# Soft tissue deformability, growth, and anchoring as multiscale facial sagging mechanisms

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**Abstract**

Despite growing interest in anti-aging products and surgical procedures, the mechanistic links between age-based biomechanical tissue alterations and the emergence of a sagged facial appearance have remained relatively unexplored. Here, we provide corresponding insights by leveraging accurate *in vivo* characterization of the non-linear, time-dependent mechanics of cheek soft tissues to inform anatomically-accurate computational face models. We report that age-based changes in tissue deformability are locationand layer-specific, measuring-for the first time-stronger softening for the subcutis (2.7×–14.2×) than for the cutis (1.9×). Corresponding experimentally-informed simulations indicate that biomechanical alterations of the cutis, subcutis, and dermal anchoring structures are necessary conditions towards recapitulating jowl formation, though each insufficient on its own. We relate this to the mechanical gradients across facial tissues, whereby softening of the stiffer outer layers is required for deeper tissue aging to appreciably influence the facial appearance and significantly activate stretch-based mechanobiological pathways driving skin growth. We envision these findings to inform the development of surgical and cosmetic anti-aging strategies rooted in biophysical principles.

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