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Evaluation of eyelid dermal thickening following EndoliftX® treatment with a 1470 nm diode laser: assessment using a high-frequency linear ultrasound probe

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ABSTRACT

This study examines the impact of EndoliftX® 1470 nm diode laser treatment (Eufoton®, Trieste, Italy), which utilizes specific 200-300 µm conically shaped micro-optical fibres with radial emission (ELX 200-300 Radial fibres), on eyelid dermal thickness. Ten patients underwent three laser sessions with high-frequency linear ultrasound imaging using the Esaote SL3116 probe to measure dermal changes at baseline, one month, and three months post-treatment. EndoliftX®, a minimally invasive laser procedure, delivers energy subdermally, promoting collagen remodeling and skin firming while preserving the epidermal integrity. The results indicated a consistent and significant increase in dermal thickness, demonstrating the potential of EndoliftX® as a valuable, non-surgical option for periorbital rejuvenation in oculoplastic practice. These findings underscore the importance of precise, non-invasive imaging techniques, such as the Esaote SL3116 probe, in objectively quantifying treatment outcomes.

Key words: interstitial laser therapy; skin laxity; periorbital region.

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Introduction

Overview of aging in the periorbital area

The periorbital area, encompassing the eyelids and surrounding skin, is highly susceptible to aging.[1] Over time, this region undergoes thinning, reduced elasticity, and increased laxity due to intrinsic and extrinsic factors. Intrinsically, age-related changes in dermal collagen and elastin content result in diminished skin integrity and sagging,[2] while extrinsically, exposure to UV radiation and environmental stressors exacerbate the degradation of connective tissue. Consequently, the eyelid skin, among the thinnest in the human body, is often the first area where signs of aging appear, such as fine lines, wrinkles, and excess skin, which can contribute to a tired or aged appearance.

Non-surgical interventions for eyelid rejuvenation

With growing demand for minimally invasive aesthetic procedures, non-surgical techniques for eyelid rejuvenation have become increasingly popular.[3] In oculoplastic practice, various energy-based devices, including fractional ablative and non-ablative lasers, radiofrequency, and ultrasound, are utilized to enhance skin tightness, firmness, and elasticity without the downtime associated with surgical interventions like blepharoplasty. Among these techniques, the use of lasers, particularly those operating at specific wavelengths, has gained prominence for their ability to stimulate collagen remodeling and provide a natural lifting effect by targeting the deeper layers of the dermis.

The role of the EndoliftX® technique

EndoliftX® 1470 nm diode laser (Eufoton®, Trieste, Italy) is particularly effective in non-surgical rejuvenation procedures due to its high absorption by water and collagen in the skin.[4] This targeted absorption allows the laser to generate a controlled thermal effect within the dermis, contracting existing collagen fibres and promoting fibroblast activation, leading to new collagen production over time. EndoliftX®,[5] a minimally invasive procedure, utilizes 200 µm micro-optical fibres conically shaped with specific radial emission to deliver laser energy subdermally (ELX 200 Radial fibres). The laser emission was set in pulsed mode, with a Ton of 50 ms and a Toff of 50 ms. Energy levels ranged between 20 and 30 J per eyelid. This method creates a "lifting" effect by directly applying heat to the connective tissue within the dermis, which helps tighten the skin without affecting the epidermis,[6] minimizing surface damage, and preserving the natural appearance.[7]

Mechanism of EndoliftX® and benefits for eyelid treatment

EndoliftX®'s subdermal energy application distinguishes it from conventional lasers. By inserting a radial micro-optical fibre (ELX 200-300 Radial fibres) into the dermis through a tiny entry point, the laser energy can penetrate the dermal layer with minimal invasiveness. This subdermal approach is particularly advantageous for sensitive areas like the eyelids, where traditional laser applications might damage the delicate skin surface. The thermal effect created by EndoliftX®'s wavelength induces collagen contraction and stimulates fibroblasts,[8] encouraging collagenesis, which strengthens the skin and improves elasticity over time. In clinical terms, these effects could potentially lead to a marked reduction in periorbital laxity and a more youthful contour without surgical risks.[9]

Previous research on laser treatments in the periorbital area

Prior studies have shown that laser treatments can effectively address skin laxity and improve dermal thickness across different areas of the face. However, specific research on the application of interstitial laser treatments in the eyelid area remains limited, particularly with the EndoliftX® technique. Studies on other regions suggest that EndoliftX® promotes long-lasting collagen remodeling,[2] but further research is needed to confirm its safety and efficacy specifically in the periorbital region. This study seeks to fill this gap by investigating the effect of EndoliftX® on eyelid skin thickness and elasticity, providing objective data using advanced imaging techniques.

Materials and Methods

This prospective observational study involved a sample of 10 patients (7 females and 3 males) aged 35-55 who exhibited moderate to severe periorbital skin laxity. Given the focus on a detailed analysis of dermal changes, the small sample size allowed for in-depth examination of each patient's response to the EndoliftX® procedure. The study took place in a clinical oculoplastic setting, and all patients provided informed consent in accordance with ethical guidelines.

Inclusion and exclusion criteria

Participants included adults with visible periorbital skin laxity and no recent history of laser or surgical treatments in the area. Patients who had received anti-aging treatments such as dermal fillers, neurotoxin injections, or any form of laser resurfacing within the past three months were excluded to ensure that observed changes could be attributed solely to the EndoliftX® treatment. Exclusion criteria also encompassed patients with active skin infections, photosensitivity, autoimmune diseases affecting the skin, and a history of eyelid surgery or conditions such as blepharitis or rosacea.

Laser treatment protocol with EndoliftX®

The EndoliftX® procedure involved the use of a 1470 nm diode laser connected to micro-optical radial fibres,[10] measuring 200 or 300 µm in diameter (ELX 200-300 Radial fibres). The choice of micro fibre diameter[11] was based on the specific requirements of each patient's dermal thickness and target area, with 200 µm fibres used for precise work in thinner regions and 300 µm fibres for areas where deeper collagen stimulation was desired.[12] Each patient underwent three treatment sessions spaced one month apart, following a standardized protocol designed for eyelid skin.[13] Energy levels ranged between 20 and 30 J. The laser emission was set in pulsed mode, with a Ton of 50 ms and a Toff of 50 ms. The EndoliftX® fibre was introduced subdermally through a micro-incision, allowing the laser to be delivered directly within the dermal layers. This subdermal application enables collagen remodeling at a deep level, as the heat generated by the laser contracts existing collagen fibres and stimulates fibroblasts, promoting collagen synthesis.[14] For patient comfort, a topical anesthetic cream, containing lidocaine (base) 25 mg (2.5%) and prilocaine (base) 25 mg (2.5%) in a hydrophilic base composed of macrogol 300, macrogol 1500, carbomer, sodium hydroxide (for pH adjustment), and purified water (EMLA®), was applied to the treatment area 30 minutes before each session. Cooling measures, such as the use of cold-air devices, were employed during the procedure to minimize the risk of erythema and oedema.[15] Following the procedure, a topical cream containing gentamicin and betamethasone was applied in accordance with the standard EndoliftX® protocol. Patients were advised to continue daily applications for an additional 72 hours and were instructed to avoid any pressure or contact on the periocular area during this period.[16]

No post-procedural complications were observed, apart from a transient moderate oedema, which resolved spontaneously within five days.[17]

Primary outcome: dermal thickness evaluation

The primary outcome measure was the change in dermal thickness in the treated eyelid area, assessed using the Esaote SL3116 high-frequency linear ultrasound probe.[18] This device, with an 18 MHz frequency and a 6 cm field of view, provides exceptional imaging quality, particularly suited to the eyelid's thin dermal structure. Ultrasound assessments were performed at three consistent points on each eyelid (upper and lower) for each patient, and measurements were taken at baseline, one month post-treatment, and three months post-treatment.

Ultrasound imaging procedure

The Esaote SL3116 probe was chosen for its ability to capture high-resolution images, allowing precise monitoring of dermal thickness changes over time. Baseline images provided a reference for evaluating post-treatment changes, with subsequent images at each follow-up session offering insights into the progression of collagen remodeling induced by the EndoliftX® laser.

Data analyses and image processing

Each ultrasound image was analyzed by trained technicians using specialized software to identify and measure dermal thickness. Given the probe's high-frequency resolution, even minimal changes in thickness were detected with high accuracy, ensuring the reliability of measurements. Data from each patient were digitally recorded and compared across the three time points, providing a comprehensive dataset for statistical analyses.

Statistical analyses

A paired *t*-test was employed to assess statistically significant differences in mean dermal thickness measurements between baseline and post-treatment stages. Statistical significance was defined at $p<0.05$. Additionally, patient satisfaction and subjective evaluations of skin elasticity were collected using standardized questionnaires to complement the quantitative ultrasound data. Patient feedback was analyzed for correlation with measured outcomes, adding a subjective dimension to the clinical assessment. Ultrasound confirmed an increase in dermal thickness.

Results

Quantitative changes in dermal thickness

The results demonstrated a significant increase in dermal thickness among all patients following the EndoliftX® treatment, as measured by the Esaote SL3116 ultrasound probe.

One month post-treatment

At the first follow-up, patients showed an average increase in dermal thickness of 0.15 mm, or approximately 12% from baseline, confirming that collagen remodeling had begun. This initial increase suggests that the thermal effects of the EndoliftX® laser produced an immediate impact on collagen contraction.[19]

Three months post-treatment

At the three-month follow-up, the average thickness increase reached 0.25 mm, equivalent to an 18% improvement from baseline. This continued increase aligns with the hypothesis that collagen remodeling and neocollagenesis, stimulated by the EndoliftX® laser, progress over several months, suggesting that the effects of EndoliftX® extend beyond the immediate post-treatment period. Figure 1 displays the mean dermal thickness values across the three time points, highlighting the steady increase over time.

High-resolution ultrasound imaging results

High-resolution images[18] captured by the Esaote SL3116 probe provided detailed views of the structural improvements within the dermis. Post-treatment images showed increased density in collagen-rich areas, with clear enhancement in dermal uniformity and thickness. Figure 2 presents side-by-side comparisons of baseline *vs.* post-treatment images, illustrating the dermal improvements achieved at the three-month mark. These images corroborate the quantitative findings, visually confirming the thickening effect induced by the EndoliftX® laser. Table 1 shows the comparison of skin thickness measured before and after treatment.

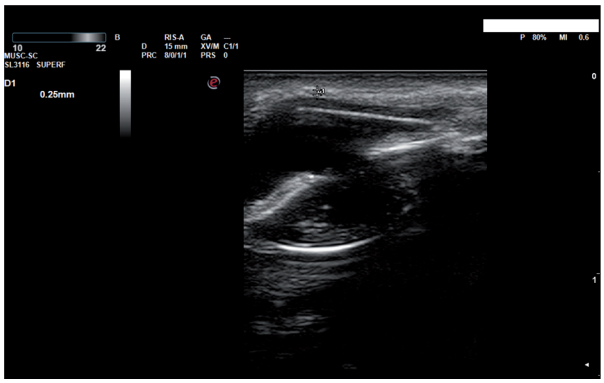

Figure 1. Pre-treatment and post-treatment ultrasound images showing overall dermal thickening in the lower eyelid region.

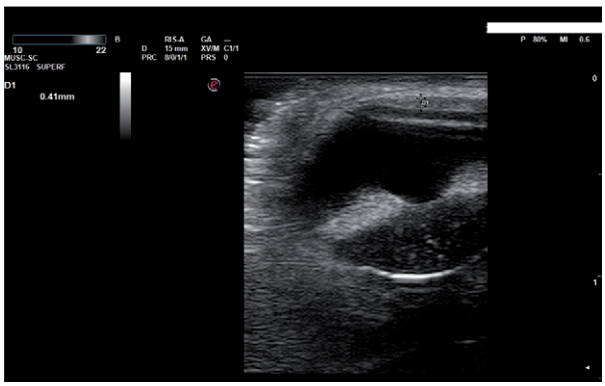

Figure 2. High-resolution ultrasound images demonstrating increased skin density post-treatment.

Table 1. Changes in skin thickness before and after treatment indicate uniform collagen stimulation and remodeling across patients with varying skin laxity.

Patient	Age	Gender	Skin thickness before treatment (mm)	Skin thickness after treatment (mm)	Increase (%)
1	40	F	0.62	0.75	20.97
2	47	F	0.68	0.81	19.12
3	50	M	0.64	0.77	20.31
4	42	F	0.61	0.73	19.67
5	35	F	0.66	0.79	19.70
6	48	F	0.63	0.76	20.63
7	55	M	0.70	0.84	20.00
8	43	F	0.60	0.72	20.00
9	46	M	0.67	0.80	19.40
10	39	F	0.65	0.78	20.00

Patient satisfaction and self-reported elasticity improvement
In addition to objective measurements, patients provided feedback on their perceived improvements in skin elasticity and firmness. Using a standardized questionnaire, participants rated their satisfaction with the treatment outcome, resulting in an average satisfaction score of 4.2 out of 5. Eight out of ten patients reported noticeable improvements in skin elasticity, with specific comments highlighting a reduction in fine lines and a firmer appearance in the periorbital region. These subjective findings support the quantitative evidence of dermal thickening, reinforcing the potential of the EndoliftX® laser as a non-surgical solution for eyelid rejuvenation.

Discussion

Interpretation of findings

The findings of this study confirm that EndoliftX® laser effectively promotes dermal thickening in the eyelid region. This increase in thickness is likely due to the laser's targeted thermal impact on collagen fibres, causing immediate contraction and triggering a longer-term remodeling process. As observed in the ultrasound measurements, dermal thickness increased progressively from baseline to the three-month follow-up, with an average enhancement of 18% over the treatment period. This sustained thickening effect aligns with previous studies on laser-induced collagen stimulation, suggesting that the subdermal application of EndoliftX® produces effective and lasting results in collagen remodeling.
The use of 200 and 300 µm radial microfibres proved beneficial in this study, allowing for targeted treatment in areas with varying skin thickness. The 200 µm fibre provided precise energy delivery in the more delicate regions of the upper eyelid, while the 300 µm fibre allowed for deeper collagen stimulation in the lower eyelid, which typically exhibits greater thickness. This adaptability in fibre choice may be critical in tailoring treatments for individual patients, ensuring that energy delivery is optimized according to the specific anatomical and structural characteristics of the eyelid skin.

Clinical implications

Potential advantages of EndoliftX® in oculoplastic practice
EndoliftX® offers a promising, minimally invasive alternative to surgical blepharoplasty for patients seeking periorbital rejuvenation. By delivering energy directly within the dermal layers, EndoliftX® promotes collagen contraction and synthesis while preserving the epidermal integrity, minimizing the risk of surface damage or scarring. For oculoplastic surgeons, this technique provides a valuable addition to the repertoire of non-surgical interventions, particularly for patients who wish to avoid the risks and downtime associated with surgery. Additionally, the high satisfaction rates reported by patients in this study indicate that EndoliftX® outcomes align with their expectations for natural-looking, gradual improvements in skin firmness.

Role of high-frequency ultrasound in treatment monitoring
The integration of high-frequency ultrasound imaging, specifically using the Esaote SL3116 probe, represents a significant advancement in the objective evaluation of treatment outcomes. Traditional assessments of cosmetic procedures have often relied on subjective evaluations or visual inspections, which lack precision and reproducibility. In this study, ultrasound imaging provided reliable, quantifiable measurements of dermal thickness, allowing for an accurate assessment of treatment efficacy. By enabling clinicians to visualize changes in the dermal layer over time, high-frequency ultrasound can serve as a valuable tool for monitoring progress, making real-time adjustments to treatment protocols, and documenting outcomes for research and clinical practice.

Technical considerations and limitations

Limitations in fibre selection and energy parameters
While the EndoliftX® procedure showed positive outcomes in this study, there are technical considerations that may affect its efficacy. For instance, the choice between 200 and 300 µm micro radial fibres should be tailored to the patient's specific anatomical features, as energy penetration depth varies with fibre diameter. In patients with very thin dermal layers, even a 200 µm fibre may deliver excessive energy, potentially leading to discomfort or adverse effects. Conversely, in patients with thicker skin, the 300 µm fibre may be necessary to achieve the desired depth of collagen stimulation.[20] As EndoliftX® technology continues to evolve,[21] the development of an adjustable combination of different settings (power, pulse duration, and energy delivered) may allow for even greater precision and customization.

Challenges in ultrasound imaging of eyelid skin
Although the Esaote SL3116 probe provided high-resolution images, ultrasound imaging of the eyelid region poses unique challenges due to the skin's thinness and mobility. Minor movements, even those caused by blinking, can affect image clarity and consistency, requiring technicians to take multiple measurements to ensure accuracy. Additionally, variations in probe pressure can alter thickness measurements, necessitating a standardized technique for obtaining consistent readings. Future studies may benefit from automated or robotic ultrasound systems that maintain consistent pressure and positioning, further enhancing the reliability of measurements in delicate areas like the eyelids.

Sample size and generalizability
The primary limitation of this study is its small sample size, which restricts the generalizability of the findings. While the results indicate significant improvements in dermal thickness, further research with larger and more diverse populations is necessary to confirm these findings and assess variations in treatment response. Additionally, studies involving different skin types and ages would provide a broader understanding of how demographic factors influence outcomes with the EndoliftX® technique. Larger sample sizes would also increase the statistical power of the results, allowing for more precise conclusions regarding the efficacy and safety of 1470 nm EndoliftX® laser treatments.

Future research directions
Comparative studies with other laser technologies
This study focused exclusively on the EndoliftX® system. Future research should investigate the efficacy of the same wavelength when applied using fractional modalities (*e.g.*, LightSCAN™) immediately afterward in a "sandwich" procedure, including fractional CO_2 lasers or radiofrequency devices, which are also commonly employed for periorbital rejuvenation. Comparative studies could determine if EndoliftX® offers superior outcomes in terms of collagen stimulation,[20] patient satisfaction, and treatment safety, helping clinicians make more informed decisions regarding the best technology for different patient needs. Furthermore, such studies may reveal specific advantages of the subdermal EndoliftX® technique relative to surface-based laser (transdermal) applications.

Long-term follow-up and maintenance treatments
While the three-month follow-up period in this study provided valuable insights into the short-term effects of EndoliftX®, further research is needed to assess the long-term durability of the treatment results. Studies tracking patients for 12 months or longer would provide a clearer picture of the duration of dermal thickening and collagen remodeling induced by the EndoliftX® laser. Additionally, long-term studies could determine the optimal maintenance regimen to sustain treatment benefits over time, potentially offering a more standardized approach for clinicians when advising patients on post-treatment care.

Conclusions
This study demonstrates that EndoliftX®, delivered *via* 200 and 300 µm optical radial fibres, effectively enhances dermal thickness in the eyelid region, providing a minimally invasive option for periorbital rejuvenation. The subdermal application of energy allows for targeted collagen remodeling, with significant increases in dermal thickness observed at both one and three months post-treatment. These findings suggest that EndoliftX® may serve as a valuable alternative to surgical blepharoplasty for patients seeking non-surgical solutions to eyelid laxity. The use of high-frequency ultrasound imaging with the Esaote SL3116 probe proved critical in quantifying treatment outcomes, offering an objective method for monitoring changes in dermal structure over time. By combining advanced imaging technology with the precise energy delivery of EndoliftX®, this study provides a foundation for future research on non-surgical eyelid rejuvenation. Additional studies with larger sample sizes, longer follow-up periods, and comparative analyses with other laser technologies are recommended to confirm these results and refine treatment protocols.

Contributions
GM, clinical evaluation, data collection, manuscript draft; RR, study design, ultrasound evaluation, manuscript review. All authors have read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Conflict of interest

The authors have no conflict of interest to declare.

Ethics approval and consent to participate

This study involved only non-invasive ultrasound evaluation of dermal thickness in patients undergoing eyelid treatment using the EndoliftX® clinical protocol, which is based on a 1470 nm diode laser. No tissue samples were collected, and no identifiable patient data were used. All procedures were carried out as part of routine clinical practice. Therefore, ethical committee approval was not required, in accordance with applicable research regulations. All participants provided informed consent to participate in this study.

Availability of data and materials

All data underlying the findings of this study are available from the corresponding author upon reasonable request.

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