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PERSPECTIVES ABOUT FULL-FIELD 3D STRAIN MEASUREMENT IN SOFT TISSUES

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Abstract

Due to the complex anisotropic structure of many soft tissues and the nonlinearity of their mechanical response, strain gradients can vary significantly not only at the surface but also through the thickness of the tissue. In this context, a full-field 3D deformation measurement that can penetrate the tissue is required to unravel the non-uniformity. Digital volume correlation (DVC) goes beyond the surface information by using volumetric image data, e.g., 3D image volume consisting of several 2D cross-sectional images. In the current contribution, we highlight the potential of DVC in combination with optical coherence tomography (OCT) imaging to quantify three-dimensional local strains in different native or tissue-engineered soft tissues during uniaxial and biaxial testing and even to investigate fracture. One of the interesting results was to measure all the strain components during tensile loading of porcine aortas, enabling to assess their local volume changes with a spatial resolution of approximately 20 µm. Although global volume of the specimen is preserved, local variations were detected, indicated possible interstitial fluid motion inside the specimens during testing. To the best of our knowledge, this was the first time that such a manifestation of poroelastic effects in soft tissue could be quantified thanks to the OCT-DVC method [1]. We were also able to visualize and quantify the intramural strain distributions in the aortic wall under crack propagation [2]. Despite these achievements, low penetration (0.5 mm), time of image acquisition, and possible artefacts caused by local refractive index changes are still limitations of OCT that we are trying to overcome to popularize OCT-DVC for probing the microscale mechanical behaviour of soft tissues and hydrogels and open new perspectives for studying deformation mechanisms in soft matter.

Keywords:

Digital Volume Correlation Optical Coherence Tomography Soft Tissue Mechanics Three-Dimensional Strain Measurement Poroelastic Effects