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Testing expert discussion around skin biomechanical properties

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What's inside

Biomechanical Properties and the Skin: Implications for Cosmetic Science

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As the body's largest organ, the human skin serves a multitude of physiological functions, such as protection against environmental aggressors, thermoregulation, immune defense and even sensory perception.
Structurally, skin comprises three main layers: the epidermis, dermis, and hypodermis, each with distinct contributions to the skin's mechanical performance. The dermis, rich in extracellular matrix (ECM) components like collagen and elastin, plays a particularly central role in mechanical resilience.
Biomechanical properties of the skin, meaning elasticity, tonicity, viscoelasticity, firmness, extensibility, and surface topography are key indicators of skin condition and are more and more used in dermatological research and cosmetics testing. These properties both intrinsic factors, such as age and genetics, and extrinsic influences, such as exposome, i.e pollution, UV exposure, humidity, and the application of personal care products. Skin aging and various diseases such as psoriasis affect skin mechanics. Therefore, studies of skin elasticity are potentially useful in assessing the efficacy of cosmetics products in terms of emollience and hydration. The mechanical properties of the skin are determined by the **thickness and quality of the epidermis, dermis and subcutis**. The epidermis, especially the stratum corneum, is a tight barrier against the external environment. It is tough and resilient due to the presence of fibrous keratin. The dermis layer is 1 mm thick and consists of a network of collagen with interspersed elastic fibers and lymphatic elements.

The influence of extrinsic and intrinsic factors on the skin's biomechanical properties

The biomechanical properties of skin are constantly under the influence of intrinsic and extrinsic factors. Intrinsic factors include hormonal changes and ageing and contributes to the gradual decline of elastin and collagen production, fibroblast activity, ECM integrity. These factors result in diminished elasticity of the skin, as well as a loss of firmness. With advancing age, the skin's capacity to rebound after deformation reduces due to collagen and elastin alteration.

At the same time, extrinsic factors, which include UV exposure, pollution, smoking, diet and even mechanical stress, also have an impact on the skin's biomechanical properties. Among these, UV exposure and specifically UVA are the most significant contributor to premature skin ageing, which is referred to as photo ageing. Pollution and smoking exacerbate oxidate stress and inflammation, having a direct impact of skin barrier function and mechanical weakening. Mechanical stress from repetitive facial movements, such as smiling, frowning or raising your eyebrows, can promote wrinkles formation.

The development of skincare formulations tailored specifically for **menopausal women reflects** an increased awareness of their **unique dermatological and physiological needs.** The decline in estrogen levels induces significant skin changes, including reduced density and elasticity, increased dryness, slower cellular renewal, and diminished collagen and hyaluronic acid production. In response, the cosmetic industry is formulating targeted products designed to enhance hydration, mitigate inflammation, and counteract oxidative stress to reinforce the skin barrier. Furthermore, menopausal skincare is adopting a holistic approach that integrates topical treatments with nutraceuticals to promote overall well-being.

Structural basis of skin biomechanics

The mechanical behavior of skin is determined by its structural composition. The **epidermis**, although thin and avascular, provides barrier functionality. The **dermis**, comprising a dense ECM, is the main contributor to tensile strength and elasticity. The **hypodermis**, rich in adipose tissue, provides cushioning and mechanical support.

Central to the dermis is the extracellular matrix (ECM), a specialized network of fibrous and non-fibrous components. The ECM composed of hundreds of proteins is a dynamic network controlling the proliferation, adhesion, migration, polarity, differentiation, and apoptosis of the cells. The in-vitro or ex-vivo assays

can target the various biological mechanisms providing limitless opportunities of claims support.

What methods exist today to in vivo assess the performance of skin care on biomechanical properties of the skin?

In cosmetic science, quantitative and visual analysis of skin mechanical properties is essential to evaluate the effects of lifting, anti-aging, anti-sagging topical applications and injectable treatments. The development of non-invasive techniques, such as suction-based deformation analysis and optical imaging, has significantly enhanced the ability to study skin mechanics in-vivo.

The implementation of efficacy studies refers to the regulations in each area of the world and sometimes in each country. In Europe, the reference is the European regulations for cosmetics (CE. N 655/2013 Art.20 -Art.22) with mainly the Product Information File (P.I.F). To support product claims, cosmeticians must in Europe meet the **6 common criteria: Compliance with Legislation, Truth, Adequate and Verifiable Evidence, Sincerity, Fairness, and Informed Choice.** There are no specific standards for each test (except for sensory analysis and sun protection factor cf. ISO) and cosmetics may follow guidelines for human testing such as EEMCO, Good Clinical Practice...

These scientific processes of objectification protect the consumer against misleading claims and preserve the credibility of the cosmetics industry. Test managers can choose to validate the performance of their active ingredients or finished products on humans from 4 categories:

1. **Consumer tests**: These studies are carried out by a naïve panel under the normal conditions of use of the product. The consumer's feeling about the effectiveness of the product is collected through a self-assessment using a custom-designed questionnaire.
2. **Sensory or emotional analysis:** These tests are carried out by qualified experts or naïve panels, in real conditions or online, to object to the activities of the product perceived by the subjects.
3. **Clinical scores**: this is a scientific approach to the evaluation of the effectiveness of the product by trained experts using specific scales and descriptors. The scorage by experts using specific visual and tactile scales are complementary analysis that can be also completed by auto-evaluation of the volunteers or specific consumer studies.
4. **Biometrological tests:** This is the objectification of performance by measuring the physico-chemical characteristics of the skin, hair or nails using measuring devices. They make it possible to visualize or quantify the different activities of the products on the skin, hair or nail mechanisms.

The skin's mechanical characteristics are diverse and interdependent, reflecting the **complex interplay between its 3 layers,** and its cellular and extracellular components. These properties are dynamic and respond to both physiological states and external stimuli, making them essential metrics in cosmetic testing.

Elasticity reflects the skin's ability to return to its original shape after mechanical stress, primarily governed by the quality and organization of elastin fibers. Viscoelasticity denotes the time-dependent recovery behavior, influenced by the ECM's hydration level and composition. Firmness and stiffness describe the skin's resistance to deformation and correlate strongly with collagen content and dermal density. Extensibility measures the capacity of the skin to stretch, critical in maintaining functionality during movements and in contexts such as wound healing.

Some definition of the parameters studied:

- **Elasticity**: The skin's ability to return to its original shape after deformation.
- **Firmness**: This is the skin's ability to resist deformation under the effect of an external force. It reflects the stiffness and elasticity of the skin. Firm skin retains its shape and structure under applied force and quickly returns to its original state.
- **Stiffness**: This is the resistance of the skin to deformation under an applied force.

• **Viscoelasticity**: A property of the skin that combines both viscous and elastic characteristics, influencing the way it deforms and recovers over time.

Collectively, these properties not only define the skin's mechanical behavior but also serve as biomarkers for aging and treatment efficacy in dermatological and personal care applications. Beyond the consumer tests and the scorage by experts we have categorized the assessment of **the biomechanical properties of the skin in 2 parts:** one dedicated to **direct measurements** and the second one dedicated to **indirect evaluation.**

The direct measures of the mechanical properties of the skin

A real-time deformation using several techniques **-ballistometry, suction (with or without imaging), indentation, or air flow-** is implemented one or several times on the skin surface. The techniques used make it possible to evaluate the mechanical response of the skin to an applied force.

Devices	Indentometry	Ballistometry	Suction	Air flow	Light Impulse
Adhelaskin - LTDS		X			
Ballistometer BLS780 - Diastron		X			
Cutiscan CS100 - C+K			With imaging		
Cutometer - C+K			X		
Dermalab Elasticity - Cortex			X		
Dynaskin2 - Eotech				X	
Easystiff - Biomeca	X				
Elastimeter - Delfin	X				
Indentometer IDM800 - C+K	X				
Myopro 1B - Myoton					X
SkinFibroMeter - Delfin	X				
Skinflex - Orion				X	
Underskin - LTDS				X	
Waveskin - LTDS				X	

Then, the biomechanical behavior induced is measured through optical or fringe projection principle.

Reminder of the different direct measurement methods:

• **Ballistometry**: The method is based on the impact of an object at constant force, then evaluate firmness and dynamic resilience according to the degree of rebound.

• **Suction**: A depression is caused on the surface of the skin by vaccuum. Aspirated, the skin is stretched vertically by suction. By releasing the suction, the skin returns to its original position. The degree of deformation is measured by the sensors as well as the speed and extent of the return to normal after the deformation.

• **Indentation**: A controlled force is applied locally to the surface of the skin using an instrument with a tip of a specific shape and size. The measurement considers the applied force and penetration depth and evaluates the elasticity, stiffness, viscoelasticity. Probes with 3 different pin Ø (2, 3 and 5 mm Ø) for various skin sites. The smaller the diameter, the deeper the pin goes into the skin. Special shaped probe for the measurement of the scalp (pin 1 mm Ø).

• **Air Flow without contact:** A calibrated air jet perpendicular to the skin surface produces local deformation and induces the skin depression. Measurement takes place in three consecutive acquisitions. The area of interest before deformation, during deformation after deformation. Measurement is performed using a 3D fringe projection sensor.

• **Light Impulse:** An air flow is applied onto the surface of the skin which generates the propagation of Rayleigh waves. The speed of the propagation of the waves is measured in 7 directions.

The indirect measures of the mechanical properties of the skin

Indirect measurements, analyze the assessment of parameters that are linked to the biomechanical properties of the skin and give information on: Collagen, Face analysis and volume, molecular composition, proteomics and metagenomics, dermis size and shape, Skin aspect and structure. *On the clinical testing platform, you can find several methods of analysis and laboratories providing these methods by connecting for free.*

Studied effect	Methods and devices
Face morphology and volume	EvaFACE, EvaFACE-S5 (Eotech), Antera 3D (Miravex), C-Cube Clinical Research (Pixience), DynaCam, ColorFace, FaceScan 3D
Skin surface	Visioscan VC (Courage&Khazaka), DermaTOP-HE-S, EvaSURF, AEVA-HE2-M (Eotech), C-Cube Clinical Research (Pixience), Antera 3D (Miravex), Clarity Research System, Clarity 3D Mini, Q-scope, EveKey Skin Analyzer, Bio Blue Light Scanner, SpectraFace, TiVi 60 Skin Damage Visualizer, SkinCam, Medicam 1000, Proscope, EOS 5DS R multispectral camera, Dermatoscope Delta 20 plus.. and other cameras
Skin structure, dermis size and shape	DUBSkinScanner 33, DUB SkinScanner 75, DUBSkinScanner 22 (Eotech), VivoSight Dx (Vivosight), DeepLive LC-OCT, Light Microscopy [Suction Blister]
Metagenomic	MS/MS-16S rRNA-PCR + Coravalid Bioinformatic System (Phylogene), DNA Microarray Sequencing, GenoBiome Skin, Genome Shotgun
Collagen	DermaLab skinlab ultrasound (Cortex Technology), VivoSight Dx [OCT System] (Vivosight), RSOM Explorer C50, SIAScope, Scanning Electron Microscope, K-Probe XPolar - Polarimetric Microscopy, DeepLive LC-OCT,
Full Face analysis	Visioface, Visioface Lite (Courage & Khazaka), AEVA-HE²-L (Eotech), HeadScan V05 - R&D, HeadScan Dynamics III, (Orion Technolab), F-Ray, VISIA-CR - Gen 2, Cydolia 3D Acquisition System, DynaCam, ColorFace, VISIA-CR - Gen 5

The preliminary discussion with the CROs to design the protocols parameters (timeline, duration, conditions of use of the products, inclusion criteria, instrumentation choice …), seems to be essential to define the best protocol to support the claim substantiation.

The evolution of technology in the no contact probe, the data acquisition and treatment with the use of I.A algorithm may give the direction of non-contact and optical solutions.

In the highly competitive cosmetics industry, the quantification of skin biomechanical properties has become a critical tool not only for product development but also for substantiating marketing claims. Consumers increasingly demand evidence-based efficacy, driving brands to leverage biomechanical data, such as improvements in elasticity, firmness, and wrinkle reduction as measurable outcomes. Advanced skin testing technologies provide objective, reproducible metrics that support product differentiation and regulatory compliance. By demonstrating scientifically validated effects on skin mechanics, companies enhance consumer trust and brand credibility. Moreover, these biomechanical markers help tailor personalized skincare solutions, aligning with trends toward individualized beauty regimens. Thus, integrating biomechanical assessments into cosmetic marketing strategies enables a compelling narrative rooted in science, reinforcing product value and driving consumer engagement.

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Skin Mechanical Integrity: In Vitro Tools and the Role of the Extracellular Matrix

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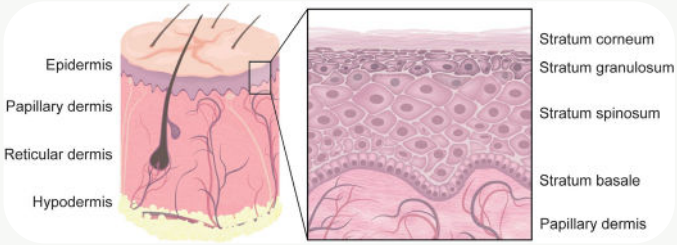
The skin is subject to constant mechanical stresses, including stretch and compression due to body movement. In the skin the extracellular matrix (ECM) provides the structural support, which allows the skin to withstand external forces without compromising its integrity and function. Skin behaves as a viscoelastic material, combining viscous responses (slow deformation under stress) and elastic responses (recovery of original shape post-deformation).

This mechanical behavior is primarily attributed to the dermis, which contains a dense fibrous ECM composed mainly of collagen (77%) which confers skin tensile strength and elastin fibers (4%) which provide elasticity. These fibrillar proteins are embedded in a hydrated matrix of glycosaminoglycans (GAGs), which contribute to shock absorption and hydration maintenance. In parallel, the epidermis, through its stratified layers of keratinocytes, provides an additional degree of mechanical rigidity, particularly evident when comparing tensile and indentation measurements. Beyond passive mechanical support, skin cells are active mechanosensors. They detect and respond to their physical environment through mechanotransduction pathways that regulate processes such as migration, proliferation, and differentiation. This sensitivity is critical for maintaining tissue homeostasis and coordinating repair following injury.

Age-related changes in skin illustrate the consequences of altered mechanical balance. With aging, collagen fibers become excessively crosslinked via glycation, increasing rigidity while decreasing elasticity. Elastin degradation and disorganized ECM architecture further compromise mechanical performance. These alterations highlight the importance of evaluating ECM composition, organization, and functional integrity under controlled in vitro conditions.

In vitro analysis of skin mechanics typically involves characterizing ECM structure, protein localization, organization, degradation in relation to the mechanical resistance of the skin. Key targets include collagen fiber synthesis, degradation and alignment, elastin fiber integrity, fibrillin microfibril organization (Fibrillin-1, Fibrillin-2), matrix metalloprotease and GAG content and distribution as well as cell contractile capacity.



What are the major components of the ECM that can be studied?

1. Collagens, backbone of the tissue architecture, are categorized into 3 main sorts:
• fibril-forming collagens (types I, II, III),
• network-forming non fibrillar collagens (type IV), that composed a non-fibril network.
• fibril-associated collagens (types IX, XII), and others (type VI).

2. Glycosaminoglycans (GAGs) are polysaccharides and help to keep water. The diversity of proteoglycans and their high interaction with growth factors and their receptors provides structural basis for a multitude of biological functions. They are divided in four groups: hyaluronic acid, keratan sulfate, chondroitin/dermatan sulfate, andheparan sulfate.

3. The laminins forms networks that remain in close association with cells through interactions with cell surface receptors.

4. The role of the fibronectin fibrils is the attachment and migration of cells, like a “biological glue”.

5. Elastin fibers confer elasticity and through cross-links with tropoelastin mediated by LOX finally form desmosine or isodesmosine.

Among advanced tools for such analysis, Atomic Force Microscopy (AFM) has emerged as a powerful technique. AFM is a scanning probe method that provides

nanoscale resolution for both topographical imaging and mechanical measurements. It can map surface roughness and elasticity by performing localized force spectroscopy, acting effectively as a nanoindenter. AFM also enables simultaneous mechanical and morphological analysis, especially when combined with optical microscopy such as confocal microscopy. This dual capability allows researchers to directly correlate biomechanical behavior with biomolecular features. For example, AFM coupled with X-ray diffraction (SAXS) allows Imaging and in situ characterization of the nanostructure of dermal collagen fibers and networks. AFM has been used to assess the strength of cell–matrix interactions, cell-generated traction forces, and the mechanical properties of ECM networks, including collagen and fibrillin structures.
In vitro assessment of the mechanical components with tools like AFM provide a precise platform for exploring the structural and functional complexity of skin tissue and offer an interesting insight into the efficacy of cosmetic formulations and active compounds.

In conclusion, this incredible network that represents the skin extracellular matrix, substrates for matrix metalloproteinases (MMPs), stocks bioactive fragments, and adhesive proteins. It is also modulated by exogenous environment. The own biochemical properties of the ECM can be studied in many ways through the analyse of its various components and their interactions and constitute a “gold” support to substantiate ingredients and finished product claims.

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Testing the Efficacy of Cosmetics Products for Skin Rejuvenation Based on their Biomechanical Properties

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The biomechanical properties of human skin play an important role in its integrity and ability to remain intact.

IEC has an **expertise in this field since 1994** in participating in several research projects and congresses *[IFSCC Cannes 1998: Investigations on strech marks, tensing, firming products], [ISBS Lisboa 2016: immediate and long term effects with illustration of skin deformations], [Cosmetotest, Lyon 2024: non-contact measurements for investigating the effect of cosmetic products]*, as well as the thesis **«Dynamic non-contact measurement SkinFlex ®"** in collaboration with Orion TechnoLab in 2020.

Biomechanical properties are assessed using subjective **(visual and tactile)** evaluation methods during an **In Use Test** and/or objective **methods to measure the effects of cosmetic products,** particularly when we want to claim "restructuring, protective, repairing, anti-wrinkle, anti-aging" effects...) The effects can be quantified on the surface, at micro-relief level, but also deep in the epidermis and/or dermis.The previous claims can be assessed either after "induced" stress, which can be mechanical (stripping), chemical (SLS) or UV exposure (ORIEL lamp). These methods make it possible to reproduce, over a limited period of time, the effects of various external aggressions (exposure to UV rays, pollution ....) and the benefits of cosmetic products on the viscoelastic properties of human skin.

Damage to the biomechanical properties of facial and body skin, resulting in skin aging, can also be assessed when these areas have been **"naturally" damaged in the case of photo-aged skin,** or in the case of **stretch marks** characterized by strong anisotropy and presenting degraded viscoelastic properties.

In order to assess the skin's biomechanical properties, it is possible to follow the evolution of various parameters such as **microrelief restructuring, wrinkle reduction, dermal thickness, firmness/tonicity/elasticity.**

As previously mentioned, **tactile scores** realized by trained expert and supplemented by subjects' **self-assessments** can be used to evaluate skin firmness, density and elasticity.

Instrumental methods relating to the biomechanical properties of the surface enable the restructuring effect corresponding to an improvement in micro-relief to be claimed by following changes in the **micro-depression network** [Cyanocylate / Moisture Map ® MM200 (C & K)] and/or structural parameters such as **entropy, anisotropy** index [Moisture Map MM200, Visioscan ® VC20 (C& K)]; C-cube (Pixience)].

To determine the depth effect of a cosmetic product, the use of an **ultrasound device** with a 25 MHz probe [Dermcup ®] provides information on the structure of the dermis and the mechanical properties of the skin.

The firming effect of a product, such as firmness and elasticity, can be assessed by deforming the skin under the **effect of suction [Cutometer TM (C&K)] or torsion [Torquemeter TM (Diastron)].**

A calibrated air jet can be used to deform the skin. This quantifies the volume of depression, surface area, depth and firmness immediately after product application [SkinFlex TM (Orion Concept)], [DynaSkin V1 TM & Dermatop (Eotech)], but also the latest version of **DynaSkin V2 ™ coupled with AEVA (EOTECH)**, which not only provides results on the skin's biomechanical properties, but also information on the whole face (plumping effect on cheekbones, lower cheeks / anti-wrinkle effect...).

Based on its **multi-ethnic panel** due to the geographical distribution of its centers [Europe, Asia, Africa] and its new integration in SGS Group, IEC entity offers a global evaluation of the biomechanical properties of the skin on different skin types.

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Evaluation of the Biomechanical Properties of the Skin-Insight on this Significance in Cosmetic Research

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The human skin is a complex and multifunctional organ, in fact, it is the largest organ of the body. Composed of multiple layers including the epidermis, dermis, and hypodermis, the skin plays a vital role in protecting the body from mechanical, chemical, and biological threats. As the most visible part of our body, the skin's overall appearance — including its color, firmness, and texture — often forms the first impression of a person's health and well-being.

With growing awareness of the importance of skin health, the demand for skincare products has significantly increased over the past decade. Today, a wide variety of cosmetic products are available that aim to cleanse the skin, maintain moisture balance, stimulate cellular metabolism, and shield against harmful ultraviolet (UV) radiation thereby contributing to optimal skin function.

However, as consumers are today more informed and science-oriented, cosmetic developers face increasing pressure to create products that are both evidence-based and results-driven. **This is where biometrology comes into play!** Biometrology involves the quantitative measurement of skin properties such as hydration, sebum production, trans-epidermal water loss, melanin content, and skin elasticity. These measurements provide **scientific insight** into skin condition and **treatment effectiveness**, bridging the gap between cosmetic claims and measurable outcomes.

Application of instrumentation for measurement of biomechanical properties in clinical research

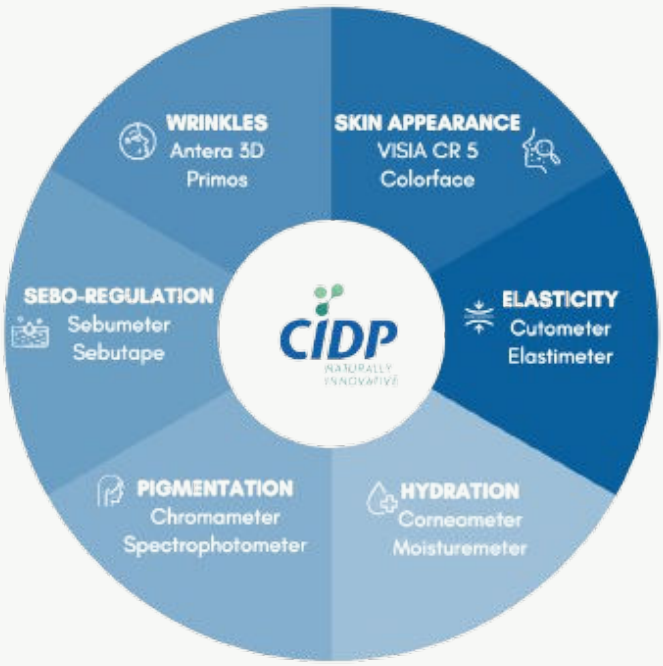
The instruments used for biomechanical properties are generally classified according to their mechanism of action [1].

A few examples would include suction-based devices such as the Cutometer that can measure the skin elasticity through the creation of a negative pressure (vacuum). Different cutometer probes are used depending on the area to be assessed on the body.

Capacitance-based devices such as the Corneometer allow for measurement of hydration.

Open-chamber diffusion principle-based devices such as the Tewameter enable measurement of water vapor gradient of the skin for the assessment of trans-epidermal water loss (TEWL).

Recent development in the field of skin imaging has also enables the visualization and ultimately the quantification of parameters such as wrinkle depth, skin texture, pigmentation and redness, collagen density and skin thickness through devices like the Antera 3D and Dermascan C.



How to substantiate these claims

Scientific integrity and trust are the foundations of the dermo-cosmetic industry and claims attributed to any product have to be substantiated in a robust manner. Therefore, the need for instruments and their related

methodologies is not negligible.

One of the most important claims in cosmetic products is hydration. Synonymous to good health, skin hydration can be measured with the corneometer, the higher the value, the more hydrated the skin is. Additionally, a well hydrated skin also indicates a strong barrier function which can be determined through the measurement of trans-epidermal water loss using the Tewameter. The lower the value, the better the skin barrier function.

For the assessment of skin aging, one of the gold standards is the Cutometer for the measurement of skin elasticity. Several parameters such as R0, R2, R7 provide different insights. The higher R2 and R7 values suggest better elasticity.

Another sign of aging is the appearance of wrinkles, wrinkle-reduction claims can be substantiated using the Antera 3d and the Dermascan through multi-spectral imaging and high-frequency ultrasound respectively.

There are a multitude of claims for the dermo-cosmetics industry, and these are just a few examples to showcase some instruments and techniques available at CIDP.

Efficacy studies at CIDP

With over 20 years of experience in clinical trials, CIDP has established itself as a key player in the field of clinical testing. In addition to conducting numerous safety studies, CIDP specializes in efficacy testing of investigational products designed for use on the skin, hair, and scalp.

Equipped with state-of-the-art technology across all its affiliates, CIDP offers a wide range of efficacy protocols featuring quantitative measurements on a multiethnic panel. The protocols at CIDP are designed to include a clinical scoring by dermatologist couple with various efficacy assessments at defined time points to track the improvement in skin condition following a defined period of investigational product use. Thes instrumental evaluations are carried out by trained professionals who can also analyze the data and draw conclusions in alignment with the product claims.

CIDP's approach to efficacy testing goes beyond standard industry methodologies. Leveraging its global expertise and extensive resources, the organization has developed numerous custom protocols to meet evolving industry needs thereby positioning itself as a leader in the domain.

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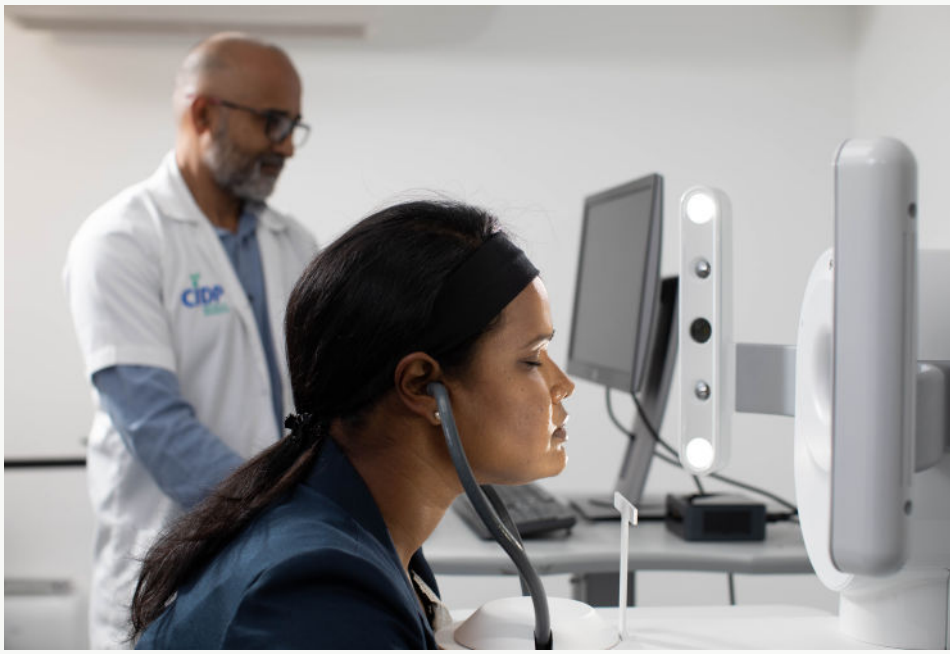

Evaluation of Eyelid Sagging with Antera 3D

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The Antera 3D system is a high-resolution, **non-invasive imaging device** used to analyze **skin properties in 3D**, particularly helpful in assessing pigmentation, vascularity, texture, and **skin surface topography**. Although the Antera 3D doesn't measure mechanical properties – e.g. **elasticity, tensile strength** – directly, it can complement biomechanical assessments by:

- Documenting surface-level changes following interventions aimed at improving biomechanical properties (e.g., after microneedling, radiofrequency, or topical retinoids).
- Helping correlate surface structure with elasticity changes measured by other instruments.

Here we report a study carried out by Hurley S. et al. on the assessment of eyelid sagging.

As the eye contour ages, the skin on the lid becomes lax often causing a voluminous protrusion where the superior palpebral sulcus begins to sag onto the upper eyelid. To investigate the possibility of **quantifying the volume of the sagging**, eyelid topographic measurements were collected on 20 female volunteers aged 50-75 years and the volume evaluated with the DermaTOP (Eotech) and Antera 3D (Miravex).

Figure 1 shows the Volume (mm3) of the sagging feature ± SD at baseline and 5 minute follow-up, on the same eye, without treatment. No significant change in feature volume with regard to baseline measurement was recorded using either the DermaTOP or the Antera 3D data.

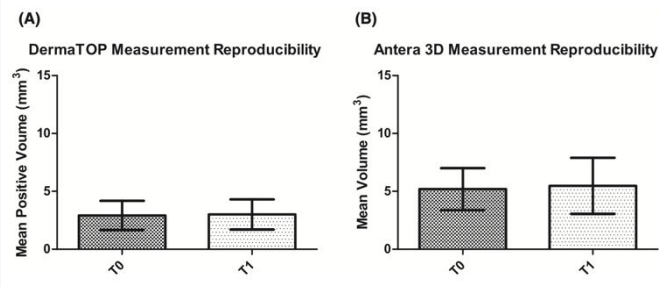

Figure 1. A, B, Reproductibility investigations. Change in eyelid sagging volume over time (± SD).

Figure 2 shows the mean Volume (mm3) of the sagging feature ± SD at baseline and 10 minute follow-up, on the same eye, after a single application of an aqueous tightening serum for the DermaTOP (2A) and 5 minute follow-up for the Antera 3D (2B). A significant 12% reduction in feature volume with regard to baseline measurement was recorded using the DermaTOP data and a significant 21.6% reduction in feature volume was recorded using the Antera 3D.

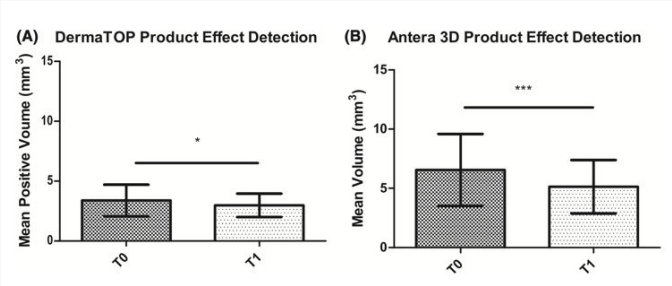

Figure 2. A, B, Product detection efficacy investigations. Change in eyelid sagging feature volume with product intervention (±SD). 12% reduction observed with The DermaTOP and 21.6% reduction in volume observed with The Antera 3D.

Figure 3 shows Antera 3D Elevations Channel (Custom 1.1 mm filter) capture for a volunteer at baseline and 5 minutes after a single application of aqueous tightening serum on the eyelid area.

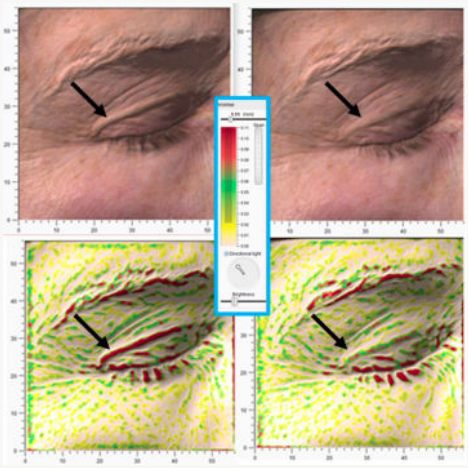

Figure 3. ANTERA 3D Colour Image and Elevations Channel custom 1.1 mm can be observed. Using the Elevations Channel highly elevated/protruding areas can be seen in red before product application (left). Following application of the tightening serum the volume of the feature is visibly and measurably decreased (right).

This study has demonstrated that both the DermaTOP and Antera 3D allow for quantitative measurement of eyelid sagging feature volume and in-turn permit evaluation of anti-ageing cosmetic preparations targeting eyelid sagging.

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Understanding the Biomechanics Behind Skincare Evaluation

Jane TERVOOREN - Vice President

Validated Claim Support

When it comes to skincare products—whether it's a moisturizer, serum, or anti-aging cream—it's easy to focus only on how they look, smell, or feel when applied. But behind the scenes, there's a lot more happening on a scientific level. One area that's gaining more attention is the use of **biomechanical testing** to evaluate how well these products actually perform. It's not just about looking good—it's about how the skin behaves and functions after application.

Skin isn't just a passive barrier, it's a dynamic, living tissue with complex mechanical behavior. It stretches, rebounds, resists force, and responds to environmental conditions. When we talk about the biomechanics of skin, we're referring to its physical properties—things like elasticity, firmness, hydration, and viscoelasticity.

All of these can be affected by skincare products and measuring them gives us a way to move beyond marketing claims and into objective efficacy.

Here are a few of the key parameters that product developers and clinical research labs look at:

1. **Elasticity and Firmness**

Elasticity is the skin's ability to return to its original shape after being stretched or changed. Think of it like a rubber band. Firmer, more elastic skin typically looks younger and healthier. Loss of elasticity is one of the signs of aging, and it's also influenced by hydration and collagen levels. Tools like the **Cutometer®** are commonly used to assess elasticity by gently suctioning the skin and measuring how well it «snaps back.»

2. **Hydration and Water Retention**

Hydration isn't just about drinking water—it's also about how well your skin holds on to moisture. Biomechanically, well-hydrated skin is more supple, more resilient, and less prone to cracking or flaking. Devices like the **Corneometer** measure the moisture content of the outermost skin layer (stratum corneum), which can reflect how effective a moisturizer is.

3. **Skin Thickness and Density**

Certain skincare products, especially those targeting anti-aging, claim to increase dermal density or even «plump» the skin. **High-frequency ultrasound imaging** can provide insights into how **thick or dense the dermis** is over time. An increase might suggest more collagen or extracellular production—both good signs.

4. **Viscoelasticity**

This one's a little more complex. Viscoelasticity refers to a material's combined elastic and viscous behavior. Skin doesn't just bounce back like a rubber band; it also flows and adapts over time. Understanding this property helps researchers see how a product affects not just quick movements (like stretching) but also slow **changes in skin shape** (like sagging).

5. **Transepidermal Water Loss (TEWL)**

This measures how much water is evaporating from your skin. High TEWL means your skin barrier might be compromised, and a good product should help lower it. Instruments like the **Tewameter®** or **Vapometer** are used for this.

Before a product ever hits the shelves, it typically goes through rounds of testing—some on lab skin models, some on human volunteers. Here's how biomechanical testing fits in:

- **Baseline vs. Post-Application**: A subject's skin is measured before using the product, then again after hours, days, weeks, or months. This allows

researchers to track real changes over time.

- **Controlled Environments**: Because skin behavior can vary based on temperature, humidity, or even time of day, these tests should be done in climate-controlled lab space.
- **Standardized Application**: The test product should be applied in the same way, under professional clinical supervision. This keeps results consistent and meaningful.

One of the biggest benefits of biomechanical testing is its role in Validated Claim Support. This is the process by which brands provide scientific evidence to back up the claims they make about their products—things like «improves skin elasticity in 21 days» or «clinically proven to increase hydration.»

Validated Claim Support means that a claim isn't just made because it sounds good—it's made because there's real, measurable data behind it. This is especially important in today's market, where consumers are skeptical and regulators (in places like the EU or U.S.) are tightening standards for what companies can legally say on packaging and ads.

Here's how biomechanical testing supports this process:

- It provides **quantifiable results** that can be measured before and after use.
- It uses **standardized methods** and equipment that are recognized in clinical and scientific communities.
- It makes claims more **trustworthy**, reducing the risk of false advertising and increasing consumer confidence.

In short, biomechanical evaluation is a critical tool not only for product development but also for marketing with integrity.

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As technology gets better and less invasive, we'll likely see more real-time, **personalized skin assessments.** Imagine using a smartphone app connected to a small device that tells you how elastic or hydrated your skin is, right at home. This could help users choose products tailored specifically to their skin condition at that moment—almost like a skincare GPS.

We're also starting to see AI and machine learning applied to skin data, which may soon allow companies to predict how your skin will respond to a product even before you try it.

Evaluating skincare products isn't just about rubbing something on your face and hoping for the best. By tapping into the biomechanical properties of the skin, researchers and developers can take a more scientific, reliable approach to measuring real results. Whether it's improved hydration, reduced sagging, reduction in fine lines or more bounce to your skin, biomechanics is helping to bring clarity and trust to the skincare world—giving your customers a reason to believe.

Validated Claim Support can help turn these insights into more than just science—they become promises that your customers can actually believe in.

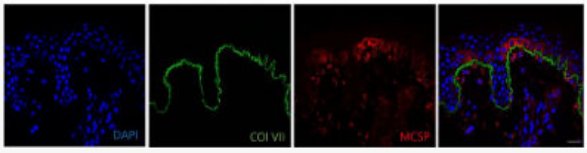
Atomic Force Microscopy Uncovers How Skin Stem Cells Lose Their Mechanical Vitality

Julien CHLASTA - Vice President

BioMeca

Introduction: why mechanics matter in skin biology

When we talk about youthful skin, conversation usually drifts toward collagen content, antioxidant levels, or the latest retinol derivative—but the story is incomplete without physics. Deep inside the epidermis lies a sparse population of inter follicular stem cells (ISCs) that constantly regenerate the surface. These cells occupy the tips of dermal papillae at the undulating dermo epidermal junction (DEJ), a niche whose stiffness and geometry quietly dictate whether ISCs keep dividing or slip into senescence. Until recently, that mechanical dimension was largely invisible. BioMeca's newest study—performed with high resolution atomic force microscopy (AFM)—changes the narrative by quantifying how the nanoscale "hardness" of ISCs and their extracellular matrix evolves from youth to old age. The work amounts to a mechanical biography of epidermal stem cells, and the plot twist is simple: young ISCs are noticeably stiffer than their neighbours, yet this competitive edge fades as decades pass.



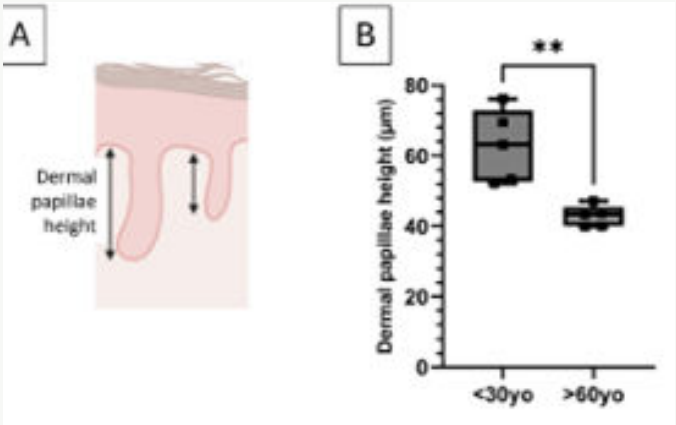
Methods in brief: mapping stiffness at the nanoscale

The team obtained fresh abdominal skin from female donors ranging from 20 to 78 years. After cryo sectioning each specimen into 16 µm slices, researchers fluorescently labelled MCSP (a canonical ISC marker) and collagen VII to map papillae versus rete ridges. AFM measurements were carried out in Quantitative Nanomechanical Mapping mode: a sharp silicon nitride tip indented 25 × 25 µm grids, gathering 4 096 force curves per area. By fitting each curve with Sneddon's model and correcting for tip geometry, the group extracted the elastic modulus for every pixel, generating colour coded stiffness heatmaps alongside fluorescence images. Importantly, sections were chemically fixed and submerged in phosphate buffered saline to eliminate artefacts from turgor pressure, ensuring that differences truly reflected material properties rather than fluid dynamics.

Core results: stiffness is a marker of youth

Three findings stand out. **First**, in skin from donors under 30, ISCs perched above dermal papillae are roughly 1.4 times stiffer than basal keratinocytes sitting above neighbouring rete ridges, confirming that rigidity is an intrinsic feature of the stem cell state. **Second**, the basement membrane and upper papillary dermis directly beneath those youthful ISCs are stiffer than the matrix beneath ridges, hinting at a reciprocal relationship in which a firm niche reinforces a firm cell and vice versa. **Third**, both advantages collapse in donors over 60: papillae flatten, the matrix softens and ISC stiffness converges with that of ordinary basal cells. In statistical terms, the once clear modulus gap shrinks to non significance.

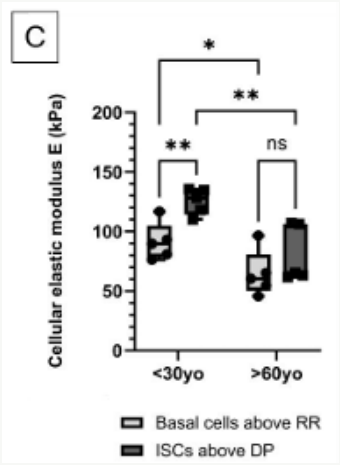
Two corollary observations enrich the story. Papilla height positively correlates with ISC stiffness, whereas ridge cell stiffness stays flat regardless of topography, suggesting that the three dimensional architecture of the DEJ actively tunes mechanical cues.



Meanwhile, fluorescence activated cell sorting revealed that only about 13 % of basal keratinocytes were MCSP high; these cells were larger, spread more rapidly on collagen coated dishes and, crucially, retained higher elastic modulus ex vivo—evidence that stiffness is tied to cytoskeletal organisation rather than passive tissue context alone.

Biological interpretation: a feedback loop gone slack

Why should a stem cell be stiff? One hypothesis is that a stronger actin–myosin cortex and reinforced nucleus protect genomic integrity during frequent divisions. A rigid cell may also generate higher traction forces, facilitating upward migration when differentiation is triggered. Conversely, a softening niche could diminish cytoskeletal tension, blurring polarity cues and slowing turnover, as commonly seen in aged skin where wound healing is delayed and the epidermis thins.



The BioMeca data therefore point to a self reinforcing loop: a raised papilla with a tense basement membrane maintains ISC rigidity; rigid ISCs, in turn, help preserve local matrix architecture, perhaps by secreting laminin 332 and collagen VII. Ageing breaks the loop from both ends—matrix glycation cross links are lost, matrix metalloproteinase activity rises, papillae flatten and cells soften. The mechanical conversation turns into a whisper, and regenerative capacity wanes.

Applications: from diagnostics to product design

Mechanics as an early biomarker. Because modulus declines precede visible histological changes, AFM could serve as a sensitive assay in ageing studies or efficacy screenings for cosmetic actives. A topical believed to "rejuvenate" skin could be vetted in weeks by measuring whether it rescues ISC stiffness, long before wrinkles flatten.

Topographical tissue engineering. Three dimensional skin equivalents often ignore dermal papillae, producing a billiard table DEJ that fails to sustain genuine stem cells. Replicating young like topography and stiffness in scaffolds might extend culture longevity, improving grafts for burns or genetic diseases.

Matrix-targeted skincare. Formulations that up regulate collagen VII, perlecan or nidogen—molecules central to DEJ tensile integrity—could restore the niche's mechanical tone. Likewise, cross linking enhancers or sugars that resist glycation breakdown may hold promise. The takeaway is clear: chemistry should serve mechanics, not replace it.

Methodological robustness and limitations

With over 15 AFM maps per donor and thousands of indentations per condition, the dataset boasts statistical power. Still, stiffness is just one mechanical parameter; viscoelasticity and adhesion energy, which AFM can also measure, were beyond this study's scope. Moreover, donor variability in hormonal status or sun exposure could confound results. Future work combining nano mechanics with single cell transcriptomics might disentangle whether softness is a driver of transcriptional drift or a downstream effect.

Conclusion

Youthful skin is, quite literally, harder at the nanoscale. BioMeca's AFM based portrait shows that when the DEJ flattens and softens with age, inter follicular stem cells lose their mechanical identity, and epidermal renewal slows. The next generation of anti ageing strategies will therefore need to think not only biochemically—boosting collagen or scavenging free radicals—but biomechanically, by restoring the firm handshake between stem cell and niche that keeps skin perpetually renewing. In a field often dominated by glitzy ingredients and marketing spin, stiffness may prove the most honest metric of all.

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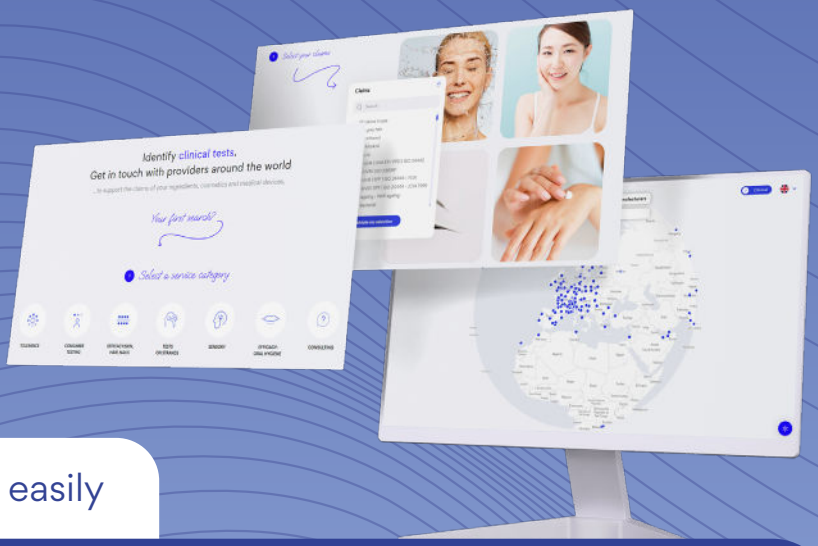

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