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IN-VIVO MEASUREMENT OF SOFT TISSUE 3D GEOMETRY AND SURFACE DEFORMATIONS

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Summary: The development of realistic biomechanical models of soft tissues requires careful characterisation of tissue mechanical properties. Most of the methods used to characterise human soft tissues in-vivo are based on measuring 2D or 3D surface deformations. However, soft tissues exhibit complicated biomechanical behaviours, which cannot be fully characterised using 2D imaging systems. To address this, stereoscopic systems have been developed to measure the surface 3D geometry and deformation of soft tissues. The accuracy of 3D measurements in such stereoscopic systems is a key factor in determining how well a computational model can describe the real behaviour of tissues. Thus, it is essential to employ accurate and robust algorithms to measure the surface geometry and deformation fields when comparing these with those predicted by computational models of tissues.

Multi-camera stereoscopic measurement of 3D surface geometry and deformations of soft tissues involves several steps, including: 1) measuring 2D deformations in each camera; 2) matching the corresponding points across the images of the multi-camera system; 3) calibration of the camera system; and 4) measuring 3D surface geometry and deformation by triangulation of the matched points. In this study, we developed a stereoscopic device that takes advantage of a set of recently developed accurate and robust image registration algorithms for each of the steps to measure surface 3D geometry and deformation. This device comprises four cameras that can acquire images of the field of view from four different locations.

The capabilities of our device to accurately track 3D surface deformations were evaluated using rubber membranes and a series of rigid body translation experiments. The device was used to identify and characterise the surface deformations that occur with uniaxial stretching of rubber dam. Using the measured 3D displacement data, the Green-Lagrange strains were calculated. The device was then used to measure 3D surface deformations and strains of post-mortem pig skin. The results illustrated that the algorithms were successfully able to track the 3D surface deformations of pig skin using only the intrinsic features of the tissue. The mean displacements calculated from the reconstructed test object were consistently within 0.01 mm of the applied shift.