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MICRONEEDLE RADIOFREQUENCY LIFTING IN CONTEMPORARY AESTHETIC DERMATOLOGY: PATHOGENETIC RATIONALE AND MORPHOLOGICAL EFFECTS

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Abstract: This paper presents the scientific rationale for the use of microneedle radiofrequency (RF) lifting in dermatocosmetology. The physical principles of the method, which enable deep restructuring of the dermal matrix through controlled thermal exposure and stimulation of neocollagenesis, are examined. The efficacy of the method is demonstrated both as a standalone approach for correcting age-related skin changes and as part of combined synergistic protocols. Instrumental verification data of the morphological effects are presented, including increases in dermal thickness and acoustic density. The findings support the high therapeutic value and safety of the method for patients with various aging morphotypes, positioning microneedle RF-lifting as a tool of precision evidence-based medicine in anti-aging correction.

Keywords: microneedle radiofrequency lifting; neocollagenesis; dermal acoustic density; dermatocosmetology; aesthetic correction; chronoaging; physiotherapeutic methods; fibroblasts; precision medicine; device-based therapy.

In contemporary aesthetic medicine, microneedle radiofrequency lifting has firmly established itself as one of the most effective and pathogenetically justified device-based methods for correcting age-related skin changes, achieving a pronounced rejuvenating effect without extensive surgical intervention. Unlike classical superficial methods, this approach is based on the controlled fractional delivery of high-frequency electrical energy directly into the dermal layer, enabling deep structural tissue reorganization. The physical principle of the method relies on the ionic conductivity of biological media, in which water containing dissolved electrolytes acts as a conductor, and as current passes through, energy is dissipated as Joule heat. Controlled heating of the dermis to target temperature ranges, delivered via microneedles, triggers activation of enzymatic processes and stimulates fibroblast functional activity-a key step in restoring the collagen framework.

In-depth pathophysiological analysis shows that the efficacy of microneedle RF-lifting stems not only from thermal injury but also from the initiation of a cascade of regenerative reactions. At temperatures in the range of 55-65 °C, collagen protein denaturation occurs, causing immediate fiber contraction and producing the primary lifting effect. However, the true value of the method lies in the subsequent phase of neocollagenesis, during which activated fibroblasts begin intensive synthesis of extracellular matrix proteins. Under conditions of age-related estrogen deficiency, when the natural synthesis of type I and III collagen is slowed, device-based stimulation becomes a critically important trigger capable of "restarting" metabolic processes within the dermis.

To evaluate the efficacy of the developed protocols, a comparative analysis of skin elasticity parameters was performed across the study groups. The results are presented in Table 1.

Table 1. Comparative dynamics of skin elasticity (R2) six months after the treatment course.

Patient group	Treatment protocol	R2 value (before treatment)	R2 value (after treatment)	Increase
Group I	RF-lifting + thulium laser + resveratrol	0.58 ± 0.04	0.84 ± 0.03	+44.8%
Group II	RF-lifting monotherapy	0.59 ± 0.05	0.72 ± 0.04	+22.0%
Group III	Laser therapy + resveratrol	0.57 ± 0.04	0.68 ± 0.05	+19.3%

The combined use of microneedle radiofrequency energy and thulium laser realizes a principle of pronounced synergism, in which radiofrequency energy achieves deep dermal restructuring by creating fractional zones of coagulation, while thulium laser irradiation promotes active epidermal renewal and additional stimulation of neocollagenesis in the superficial layers. Microneedle radiofrequency technology delivers energy directly into the deep dermis, bypassing the epidermal barrier, which minimizes the risk of hyperpigmentation and shortens the recovery period.

A key advantage of microneedle radiofrequency therapy is its capacity for selective action on the deep skin layers, confirmed by high-frequency ultrasound (HFUS) data. Using 33 MHz and 75 MHz transducers allows in vivo visualization of increased dermal acoustic density following a course of procedures. We observed that after radiofrequency energy exposure, the architecture of the dermal matrix becomes more organized, and zones of rarefaction characteristic of atrophic changes are replaced by newly formed collagen bundles.

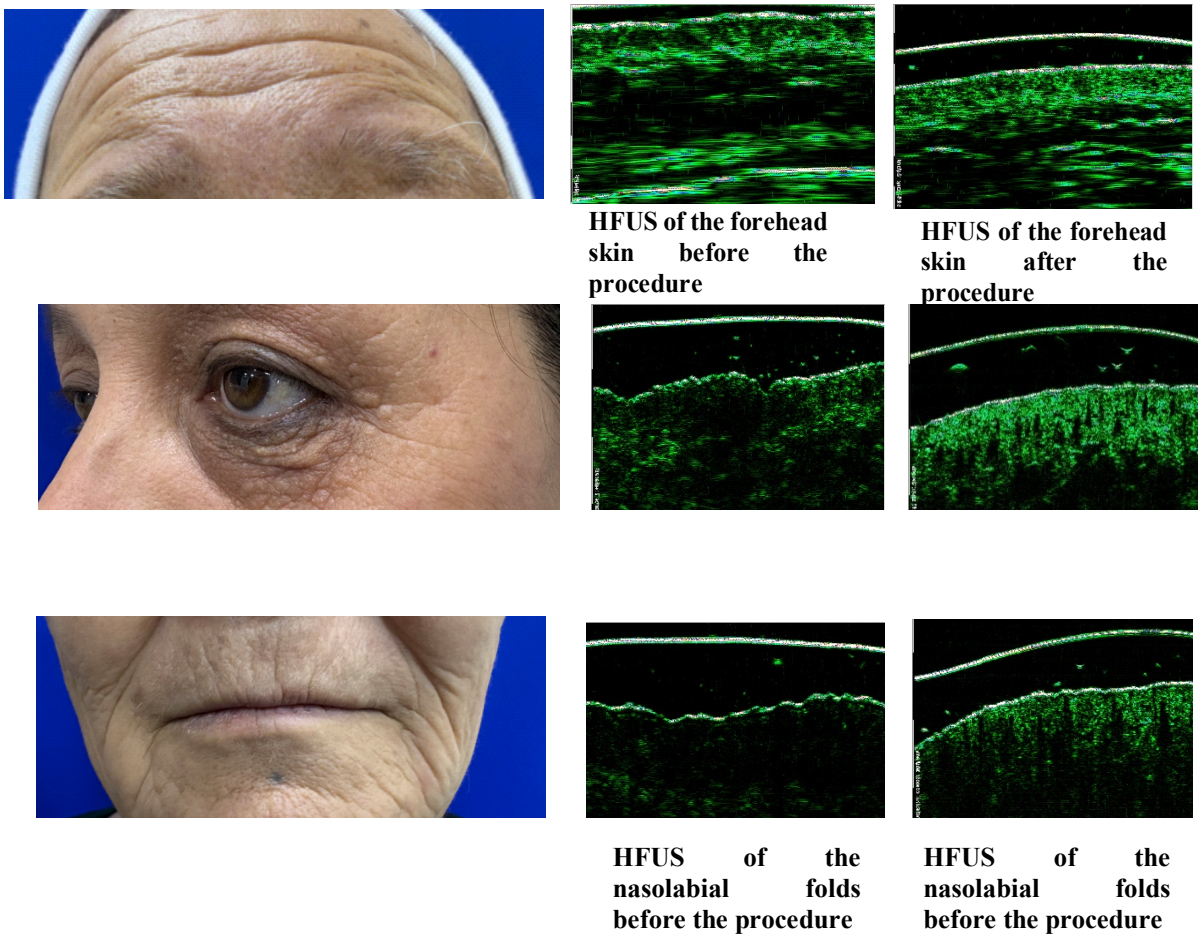

Figure 1. Representative high-frequency ultrasound (HFUS) images and clinical photographs of the forehead, periorbital, and perioral zones, illustrating dermal structure and skin surface condition in the course of combined microneedle RF-lifting and thulium laser therapy.

Analysis of these images reveals uneven echogenicity of the dermal layer: zones of reduced acoustic density are visualized, indicating fragmentation of collagen fibers and diminished functional activity, characteristic of chronoaging processes. Baseline dermal acoustic density (DAD) values in these zones are typically low, objectively confirming the presence of degenerative connective tissue changes. This baseline echographic picture is a key marker allowing patients to be stratified by risk group and radiofrequency treatment parameters to be adapted accordingly. The visually apparent rarefaction of the dermal layer on these scans correlates with clinical signs of reduced tone and the depth of expression lines, which, together with hormonal profile data (estradiol and TSH levels), forms a comprehensive diagnostic profile for the patient. Recording baseline ultrasound parameters is therefore an essential step, providing the evidence base needed to verify subsequent neocollagenesis and structural skin recovery during follow-up.

The scientific rationale for the efficacy of this method is supported by long-term clinical observation and instrumental diagnostics. Research shows that microneedle radiofrequency lifting provides the most predictable stimulation of fibroblasts, promoting synthesis of type I and III collagen as well as fibronectin and glycosaminoglycans. Under conditions of estrogen deficiency accompanying natural chronoaging, device-based stimulation becomes practically the only effective means of "awakening" the synthetic potential of fibroblasts. Our data show that after a course of procedures, patients in the older age group exhibit a statistically significant increase in dermal thickness, objectively confirming the high therapeutic value of the method.

The safety of the procedure, ensured by minimizing thermal injury to the epidermis through the use of insulated microneedles, allows correction to be performed in patients of various Fitzpatrick phototypes, including darker skin prone to post-inflammatory hyperpigmentation. Within combined protocols pairing microneedle RF-lifting with fractional thulium laser and topical phytoestrogen therapy, a synergistic effect is achieved that substantially improves the skin's biomechanical properties, including elasticity and hydration levels. Microneedle radiofrequency lifting thus represents a fundamental element of the contemporary evidence-based approach to aesthetic correction, providing high precision, predictability, and long-term preservation of aesthetic outcomes.

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