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In vivo Mechanical Characterization of Facial Skin Combining Digital Image Correlation and Finite Element

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Abstract : Facial skin is a biomedical material with complex mechanical properties of anisotropy, viscoelasticity, and hyperelasticity. The mechanical properties of facial skin are crucial for a number of applications including facial plastic surgery, animation, dermatology, cosmetic industry, and impact biomechanics. Skin is a complex multi-layered material which can be broadly divided into three main layers, the epidermis, the dermis, and the hypodermis. Collagen fibers account for 75% of the dry weight of dermal tissue, and it is these fibers which are responsible for the mechanical properties of skin. Many research on the anisotropic mechanical properties are mainly concentrated on in vitro, but there is a great difference between in vivo and in vitro for mechanical properties of the skin. In this study, we presented a method to measure the mechanical properties of facial skin in vivo. Digital image correlation (DIC) and indentation tests were used to obtain the experiment data, including the deformation of facial surface and indentation force-displacement curve. Then, the experiment was simulated using a finite element (FE) model. Application of Computed Tomography (CT) and reconstruction techniques obtained the real tissue geometry. A three-dimensional FE model of facial skin, including a bi-layer system, was obtained. As the epidermis is relatively thin, the epidermis and dermis were regarded as one layer and below it was hypodermis in this study. The upper layer was modeled as a Gasser-Ogden-Holzapfel (GOH) model to describe hyperelastic and anisotropic behaviors of the dermis. The under layer was modeled as a linear elastic model. In conclusion, the material properties of two-layer were determined by minimizing the error between the FE data and experimental data.

Keywords : facial skin, indentation test, finite element, digital image correlation, computed tomography
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