Title:

Comparison of anisotropic models to simulate the mechanical response of facial skin

Abstract:

"Physically-realistic models of the face can be applied in a wide range of domains, including biomedicine, computer animation, and forensics. There has been significant improvement in the anatomical accuracy of face models with better representation of the mimetic muscles, and realistic contact and attachments between soft and bony tissues [1,2]. Face simulations can also benefit from improved constitutive models of the skin layer. For example, better representation of the mechanical properties of facial skin can lead to improved predictions of deformations as a result of maxillofacial surgical procedures.

The objective of this work is to compare and evaluate constitutive models' ability to simulate the mechanical response of facial skin subjected to a rich set of deformations using a probe.

We developed a finite element model to simulate the facial skin experiments of Flynn et al [3]. Several anisotropic constitutive equations were tested for their suitability to represent facial skin, including models proposed by Gasser et al [4], and Tong and Fung [5]. To represent *in vivo* tension, we applied a prestress to the model prior to simulating the full set of deformations. The reaction forces due to the displaced probe were calculated. A non-linear optimization procedure determined model parameters and *in vivo* tensions that best fit the model reaction forces to the measured experimental reaction forces.

The finite element model simulated the force-displacement response of facial skin under a rich set of deformations. Use of an anisotropic constitutive law in place of an isotropic law resulted in a better fit between the models and experiments. For example, using the Gasser et al [4] anisotropic material model results in a 0.87 variance accounted for compared to 0.79 variance using an isotropic Ogden material model [3].

Future developments include the incorporation of the structure inferior to the skin in the model. We believe this will have the most significant effect on the model performance."

References:

"[1] Flynn et al. *Comput Methods Biomech Biomed Eng*, 18: 571-582, 2015
[2] Wu et al. *IEEE Trans Vis Comput Graph*, 20:1519-1529, 2014
[3] Flynn C et al. *J Mech Behav Biomed Mater*, 28: 484-494, 2013.
[4] Gasser T et al. *J R Soc Interface*, 3: 15-35, 2006."
[5] Tong, P and Fung Y-C. *J Biomech*, 9: 649-657, 1976"