Full-surface deformation measurement of anisotropic tissues under indentation

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Medical Engineering and Physics, Vol. 37, 484–493

doi: 10.1016/j.medengphy.2015.03.005.

Abstract

Inverse finite element-based analysis of soft biological tissues is an important tool to investigate their complex mechanical behavior and to develop physical models for medical simulations. Although there have recently been advances in dealing with the computational complexities of modeling biological materials, the collection of a sufficiently dense set of experimental data to properly capture their typically regionally varying properties still remains a critical issue. The aim of this work was to develop and test an optical system that combines 2D-Digital Image Correlation (DIC) and a novel Fringe Projection method with radial sensitivity (RFP) to test soft biological tissues under in vitro indentation. This system has the distinctive capability of using a single camera to retrieve the shape and 3D deformation of the whole upper surface of the indented sample without any blind measurement areas (with exception of the area under the indenter), with nominal depth and in-plane resolution of 0.05 mm and 0.004 mm, respectively. To test and illustrate the capabilities of the developed DIC/RFP system, the in vitro response to indentation of a homogeneous and isotropic latex foam is presented against the response of a slab of porcine ventricular myocardium, a highly in-homogeneous and anisotropic tissue. Our results illustrate the enhanced capabilities of the developed method to capture asymmetry in deformation with respect to standard indentation tests. This feature, together with the possibility of miniaturizing the system into a hand-held probe, makes this method potentially extendable to in vivo settings, alone or in combination with ultrasound measurements.