Finite Element Analysis of Surface Strains in Fingertip Mechanics

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Abstract

This study combines numerical modeling and experiments, aiming to better understand tactile perception. Using finite element modeling (FEM), we investigate whether and how the biomechanics of subcutaneous tissue influences skin surface deformations under flat plate loading. Tactile sensation arises from subcutaneous mechanical sensors detecting strains in the skin. Although fingertip surface strains can be measured with high accuracy during normal and tangential loading (1,2), the monitoring of subsurface strains remains challenging. This limitation complicates the interpretation of surface strains in relation to tactile perception (3).
The finite element model of the fingertip incorporates a realistic heterogeneous resistance to deviatoric strains as a function of depth (4) and mechanical anisotropy of the subcutaneous tissues due to collagen (5). The model is compared to experimental data measuring 3-D surface deformation of a fingertip and an inflated rubber membrane under similar condition, enabling validation and identification of the key factors driving the development of skin surface strains.

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