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Abstract

The modelling and computation of the coupled thermal and mechanical response of human skin at finite deformations is considered. The model extends current thermal models to account for thermally- and mechanically-induced deformations. Details of the solution of the highly nonlinear system of governing equations using the finite element method are presented. A representative numerical example illustrates the importance of considering the coupled response for the problem of a rigid, hot indenter in contact with the skin.

1. Introduction

The skin is the largest organ in the human body. In addition to its multiple physiological functions (e.g. thermo-regulation, vitamin D synthesis, neurotransduction), the skin acts as a complex biophysical interface protecting the internal body structures from the external environment. The nature of these interfacial phenomena spans the mechanical, thermal, biological, chemical, radiological and electromagnetic domains (Burns et al., 2004; Limbert, 2014). The nonlinear interplay between these processes presents researchers with numerous challenges when attempting to develop a mechanistic understanding of skin physiology in health, disease and trauma.

As depicted in Fig. 1, the skin can be divided roughly into four main layers: the stratum corneum, viable epidermis, dermis and hypodermis. Each of these layers has a complex microarchitecture and distinct material properties. The skin thickness varies according to body location from approximately 0.5 mm to 4 mm.

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