Surface strain-field determination of tympanic membrane using 3D-digital holographic interferometry

Hernandez-Montes, Maria del S.; Mendoza Santoyo, Fernando; Munoz, Silvino; Perez, C; de la Torre, M; Flores, M; Alvarez, L.

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Abstract

In order to increase the understanding of soft tissues mechanical properties, 3D Digital Holographic Interferometry (3D-DHI) was used to quantify the strain-field on a cat tympanic membrane (TM) surface. The experiments were carried out applying a constant sound-stimuli pressure of 90 dB SPL (0.632 Pa) on the TM at 1.2 kHz. The technique allows the accurate acquisition of the micro-displacement data along the x, y and z directions, which is a must for a full characterization of the tissue mechanical behavior under load, and for the calculation of the strain-field in situ. The displacements repeatability in z direction shows a standard deviation of 0.062 μm at 95% confidence level. In order to realize the full 3D characterization correctly the contour of the TM surface was measured employing the optically non-contact two-illumination positions contouring method. The x, y and z displacements combined with the TM contour data allow the evaluation its strain-field by spatially differentiating the u(m,n), v(m,n), and w(m,n) deformation components. The accurate and correct determination of the TM strain-field leads to describing its elasticity, which is an important parameter needed to improve ear biomechanics studies, audition processes and TM mobility in both experimental measurements and theoretical analysis of ear functionality and its modeling.