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THE INFLUENCE OF HORMONAL STATUS ON SKIN CHRONOAGING PROCESSES: PATHOPHYSIOLOGICAL ASPECTS AND PREDICTIVE DIAGNOSTICS

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Abstract: This paper presents a theoretical and practical analysis of the influence of hormonal status on skin chronoaging processes. The study is based on an integrative approach combining endocrinological assessment (estradiol, TSH, T4, prolactin) with high-frequency ultrasound sonography (33 MHz and 75 MHz). Systemic hormonal imbalance is shown to be a key predictor of dermal matrix degradation. The efficacy of a combined protocol comprising microneedle RF lifting, thulium laser, and topical resveratrol therapy is substantiated. The developed algorithm for personalized correction ensures a high degree of treatment targeting, allowing involutional processes to be slowed and structural skin integrity to be restored. These findings open new prospects for predictive anti-aging medicine and for optimizing dermatocosmetology protocols based on evidence-based instrumental diagnostics.

Keywords: chronoaging; hormonal status; estradiol; high-frequency ultrasound; microneedle radiofrequency lifting; thulium laser; resveratrol; dermatocosmetology; dermal acoustic density.

The problem of biological skin aging in contemporary dermatology and gerontology has long outgrown the scope of purely cosmetic concerns, acquiring the status of a fundamental medical challenge rooted in systemic changes within the human body. Chronoaging, as a genetically determined process, is a multifactorial phenomenon in which the neuroendocrine axis serves as the key regulatory link maintaining tissue homeostasis. Research over recent decades convincingly demonstrates that the skin is not merely a passive barrier organ but a highly active, hormone-dependent structure possessing its own receptor network for steroid hormones, thyroid hormones, and growth factors. The decline in the functional potential of fibroblasts and keratinocytes during natural biological aging correlates directly with systemic shifts in the individual's hormonal profile, necessitating a revision of classical approaches to anti-aging therapy in favor of an integrative model grounded in a thorough analysis of metabolic status. Studying the role of estradiol, prolactin, and thyroid hormones in regulating dermal metabolism offers a new perspective on the pathogenesis of wrinkle formation and atrophic changes, shifting diagnosis from the realm of subjective assessment toward precise, quantifiable parameters verifiable by high-frequency ultrasound sonography.

The endocrine theory of aging, which regards hormones as the principal conductors of metabolic processes, finds its most vivid expression in female skin physiology, where the menopausal transition serves as a biological marker of accelerated involutional change. A sharp decline in 17?-estradiol concentration leads to a deficit of the signaling stimuli required to sustain fibroblast synthetic activity, which is clinically manifested not only in epidermal thinning but also in profound structural remodeling of the dermal matrix. Our research shows that estrogen deficiency triggers a cascade of destructive processes, activating matrix metalloproteinases that accelerate the "enzymatic digestion" of type I and III collagen fibers. As sex hormone levels decline, the interaction between cells and the extracellular matrix is disrupted, making normal renewal of the collagen framework impossible even under intensive external treatment. Hormonal status therefore serves as

the foundation upon which the body's response to any anti-aging intervention is built, whether device-based methods or nutraceutical support, making preliminary screening of the endocrine background mandatory for any personalized treatment protocol.

The functional status of the thyroid gland, represented in our study by TSH and free thyroxine levels, also plays an important role in the pathogenesis of chronoaging. Thyroid hormones govern the intensity of overall cellular metabolism, regulating the rate of epidermal cell renewal and post-injury repair. Even subclinical thyroid dysfunction, often undetected on standard examination, creates a metabolic background that substantially slows regeneration and reduces the skin's water-retention capacity. In our observations, patients with borderline TSH values showed a more pronounced tendency toward the fine-wrinkled aging type, attributable to impaired hydration processes and reduced hyaluronic acid synthesis. This supports the concept of the skin as an indicator of systemic health: any metabolic shift occurring at the level of the hypothalamic-pituitary-thyroid axis is inevitably reflected in the structural parameters of the dermis, visible on high-frequency ultrasound scanning as areas of reduced acoustic density.

Equally debated and practically significant is the role of prolactin in the development of age-related skin changes, a topic that has long remained outside the focus of aesthetic dermatology. Excess prolactin production under stress-an inevitable companion of the modern pace of life-stimulates specific skin receptors, contributing to impaired keratinocyte differentiation and the development of chronic inflammation. Our data indicate that elevated prolactin levels are often associated with the deformational aging type, characterized by pronounced tissue puffiness and pastiness, which complicates device-based correction and requires preliminary stabilization of neuroendocrine status. Understanding the pathogenetic role of prolactin allows for more precise treatment selection, avoiding procedures that could exacerbate underlying inflammation and favoring protocols that include antioxidant support and gentle device-based intervention.

Integrating instrumental diagnostic methods into the assessment of hormone-dependent aging enables a shift from conjecture to rigorous evidence-based medicine. High-frequency ultrasound at 33 MHz and 75 MHz allows in vivo analysis of dermal morphology, providing objective documentation of epidermal thinning and dermal matrix degradation that directly result from hormonal deficiency. Comparative analysis of dermal acoustic density across different age groups convincingly demonstrates that structural tissue changes occur in parallel with hormonal profile dynamics, allowing ultrasound markers to serve as prognostic criteria. Developing a personalized correction algorithm based on ultrasound morphometry and endocrine parameters makes it possible to predict treatment efficacy before procedures begin, substantially improving patient satisfaction and ensuring the durability of aesthetic outcomes.

A promising direction in correcting hormone-related age-related changes is the synergy between device-based methods and the targeted delivery of biologically active molecules such as resveratrol. Using microneedle radiofrequency lifting combined with fractional thulium laser not only stimulates neocollagenesis through thermal activation of fibroblasts but also creates microchannels for deep phytoestrogen penetration. Resveratrol, with its pronounced antioxidant and hormone-like effects, provides local support for skin metabolism by activating estrogen receptors and reducing oxidative stress. This approach is pathogenetically justified, as it aims to restore the lost hormonal signal directly within the target tissues, making the therapy maximally targeted and physiological.

In conclusion, it should be noted that the future of dermatocosmetology lies in interdisciplinary collaboration between dermatologists and endocrinologists, grounded in a deep understanding of the biological laws of aging. Only through the integration of systemic hormonal analysis and high-technology instrumental tissue monitoring can

stable, predictable, and safe correction outcomes be achieved that meet the highest standards of contemporary aesthetic medicine. We are convinced that the transition to predictive diagnostic models using artificial intelligence to process integrated data on hormonal status and ultrasound morphology will be the next evolutionary step in the specialty's development, enabling effective management of aging processes and long-term preservation of the skin's functional reserve.

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