New Insight in Skin Biomechanics Through Combined Approaches: Measurements and Numerical Simulations

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Abstract

Quantifying the mechanical properties of human skin is a challenging endeavour. Skin is a complex material, which varies according to age, body location, and physical health. In addition, it is in a state of tension, which also varies from person to person. There are many benefits to overcoming these challenges, including improved identification of skin pathologies, better design of artificial skin, and superior surgical incision methods to reduce scar formation. Better knowledge of skin properties also leads to improved design of personal care products that interface with skin, such as razors, sticky-plasters, and moisturisers.

Several combined numerical-experimental methods have been developed to characterise the mechanical properties of skin. Typically, deformations are applied to skin and parameters of an analytical or finite element model are varied until the model results match the experimental results. Experimental protocols have included applying uniaxial or biaxial tension, suction, torsion, and normal indentation. These methods have drawbacks because they only apply deformations in a limited number of in-plane directions (biaxial tension) or are unable to characterise the directional properties of skin (suction, torsion, normal indentation).

In this talk, I will discuss recent developments in characterizing the mechanical properties of human skin. I will detail a numerical-experimental protocol where a rich set of deformations are applied to the surface of in vivo skin and a finite element model is used to simulate the experiment. This method has been applied to estimate mechanical properties and in vivo tensions of different points of volunteers’ arms and faces. Results demonstrate the wide variation in skin properties and the importance of a patient-specific model to answer questions.

Underlying this numerical-experimental approach is the use of different constitutive equations of skin to describe its stress-strain behaviour. I will also give an overview of different types of constitutive equations used and some recent fibre-based models that have accurately simulated in vitro tests of human skin.