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In vivo pilot study of the effects of a subdermal 1470 nm diode laser on human skin

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ABSTRACT

This *in vivo* pilot study investigates the histological regenerative effects of a subdermal 1470 nm laser (EndoliftX®, Eufoton® , Trieste, Italy) on human abdominal skin, aiming to assess its role in dermal remodeling. Laser energy was delivered at 5, 20, and 40 J/cm^2 to defined areas of abdominal skin in patients undergoing abdominoplasty. Biopsies were obtained at 3 and 6 months post-treatment and assessed for changes in dermal thickness, collagen, and elastin content compared to the control untreated region. Histological staining and image analysis revealed that the 5 and 20 J/cm^2 treatments significantly increased dermal thickness and collagen deposition, particularly with the 20 J/cm^2 dose, which induced dense, organized collagen bundles indicative of neocollagenesis. Sirius red staining showed increased type III collagen, and Verhoeff-Van Gieson (VVG) staining indicated enhanced and more aligned elastin fibers at moderate energy levels. Conversely, the 40 J/cm^2 treatment dose showed signs of collagen fragmentation and reduced elastin coherence, suggesting potential thermal damage. These findings confirm the efficacy of EndoliftX® in promoting skin tightening and remodeling at optimal energy settings while highlighting a non-linear dose-response relationship. The results support further development of personalized protocols for minimally invasive procedures in regenerative medicine and aesthetic dermatology.

Key words: diode laser therapy; Endolift®; skin tightening; lipolysis.

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Introduction

Since the 1990s, there have been significant advancements in the medical and surgical use of laser technology. In dermatology, a variety of laser techniques, including non-ablative, ablative, and fractional methods, are widely utilized for skin rejuvenation, scar treatment, and pigmentation correction.[1-4] While non-ablative lasers are non-invasive, delivering energy beneath the skin without damaging the surface, ablative lasers are considered minimally invasive, as they remove the outer layers of the skin to stimulate regeneration.[5] Beyond these surface-level interventions, lasers have also become integral to more invasive procedures. A key example is laser-assisted liposuction, a technique with a long clinical history.[6] This approach uses laser energy delivered directly beneath the skin to liquefy fat, tighten tissue, and enhance contouring, often improving both aesthetic outcomes and skin retraction.

Laser-assisted liposuction (also known as laser lipolysis) is a minimally invasive technique that associates a microcannula with an optical fiber for laser emission. High laser energy induces adipose tissue thermolysis and coagulates small blood vessels.[7-9] Compared to classical liposuction, this procedure results in the reduction of intraoperative bleeding, better skin contraction, and a quicker recovery time.[10] The first laser to be cleared by the U.S. Food and Drug Administration (FDA) for laser lipolysis was a 1064 nm 6W Nd:YAG laser in 2006; since then, a variety of improved laser lipolysis systems with various wavelengths have been introduced. Among them, a laser diode system (LASEmaR® 1500, Eufoton®, Trieste, Italy) with a 1470 nm wavelength, emitted through an optical fiber with variable dimension (ranging from 200 to 600 m) and variable distal tip geometry (linear, radial, or mixed), used inside the cannulas, was associated with liposuction techniques.[11-12]

In recent years, the 1470 nm wavelength laser has been increasingly employed in surgical applications. Lasers operating in the vicinity of 1500 nm are characterized by their high absorption in water, a property that underlies their distinct biological interactions. These water-specific lasers are predominantly utilized in urological procedures and endovenous vein ablation therapies. Notably, the 1470 nm diode laser demonstrates significant tissue penetration capabilities (2-3 mm in depth) and concurrent interaction with adipose tissue.[13-14]

A recent, non-surgical development is the use of laser fibers subcutaneously on an outpatient basis. These procedures, known as EndoliftX®, involve inserting a thin, disposable laser fiber under the skin to deliver targeted energy to subdermal tissues.[15-17] Several clinical studies demonstrate that this technique is safe and effective in reducing subcutaneous fat and in obtaining a skin-tightening and regenerative effect.[18-24] A positive effect of EndoliftX® has also been observed in the treatment of skin disorders such as hypertrophic scars and acne.[25-26]

Although subdermal high-power lasers are widely used in clinical practice, the underlying mechanisms and histopathological features of skin remodeling remain partially unclear. The mechanism is thought to include the thermal activation of fibroblasts, new collagen formation, and collagen denaturation, resulting in collagen shrinkage and skin remodeling.[27] Skin tightening has been mainly quantified in the literature with photographic documentation and measurements of skin elasticity.[28-29] Fewer studies have explored the histological changes in skin treated with 1470 nm subdermal high-power laser, and several of these observations were obtained in animal models, with the advantage that more detailed time courses and more numerous sampling can be performed.[30-31]

Adjustable parameters play a crucial role in the effectiveness and safety of endolaser treatments. Factors such as power, emission mode, fiber core diameter, distal tip geometry, movement speed, and the total amount of energy delivered to the tissue (in joules) must all be carefully considered. However, a major limitation in current literature is the lack of standardization, as different studies often employ varying combinations of these parameters, making comparisons difficult. In this study, all key variables were carefully parameterized to provide a reliable and reproducible starting point. It is important to note that even minor changes, for example, using a fiber with a different core diameter, can significantly alter both the energy distribution and the resulting biological effects. Therefore, maintaining strict control over procedural variables is essential when aiming to replicate results or assess the efficacy of different protocols.

This study was designed to evaluate the *in vivo* effects of a subdermal/deep dermal high-power 1470 nm diode laser (LASEmaR® 1500 - EndoliftX®) and includes histological analysis of biopsies taken from human abdominal skin treated with EndoliftX® at varying energy densities in patients undergoing abdominoplasty.

Materials and Methods

Experimental design

Ten subjects (five at each time point), scheduled to undergo abdominoplasty for body contour improvement and/or correction of diastasis or hernia, provided informed consent for subdermal/deep dermal treatment using the LASEmaR® 1500 - EndoliftX®. The procedure was performed with EndoliftX® laped and tapered-shape fibers at varying energy settings on three 3×3 cm areas of healthy abdominal skin close to the surgical wound. Biopsies of the treated skin areas were collected at 3 and 6 months post-treatment. A non-treated control area of the same size was also biopsied for comparison.
All procedures were performed by a single operator to minimize variability. This model utilizes the feasibility of performing serial biopsies at multiple time points in patients who already have an abdominoplasty scar, typically averaging 34 cm in length, thereby minimizing additional cosmetic impact. Evidence suggests that patients exhibit greater psychological and cosmetic acceptance of procedures conducted through or adjacent to pre-existing scars compared to the creation of new surgical sites.

Surgical technique and laser treatment

The techniques for traditional abdominoplasty and lipoabdominoplasty used in this study were carried out as previously described in the literature.[32-33] Patients were marked with a midline drawing from the xiphoid to the umbilicus and the anterior vulvar commissure. The incision was marked on average 7 cm superior to the vaginal introitus. It was then extended 7 cm to each side, resulting in a straight line roughly 14 cm above the mons pubis. Tumescent liposuction, initiated with infiltration of Klein solution (lidocaine 0.1%, epinephrine 1:1.000,000), was employed as needed to achieve optimal body contouring.[34] Fat aspiration was carried out using a 3-4 mm cannula connected to a suction-generating source. Abdominoplasty is standardized according to Saldanha's technique, starting with the isolation of the superficial fascia over the entire sub-umbilical portion. The dissection proceeds along the plane of the muscular aponeuroses down to the umbilical level. Once the infraumbilical undermining is completed, the flap is divided at the midline, and the umbilicus is freed through a circular incision while remaining attached to the fascia. Undermining then continues in the supraumbilical area and may extend to the xiphoid process, depending on the extent of rectus muscle plication required. For diastasis repair, plication of the rectus muscles was performed with a combination of interrupted, buried, figure-of-eight #0 polydioxanone suture and running #0 Maxon (Covidien, Mansfield, MA). Excess skin from the lower abdomen should be removed after checking that the flap easily reaches the symphysis pubis. The abdomen is closed at two levels, with Vycril 3-0 for the subcutaneous cellular tissue and 4-0 for the subdermis. Two suction drains were used in all cases in the pubic area and then removed on the second postoperative day. At the end of abdominoplasty procedures, three of the four 3x3 cm areas designed on abdominal skin were subdermally irradiated with a 1470 nm diode laser EndoliftX® at the doses of 5, 20, and 40 J/cm^2, through a EndoliftX® laped and tapered-shape fibers of 300 m, at a fixed power of 2.5 W and a pulsed emission mode (50 ms on/50 ms off). In this context, the parameter J/cm^2 was considered as a simplified measure of dynamic energy delivery over an area of 1 cm^2, rather than a conventional static fluence per pulse. One area was left untreated as a control (Figure 1). Skin areas were not randomized for dose assignment. The allocation was performed based on anatomical symmetry and proximity to ensure comparability while allowing a clear distinction between treatment areas. Untreated control areas were selected in regions adjacent to the treated zones but sufficiently distant to avoid any potential influence from the laser application.
Biopsies were obtained by performing a diamond-shaped excision (1 cm) at the follow-up visit scheduled at 3 and 6 months post-treatment.

Histological studies

Following excision, each biopsy sample was formalin-fixed and paraffin-embedded. Specifically, samples were perpendicularly bisected. Then, histological sections (3 m) were cut and stained with hematoxylin-eosin (H&E) using Leica automated stainer HistoCore SPECTRA (Leica Biosystems, Nussloch, Germany). Masson's trichrome and Verhoeff-Van Gieson (VVG) stains were used to visualize collagen and elastic fibers, respectively. Additionally, picrosirius red was used to distinguish and quantify different collagen fibers, observed with bright-field or polarized microscopy. Masson's trichrome and picrosirius red stainings were performed following a manual protocol, while the VVG technique was carried out with the Ventana BenchMark Special Stains automated platform (Ventana Medical Systems, Tucson, USA).

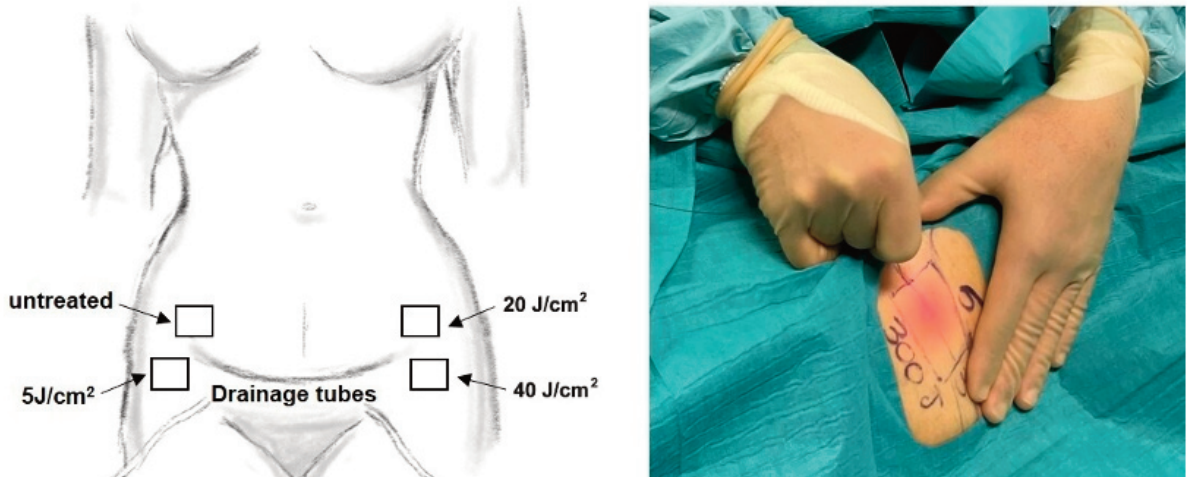


Figure 1. Designed areas and subdermal treatment using the 1470 nm diode laser EndoliftX®.

Dermis thickness

Slides stained with H&E were used to evaluate the dermal thickness of all patients. The dermal thickness was measured from the epidermal ridge and dermal papillae to the irregular dermis-subcutaneous interface. Five measurements were calculated for each tissue using NDP.view2 software (Hamamatsu Photonics Italy S.R.L.).

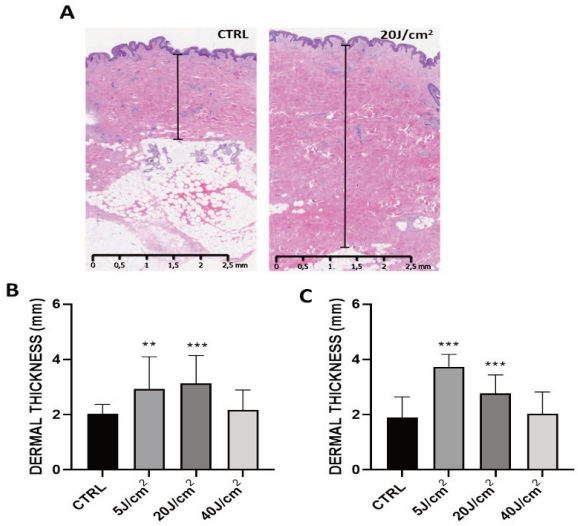
Image acquisition and procedure for quantifying collagen and elastin

Estimation of collagen content in Masson's trichrome-stained biopsies was performed using a method based on the software ImageJ/FiJi and a color deconvolution plugin as previously described.[35-36] First, the images were converted to RGB images (entering "Image" menu, "Type box" and choosing "RGB Color") and then deconvolved into their red, blue, and green (identified as collagen fibers) components using the "Color Deconvolution" in the "Plugins" menu. The threshold of the green area of the collagen fibers was manually adjusted using the "Threshold" tool. Area-based analysis ("Analyze" menu; "Area"; "Integrity Intensity"; "Limit to Threshold"; "Measurement") was finally used to extract and quantify the region of interest (ROI) from the images. For each selected ROI, the percentage of positive pixels was automatically calculated and then averaged. ImageJ/Fiji software was also employed to quantify elastic fibers, following a previously described method.[37] In brief, the original image was split into its red, green, and blue channels, and the blue channel was converted into a binary image to quantify Verhoeff-stained elastin. The total amount of elastic fibers was then assessed by measuring the percentage area (area %) occupied by the stained structures. The mean values and standard deviations of percentage measurements were calculated. Fiber orientation analysis was performed using structure tensor coherence mapping (simulating OrientationJ).[38] The slides stained with picrosirius red were examined under polarized light microscopy with a microscope (DMi8, Leica, Germany) with a 10× objective.[39]

Results

Morphological and dermal thickness analysis

The qualitative analysis and the thickness of the dermis in the control area and in the areas treated with laser at the different joule doses, as indicated in Figure 1, were carried out using slides with H&E. Representative photomicrographs of skin biopsies, either untreated or at 3 months post-EndoliftX® treatment at 20 J/cm^2, are displayed in Figure 2A. The 20 J/cm^2 treated skin showed an increase in dermal thickness over the control. No alterations were detected in the epidermis across the evaluated groups. A notable increase in dermal thickness was observed after 3 months of treatment with 5 J/cm^2 and 20 J/cm^2 compared to the control, and a statistically significant increase is



maintained after 6 months post-treatment. No significant difference was found between the control and 40 J/cm² treatment groups (Figure 2 B,C).

Quantification of collagen and elastin content

Collagen was quantified in Masson's trichrome-stained samples. Images were separated into their red, blue, and green components by deconvolution, and collagen content was quantified in the green images, in which collagen fibers show maximal separation from the background (Figure 3A).

Figure 2. (A) Representative photomicrographs of skin sections stained with hematoxylin and eosin (H&E), showing untreated skin (CTRL) and skin treated with 20 J/cm², 3 months post-treatment. (B) Quantification of dermal thickness at 3 months and (C) 6 months after treatment. Data are expressed as mean±SD from five independent measurements per patient (n=5).

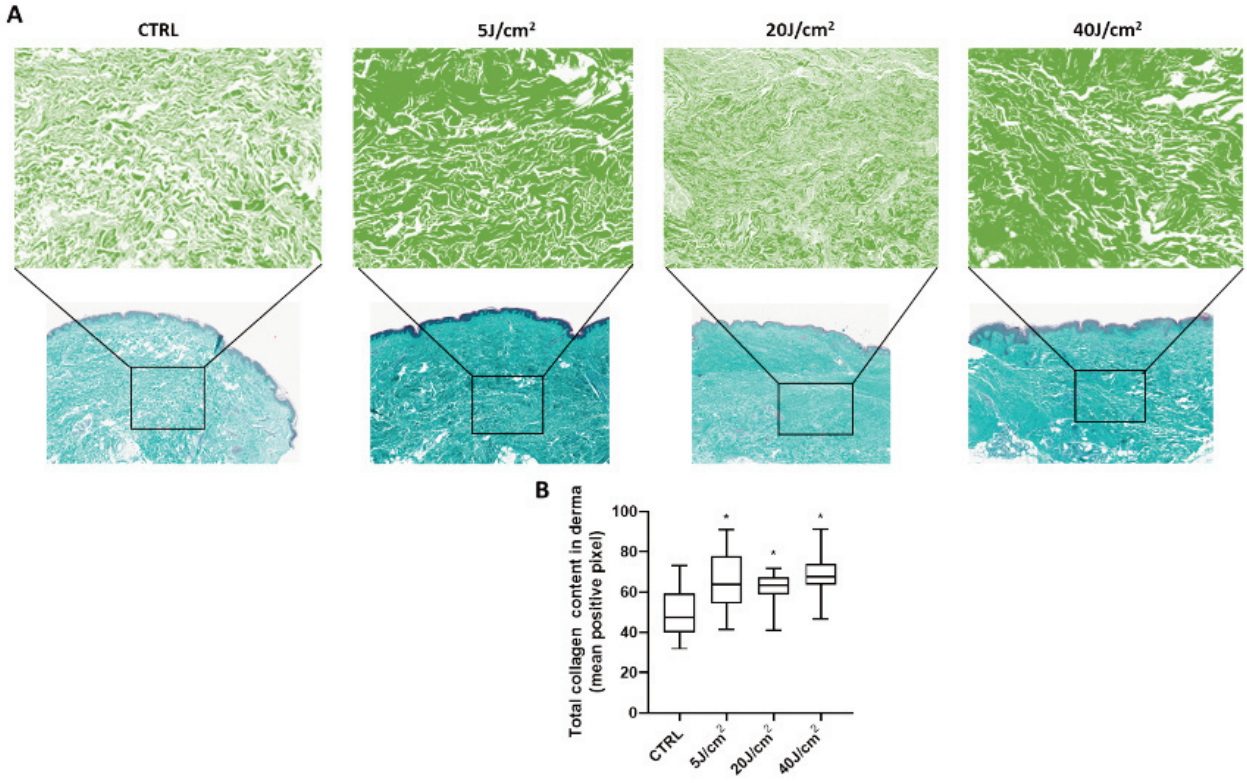


Figure 3. Images of biopsy processed by color deconvolution and collagen quantification using ImageJ software. (A) Deconvolved images into their green components (representative biopsies at 3 months post-irradiation). (B) Quantification of total collagen in biopsies from skin, untreated or 3 months post-treatment with 5, 20, or 40 J/cm², expressed as means of positive pixel ± SD of 5 patients.

At 3 months post-irradiation, collagen content was higher in all irradiation groups compared to controls (mean ± standard deviation [SD]: control [CTRL] 49.63±11.73; 5 J/cm^2 65.19±13.73; 20 J/cm^2 61.85±7.73; 40 J/cm^2 68.45±9.09) (Figure 3B). At 6 months post-irradiation, a trend in collagen increase, although not statistically significant, was observed only at 5 J/cm^2 and 20 J/cm^2 (mean±SD: CTRL 60.92±10.36; 5 J/cm^2 70.58±12.91; 20 J/cm^2 65.92±8.66; 40 J/cm^2 60.15±10.04).

The dermal collagen fibers across the analyzed samples (CTRL, 5, 20, and 40 J/cm^2) display distinct structural characteristics, which reflect laser-induced remodeling effects. In CTRL, collagen fibers appear well-distributed, forming a dense, interwoven network throughout the dermis. The architecture is homogeneous, with fibers running in multiple directions, suggesting a mature and stable extracellular matrix. This pattern corresponds to healthy, unaltered dermal collagen and serves as a reference for comparison. At 5 J/cm^2, focal zones of intensified collagen are present, which may suggest early remodeling or localized compaction. Following 20 J/cm^2 treatment, the sample shows the most extensive and intense zones of collagen condensation. Collagen fibers exhibit a wavy, bundled arrangement, consistent with active remodeling or neocollagenesis. The architecture maintains dermal integrity, but with visible densification, especially in areas perpendicular to the surface, possibly aligned with fibrous septae. This suggests a controlled photothermal effect, stimulating fibroblast activity without matrix destruction. At 40 J/cm^2, collagen is more fragmented and focal, with sharply defined high-intensity zones and reduced overall area. The fiber organization shows patches of dense collagen, surrounded by more disrupted or empty spaces. This pattern may reflect thermal damage or coagulation of collagen, followed by partial matrix collapse. The presence of compacted vertical septa supports the hypothesis of laser-induced thermal disruption, particularly affecting deeper or aligned dermal structures.

Skin sections from both control and laser-treated subjects were stained with picrosirius red and examined under polarized light microscopy. This method allows for the distinction between structurally different collagen types I and III. Newly synthesized collagen, predominantly type III, appears green or yellow, whereas mature, well-organized type I collagen bundles display red to orange birefringence.[40] In control samples, most collagen fibers appeared red, indicating the presence of thick, mature type I collagen. In contrast, in sections obtained 3 months after irradiation, particularly those treated with 5 and, more markedly, 20 J/cm^2, green/yellow areas were observed interspersed among collagen fibers, reflecting the presence of newly formed type III collagen and associated extracellular matrix remodeling (Figure 4).

While changes in collagen are often the primary focus when evaluating the effects of laser, we also aimed to investigate alterations in elastic tissue. Representative samples of elastin microscopic evaluation using Verhoeff staining are shown in Figure 5A.

The 20 J/cm^2 and 40 J/cm^2 treatments generated an increase in elastin content measured as % area of elastin (Figure 5B). Based on elastin fiber orientation analysis, 20 J/cm^2 treatment showed the highest fiber alignment, suggesting well-organized and possibly newly structured elastin fibers; 5 J/cm^2 shows increased coherence compared to CTRL, indicating some reorganization, while 40 J/cm^2 shows less alignment, suggesting possible fiber damage or fragmentation. This trend was maintained at 6 months post-treatment, although no statistically significant differences were observed, probably due to lower elastin levels in all conditions in some patients, suggesting an individual response to laser treatment and potential biological differences in the remodeling capacity of elastic fibers (mean±SD: CTRL 12.0±7.3; 5 J/cm^2 18.8±10.4; 20 J/cm^2 16.5±12.7; 40 J/cm^2 12.5±9.2).

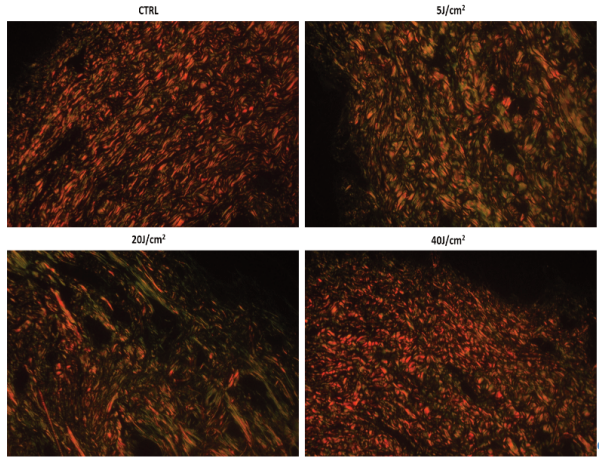


Figure 4. Representative histological sections of skin biopsies at 3 months post-laser treatment with varying joule intensities, stained with picrosirius red and viewed under polarized light. Type I collagen appears yellow-red, and type III collagen appears green. Control skin (CTRL) shows predominantly red fibers, while laser-treated samples display increased green to yellow-green birefringent fibers.

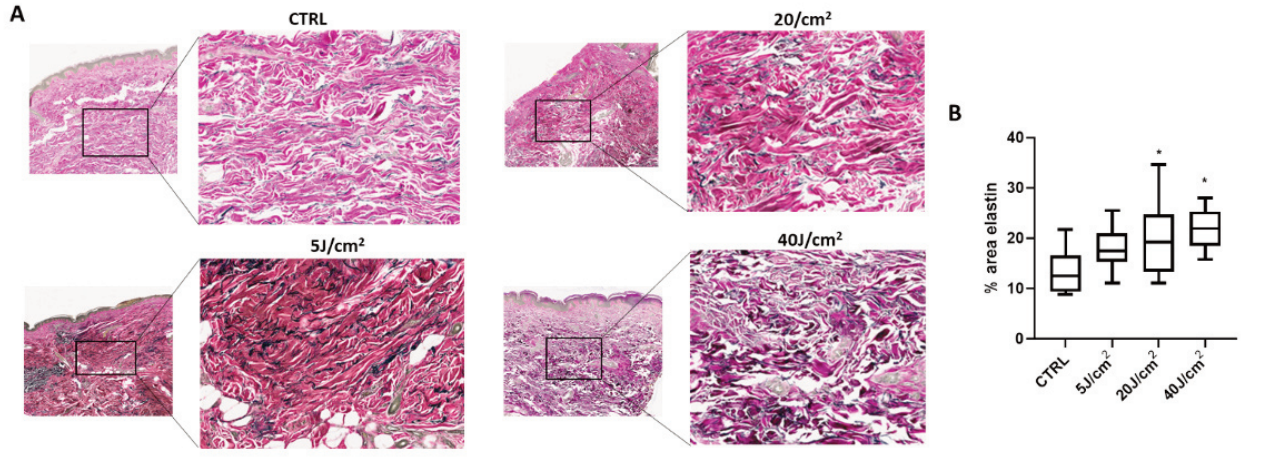


Figure 5. Elastin expression within skin at 3 months post-irradiation with different joule intensities. (A) Results of elastic fibers in tissue stained with Verhoeff-van Gieson (VVG). (B) Elastin content expressed as percentages (%) of elastin content area (in pixel^2) referred to one representative patient (n=5±SD).

Discussion

Numerous studies have highlighted the beneficial effects of subdermal/deep dermal laser technology, not only in targeting fat deposits but also in influencing the surrounding tissues. A variety of laser- and light-based technologies have been utilized in the past to enhance skin texture and overall quality. However, all these devices are applied externally, meaning that their energy, whether from lasers, light, radiofrequency, or ultrasound, must penetrate through the epidermis and dermis to effectively reach the connective tissue. A newly introduced laser technology (EndoliftX®), applied internally within the subcutaneous tissue, has recently been reported for the treatment of localized fat and skin tightening.

Although this laser was initially intended for lipolysis, its ability to induce subcutaneous tissue contraction and, most importantly, skin tightening, significantly broadens the scope of liposuction in various cases. The energy applied to the subcutaneous tissue not only breaks down fat cells (laser lipolysis) but also stimulates the production and restructuring of collagen, leading to a firming effect on the skin. In our experimental design, laser treatment at different joule doses was performed on healthy abdominal skin of subjects who underwent abdominoplasty. All four areas were unaffected by the surgical procedure but remained close enough to allow biopsies easily.

Histological staining of the biopsies at 3 and 6 months using Masson's trichrome and picrosirius red provided insights into dermal matrix changes. Quantification of collagen showed increased content in all treated areas, particularly at 20 J/cm^2. Structural differences were also noted: control samples showed mature, well-distributed type I collagen, while 5 J/cm^2-treated tissues showed localized compaction, and 20 J/cm^2 treatment induced strong, bundled fiber structures. At 40 J/cm^2, collagen appeared more fragmented, possibly reflecting thermal damage and partial matrix collapse.

The collagen matrix of the skin primarily consists of type I and type III collagen. Type I collagen provides essential structural support, ensuring the mechanical strength of the skin, whereas type III collagen is predominantly synthesized during the initial phases of wound healing, playing a crucial role in tissue repair.[41] Sirius red staining confirmed the increase in type III collagen in treated tissues, particularly at 5 J/cm^2 and 20 J/cm^2, indicative of active remodeling. The extended presence of type III collagen at three months from laser treatment can reflect ongoing dermal remodeling, contributing to improved skin pliability and elasticity during the regeneration process.

Quantification of elastin using VVG staining showed that 5 J/cm^2 and 20 J/cm^2 treatments led to a marked increase in elastin content. The highest elastin content and alignment were observed at 20 J/cm^2, suggesting that this energy level induces significant structural reorganization. The variability in elastin content observed across patients reflects individual biological differences, such as baseline skin properties and remodeling capacity. This heterogene-

ity likely contributed to the lack of statistical significance and should be considered when interpreting the results. Measurements of dermal thickness indicated an increase in thickness post-treatment with 5 J/cm^2 and 20 J/cm^2, at both 3 and 6 months. The 20 J/cm^2 led to the greatest increase in dermal and collagen fibers. Our results suggest that dermal remodeling after EndoliftX® laser is mainly through deposition of collagen type I, as the increase in type I collagen fibers appears to be greater than that of type III fibers.

The findings of our *in vivo* human study also align with those from a recent preclinical investigation using a subdermal 1470 nm high-power diode laser in rats, where increased dermal thickness and improved collagen band organization in the reticular dermis were reported following treatment.[30] Min *et al.*, demonstrated in one patient that the 1444 nm Nd:YAG laser was effective in promoting increased dermal thickness and collagen reorganization.[42] From the comparison between the two protocols, it emerged that EndoliftX® achieved effective results with a lower power setting (2.5 W *vs.* 4 W) and smaller optical fiber diameter (300 m *vs.* 600 m), suggesting improved energy targeting and potentially less invasive tissue interaction.

Emerging studies suggest that EndoliftX® may stimulate elastin remodeling, enhancing skin elasticity and resilience; however, direct histological evidence, particularly using VVG staining or quantitative morphometry, remains limited. Our findings support a potential increase in elastin content following EndoliftX® treatment, leading to improved skin texture and firmness and a general regenerative outcome.

The present study investigated the dermal response to laser treatment using a power output fixed at 2.5 W, a value considered the standard baseline for this type of fiber and clinical application, and a 300 m lapped and tapered-shaped fiber optic. While the results obtained were encouraging, they also opened several scenarios for further exploration concerning fiber type, delivery parameters, and energy distribution. The use of fibers with different calibers, both smaller and larger, may yield varying effects on tissue penetration, energy dispersion, and subsequent collagen remodeling. The laser was operated using a Ton/Toff 50/50 ms, which is a widely accepted standard to minimize the risk of overheating and allow partial tissue cooling between pulses. However, the promising results observed in this study suggest that varying this emission cycle, either by adjusting the duty cycle or testing continuous wave emission, could further refine treatment efficacy and safety.

The study placed primary emphasis on treatment safety, achieving energy deliveries up to 40 J/cm² without inducing dermal damage, necrosis, or adverse histological modifications. These findings strongly validate the protocol's safety even at elevated energy levels. A key observation from this study is that the dermal response was not linearly correlated with the amount of energy delivered.

We selected energy densities of 5, 20, and 40 J/cm² to assess dose-dependent effects of endolaser treatment on dermal remodeling. This range, from low to high fluences, was chosen to explore both safety and efficacy, following prior studies on collagen and elastin remodeling.[43-44] It is important to highlight that the study follow-up period covers 6 months after a single treatment session. At this time point, an increase in dermal thickness compared to the control sites without treatment was still evident, along with a trend toward collagen increase, although it was less pronounced than at 3 months. This pattern reflects the typical dynamics of collagen remodeling after dermal injury, where matrix deposition reaches its peak around 6 to 9 months before entering a plateau phase and subsequently undergoing gradual regression.[45] Our observations suggest that a single EndoliftX® session may initiate dermal remodeling processes that extend well beyond the standard clinical follow-up period. However, given the progressive decline in remodeling activity over time, additional treatment sessions may be required to sustain or amplify long-term effects, as demonstrated in studies on other laser-based modalities.[46] One limitation of this study is the small sample size; nonetheless, the histological findings suggest a trend toward beneficial tissue changes following the laser procedure, in line with the observed clinical improvements.[16-18]

These preliminary results support the biological rationale for laser-induced dermal remodeling and provide a basis for larger, controlled studies to further validate and expand these observations.

Conclusions

The EndoliftX® subdermal/deep dermal laser technique induces dermal remodeling and regeneration through increased collagen and elastin synthesis, especially at moderate energy levels such as 5 J/cm^2 and 20 J/cm^2. These changes are supported by structural organization, in-

creased fiber density, and dermal thickening. Importantly, responses are not linearly related to energy input, and overtreatment may lead to diminished returns. This study establishes a foundation for further research into optimal laser parameters and personalized protocols for effective and safe skin remodeling.

Contributions

DB, patient inclusion, surgical and laser treatment, and skin samples collection; DB, RD, BB, RF, methodology, and clinical data conceptualization; RS, GO, IC, SM, SS, sample processing, histological analysis validation, and data curation; TM, RS, SS, validation, formal analysis, investigation, writing – review and editing, and supervision. All the 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

The study followed the principles of the Declaration of Helsinki and was approved by the Ethics Committee of the University of Turin (no. 0271617 - 08/06/2022 - [UOR: SI000045 - Classif. III/11]). All patients provided written informed consent to participate in this study.

Consent for publication

The study details were fully explained to the volunteers, who signed written informed consent to share their anonymous data, photography, and skin biopsy procedures (excision explants).

Availability of data and materials

Data are available upon reasonable request from the corresponding author.

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