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A MATHEMATICAL MODEL OF THE CUTOMETER-SKIN COMPLEX TO EXTRACT VISCOELASTIC CONSTITUTIVE PARAMETERS OF THE SKIN

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Summary: INTRODUCTION
In skin sciences in general, and in the pharmaceutic and cosmetic industries in particular, evolution of the mechanical properties of human skin as a result of ageing, application of a topical product or altered environmental conditions are typically assessed in vivo using a wide range of devices such as cutometers. These mechanical devices measure certain implicit aspects of the mechanical properties of the skin (e.g. elasticity, viscoelasticity) but it is not clear how these measured parameters are correlated to scientifically meaningful engineering constitutive parameters such as Young's modulus, Poisson's ratio or characteristic relaxation times.
The objective of this research was to devise a mathematical model of a typical cutometer measurement test so that physical measurements could be directly linked to the constitutive parameters of a quasi-linear viscoelastic skin model.
METHODS
An analytical model of a skin patch subjected to cyclic negative pressure profiles was devised in order to express the skin bulge deformation as a function of the pressure profile and the viscoelastic properties of the skin (e.g. Young's moduli and characteristic relaxation times of a Prony series). An identification procedure between in vivo experimental measurements on human skin obtained using a Cutometer® MPA 580 (Courage and Khazaka, Köln, Germany) and a closed-form expression of the skin deflection was designed and implemented in Mathematica® (Wolfram Research, Inc., Champaign, IL, USA).
RESULTS AND CONCLUSION
The model was shown to provide excellent agreement with experimental measurements and to offer tunable accuracy depending on the number of terms in the Prony series. The approach proposed is a very computationally-economical alternative to inverse identification procedures based on finite element methods.