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Evaluation of Residual Stresses in Human Face as a Function of Growth

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Abstract : Growth and remodeling of biological structures have gained lots of attention over the past decades. Determining the response of living tissues to mechanical loads is necessary for a wide range of developing fields such as prosthetics design or computerassisted surgical interventions. It is a well-known fact that biological structures are never stress-free, even when externally unloaded. The exact origin of these residual stresses is not clear, but theoretically, growth is one of the main sources. Extracting body organ’s shapes from medical imaging does not produce any information regarding the existing residual stresses in that organ. The simplest cause of such stresses is gravity since an organ grows under its influence from birth. Ignoring such residual stresses might cause erroneous results in numerical simulations. Accounting for residual stresses due to tissue growth can improve the accuracy of mechanical analysis results. This paper presents an original computational framework based on gradual growth to determine the residual stresses due to growth. To illustrate the method, we apply it to a finite element model of a healthy human face reconstructed from medical images. The distribution of residual stress in facial tissues is computed, which can overcome the effect of gravity and maintain tissues firmness. Our assumption is that tissue wrinkles caused by aging could be a consequence of decreasing residual stress and thus not counteracting gravity. Taking into account these stresses seems therefore extremely important in maxillofacial surgery. It would indeed help surgeons to estimate tissues changes after surgery.

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