated the effect of six different CESAs on the mechanical properties of porcine aorta tissue.

Materials & Methods

The effect of staining with different CESAs on the mechanical properties of porcine aorta has been investigated by performing uniaxial tensile tests. The tangent stiffness modulus of samples stained with 1:2 Hafnium-substituted Wells-Dawson polyoxometalate (Hf-WD), Monolacunary-WD polyoxometalate (Mono-WD) at two different concentrations (i.e. 35mg/ml and 70mg/ml), Phosphotungstic Acid (PTA), Sodium Polytungstate (SPT) and Lugol's iodine in Sorensen's buffer (Lugol) were compared with non-stained control samples [i.e. in PBS and post-harvest (PH)] at different staining times.

Results and conclusion

PTA significantly altered the mechanical properties of the aorta tissue (Fig. 1.a) for all three staining times (i.e. 3 days, 8 days and 17 days). Lugol was also significantly different from the PH group for a staining time of 8 days and 17 days. No other CESA affected the mechanical properties significantly; hence, Mono-WD, Hf-WD and SPT are suitable candidates for 4D CECT. Furthermore, the penetration rate and contrast-enhancing potential of the different CESAs is also investigated, as accurate visualization of the tissue microstructure is also required for 4D CECT.

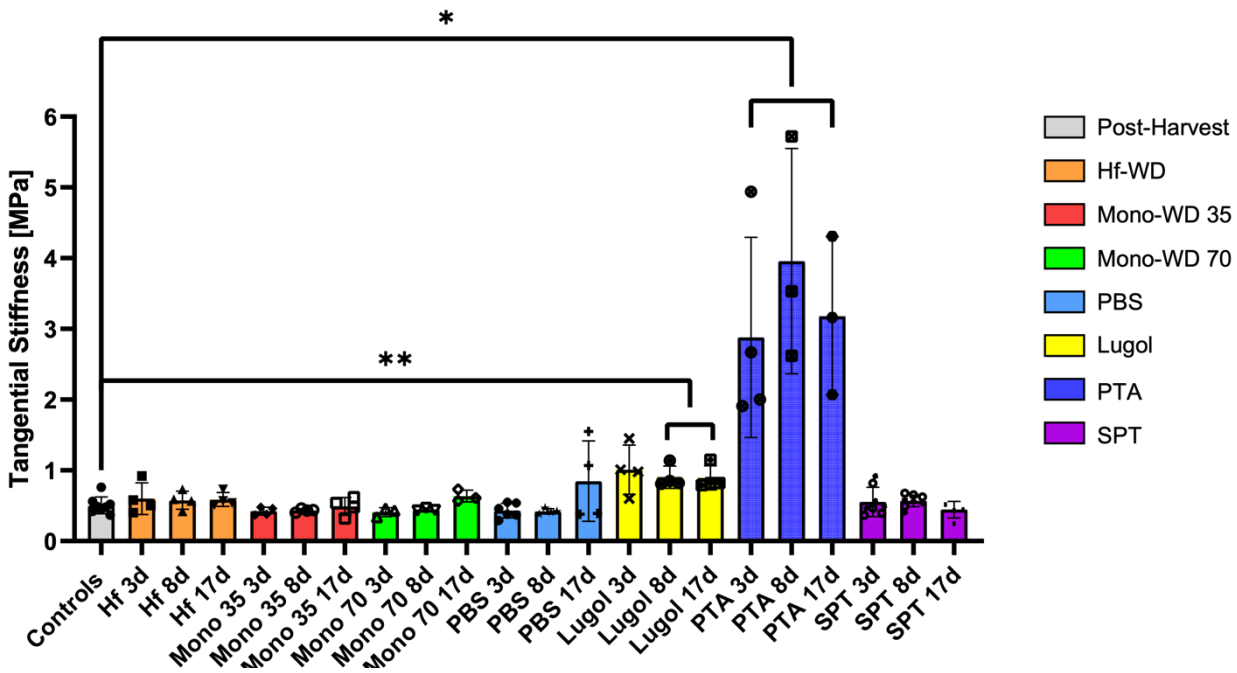

Figure 1: Tangent stiffness modulus from uniaxial tensile tests for the different conditions (6 CESAs & two Controls) in circumferential direction. n=4, except for the control PH group n=8. A Student Test was performed on the logarithmic values to obtain normality. The comparisons were made two by two between the Post-Harvest group and each of the CESA group. Then, the p-values, obtained for every comparison made, was multiplied by a correction factor (i.e. equal to the number of comparisons made - 1).