Cellular Scale Model of Stratum Corneum

R. Santoprete[1], B. Querleux[1]

[1]L'Oréal, Paris, France

Abstract

Introduction

As the outermost layer of the skin, the stratum corneum (SC) participates in the functional properties of the skin such as photoprotection, barrier to external chemicals, and body water loss, and mechanical insults.

Purpose

To better quantify the impact of the morphological and mechanical properties of the main constituents of the SC on its overall mechanical behavior, we developed a biomechanical model of the SC at a cellular scale, based on in vitro morphological and mechanical data.

Use of COMSOL Multiphysics®

A structurally-based model was developed comprising the 3 main mechanical components of the SC: corneocytes embedded into an intercellular cement, composed by a soft phase (containing intercellular lipids, water-soluble materials, and other intercellular proteoglycans) and glycol-proteic junctions called corneodesmosomes. Input parameters were taken from nanomechanical measurements on isolated corneocyte and macroscopic measurements on SC sheet. Concerning intercellular cement and corneodesmosome, in absence of experimental data, data were extrapolated and fitted from similar kind of materials.

Results

The sensitivity analysis quantified the relative impact of the mechanical and morphological properties of the SC main constituents on the overall mechanical properties. The results indicate that the best way to decrease the SC's in-plane stiffness is to reduce the rigidity of the corneodesmosomes lying in the peripheral intercellular spaces. Furthermore, preliminary results show that thickening of the peripheral spaces or, to a less extent, softening of intercellular lipids can reduce the stratum corneum stiffness. On the other hand, corneocyte plasticization does not appear to be as effective. These simulated data were then injected in a multi-layer biomechanical model of the skin in order to evaluate the impact of SC mechanical properties on the alteration of wrinkling properties of aged skin. An increase of SC stiffness induces deeper folds, which indicate a possible contribution of the SC dryness to the observed evolution of the wrinkling

behavior with aging.

Conclusion

Combining experimental and simulated data is a powerful methodology to decode the complexity of the impact of main skin components at the cellular scale on skin biomechanics. Such an approach will help to better understand aged-related effects. The knowledge of the impact of subtle changes occurring in the SC's constituents and how these are related to the overall skin properties is essential to develop targeted ingredients and most appropriate anti-aging skin care products.