Compendium of Clinical and Preclinical Studies

Laser Treatments in Aesthetics & Dermatology

June 2026

Laser&Health
ACADEMY

Content

Foreword

Bringing together scientific foundations and clinical practice

Over the past six decades, continuous scientific exploration and clinical innovation have shaped laser technology into an essential part of modern aesthetic and dermatological medicine. Today, laser-based treatments offer physicians effective and minimally invasive solutions for a wide range of skin conditions and aesthetic indications.

The Laser and Health Academy (LA&HA) is dedicated to supporting and disseminating high-quality scientific research on the safety, efficacy and clinical value of laser- and energy-based treatments. By encouraging the exchange of scientific knowledge among clinicians, researchers, and industry experts, LA&HA supports the continued advancement of evidence-based laser medicine.

This compendium brings together selected studies that reflect both the scientific foundations and clinical practice of laser treatments in aesthetics and dermatology. In the preclinical section, particular emphasis is given to basic science papers by LA&HA researchers, offering unique insight into breakthrough technologies and laser-tissue interactions that have enabled many novel treatment concepts. The clinical study section presents selected publications across different laser applications. Published in respected peer-reviewed international journals, these studies contribute to a growing body of evidence across multiple wavelengths, technologies and clinical applications. A comprehensive collection of published studies, with QR codes for convenient access to official online sources, is also provided.

We hope this compendium will serve as a valuable reference for practitioners and help spark new ideas for continued progress in aesthetic and dermatological laser treatments.

The use of lasers for medical treatments is subject to local regulations, which may vary depending on your region. Please check with the manufacturer whether a specific product or application has been approved or cleared to be marketed in your country.

Scientific background

Intense Heat-Shock Biomodulation (i-HBM) of Skin and Mucous Cells with the Fotona SMOOTH® Er:YAG Laser Modality

Authors: Lukac, M., Hreljac, I., Terlep, S., Tettamanti, M.

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Published in: Journal of the Laser and Health Academy, 2022

INTENSE HEAT-SHOCK BIOMODULATION (I-HBM) WITH NON-ABLATIVE ER:YAG SMOOTH® MODE

This theoretical and translational study describes the mechanism of **intense heat-shock biomodulation (i-HBM)** induced by non-ablative 2,940-nm Er:YAG laser (SMOOTH® mode). The aim was to explain how **very short, high-temperature superficial heat pulses can safely stimulate tissue regeneration** through indirect cellular signaling rather than direct thermal damage. The study positions i-HBM as a distinct biomodulation mechanism, different from conventional photobiomodulation or low-level laser therapy.

SHORT-DURATION HEAT SHOCKS TRIGGER STRONG REGENERATIVE SIGNALING WITHOUT TISSUE DAMAGE

The study demonstrates that **ultra-short thermal exposures (<1 ms)** generated by Er:YAG laser pulses can reach **very high surface temperatures (up to ~250°C)** while remaining within a safe biological range due to extremely rapid cooling. These heat shocks activate **heat shock proteins (HSPs)** and cellular alarm signaling pathways, which stimulate **fibroblast proliferation, collagen synthesis, and extracellular matrix remodeling.**

Unlike conventional hyperthermia, where damage increases with exposure time, the Er:YAG's **very shallow penetration (~3 µm)** allows precise delivery of thermal stress with minimal risk. The **Variable Heat Shock (VHS)** model shows that **optimal regeneration** occurs when temperature is high enough to trigger cellular response but remains below the threshold for irreversible damage. The result is a **strong regenerative cascade without significant protein denaturation or injury.**

UNIQUE DUAL MECHANISM: SUPERFICIAL HEAT-SHOCK + DEEP HYPERTHERMIA

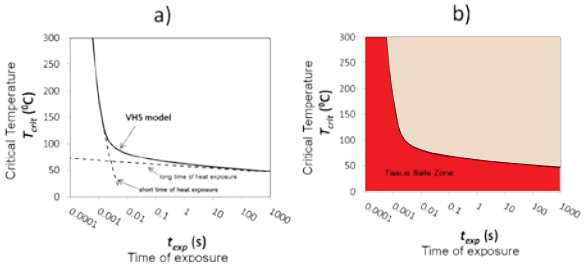
Fotona SMOOTH® mode produces two complementary regenerative effects. First, intense superficial heat-shock pulses trigger **i-HBM and cellular signaling.** Second, a gradual accumulation of deeper heat (below ~48–52°C) induces classical **hyperthermic collagen remodeling.**

Histological findings (described in the study) show that this dual mechanism results in **significant fibroblast activation and collagen production**, with regenerative effects extending up to **1600 µm depth** and persisting for months. Combination of both mechanisms produces a **synergistic effect**, with greater tissue regeneration than either mechanism alone.

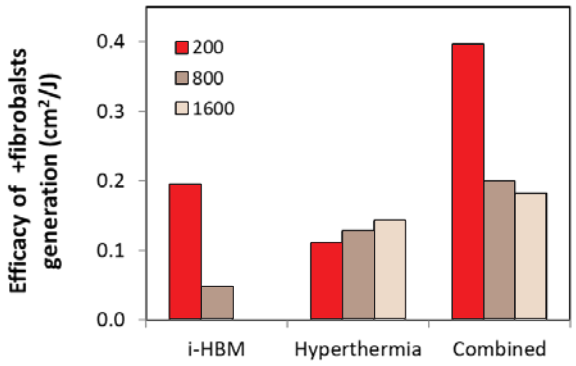
I-HBM ENABLES SAFE, SELF-REGULATED AND HIGHLY EFFECTIVE TISSUE REGENERATION

The authors conclude that i-HBM represents a **unique, self-regulating regenerative mechanism**, enabled specifically by the Er:YAG wavelength. Due to rapid cooling and the relationship between ablation temperature (~256°C) and critical damage threshold (~290°C), the treatment inherently remains within a **safe hormetic window.**

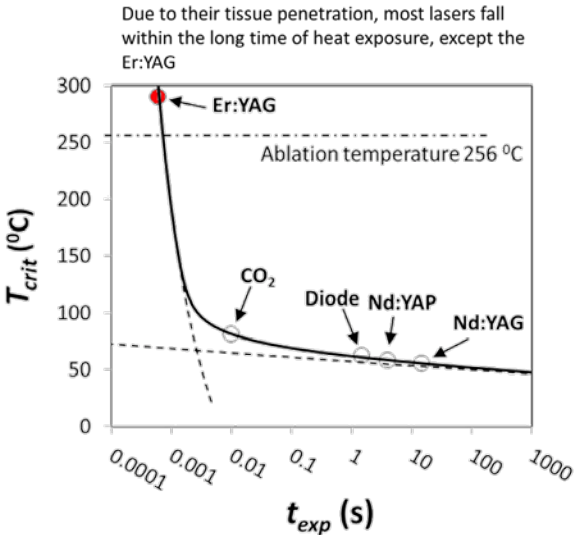
This allows delivery of **high-intensity stimulation without significant pain or tissue damage**, making it particularly suitable for superficial tissue regeneration. Clinical applications include **skin tightening, gynecology, ENT, intraoral rejuvenation, and hair restoration**, where controlled biomodulation leads to improved tissue structure, elasticity, and function.



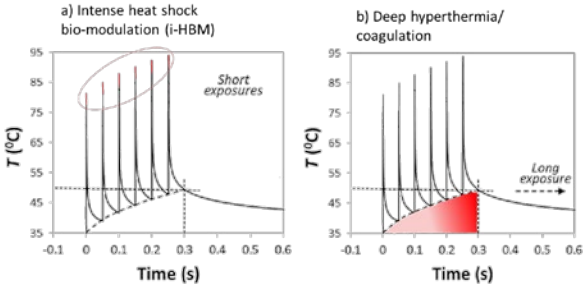
a) *VHS model's critical temperature as a function of the exposure time. Damage depends on the LEVEL of temperature and the TIME it is exposed to the tissue. The Variable Heat Shock (VHS) model is built by 2 curves: short heat exposure time and long heat exposure time.* ***b)*** *The maximum volume of Heat Shock Proteins (HSP) is created when the temperature generated is slightly below the level that produces significant, but reversible cellular damage.*



Comparison of treatment efficacies of three Fotona SMOOTH® biomodulation modalities, in terms of the number of generated positive fibroblasts per delivered laser fluence, for skin depths of 200 µm, 800 µm and 1600 µm. The results of an in-vivo immuno-histology study are shown for protocols designed to generate either predominantly i-HBM or predominantly hyperthermic biomodulation, and for a protocol combining the i-HBM and hyperthermic biomodulation effect. Results show that combining the i-HBM and hyperthermic biomodulation mechanisms results in a significant synergistic enhancement of tissue regeneration.



Critical temperatures T_{crit} (presented by grey circles), belonging to shortest exposure times achievable by different laser wavelength devices. Lasers that are not highly absorbed by water will penetrate deeper in the tissue. Once the heat has penetrated deeply it will dissipate slowly, providing a long time of heat exposure. The Er:YAG, with only 3µm of optical penetration in tissue, has a very short heat exposure time (cools very quickly) and is the only laser that can safely elevate skin temperatures above 100°C. Even when the ablation temperature of 256°C (represented by the dashed line) is reached, the skin cools down immediately, and this prevents any irreversible damage to deeper tissue, keeping the treatment within a safe hormetic zone.



Fotona SMOOTH® Mode Dual Heat Delivery. Fotona SMOOTH® emissions produce 2 very distinct types of heat depositions at different tissue depths: ***a)*** *Intense Heat-Shock Biomodulation (i-HBM): High peak temperatures on the tissue surface that last for a very short time (short exposure);* ***b)*** *Deep hyperthermia/coagulation: lower levels of gradually increasing deeper heat deposition that has longer exposure time.*

Characteristics of Non-Ablative Resurfacing of Soft Tissues by Repetitive Er:YAG Laser Pulse Irradiation

Authors: Lukac, M., Zorman, A., Lukac, N., Perhavec, T., Tasic, B.

Published in: Lasers in Surgery and Medicine, 2021

Characteristics of Non-Ablative Resurfacing of Soft Tissues by Repetitive Er:YAG Laser Pulse Irradiation

OPEN ACCESS

NON-ABLATIVE ER:YAG SMOOTH® RESURFACING AS A CONTROLLED REGENERATIVE APPROACH

This study analyzes the **mechanisms and characteristics of non-ablative Er:YAG laser resurfacing using repetitive pulse sequences (SMOOTH® mode)**, designed to induce tissue regeneration without epidermal ablation. Unlike traditional ablative resurfacing, which removes tissue and requires downtime, this approach delivers **sub-threshold cumulative energy** that **stimulates biological responses while preserving the surface layer.** The authors differentiate between conventional "sub-resurfacing" (near-ablation fluence with tissue damage) and **"smooth-resurfacing,"** which operates **below both ablation and pain thresholds**, enabling safer treatments with comparable regenerative outcomes.

PAIN THRESHOLD AS A KEY PARAMETER DEFINING SAFE AND EFFECTIVE TREATMENT

A central finding of the study is that **pain tolerance defines the upper limit of safe energy delivery**, making it a practical clinical parameter for optimizing treatment. Measurements in **15 patients** showed that the **pain threshold temperature increase remains relatively constant (~12.7°C without anesthesia and ~16.1°C with anesthesia)** across different pulse sequences. Importantly, pain correlates with the **final surface temperature (Ts)** rather than peak temperatures from individual pulses. The study also demonstrates that **longer pulse sequences allow higher energy delivery** without exceeding pain limits, enabling deeper thermal effects while maintaining patient comfort.

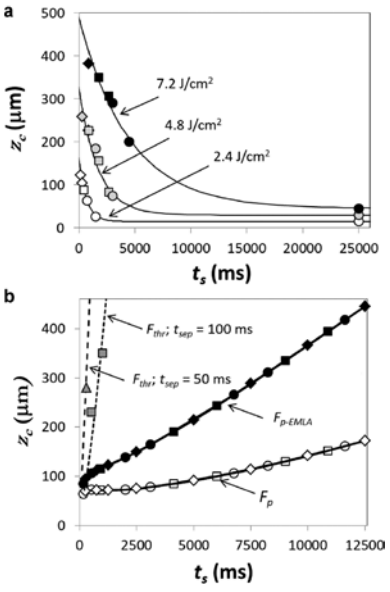
DUAL MECHANISM: SUPERFICIAL HEAT-SHOCK TRIGGERING AND DEEP COAGULATION

The study confirms a **dual biological mechanism** underlying non-ablative resurfacing. Short, high-temperature pulses create a **superficial heat-shock effect**, stimulating cellular signaling and regenerative pathways in the epithelial layer. At the same time, cumulative heat diffusion produces a **deeper thermal effect**, **resulting in collagen coagulation and remodeling within the dermis.** According to the Variable Heat Shock (VHS) model, these two processes correspond to **short- and long-exposure biochemical responses**, which together drive tissue regeneration. The study shows that **superficial effects depend on pulse number and intensity**, while **deep effects depend mainly on total energy and sequence duration**, highlighting the importance of parameter selection.

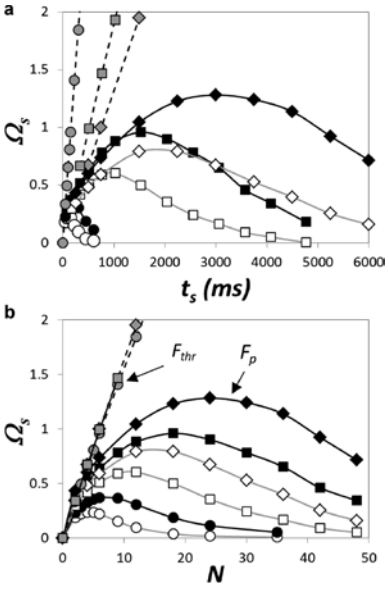
OPTIMIZED PARAMETERS ENABLE SAFE, VERSATILE, AND CLINICALLY EFFECTIVE TREATMENTS

The authors identify two optimal treatment strategies for smooth-resurfacing. **Short sequences** (ffi1–3 seconds with ~10–30 pulses) **maximize superficial heat-shock triggering** with moderate coagulation depths (~100 μm), while **longer**

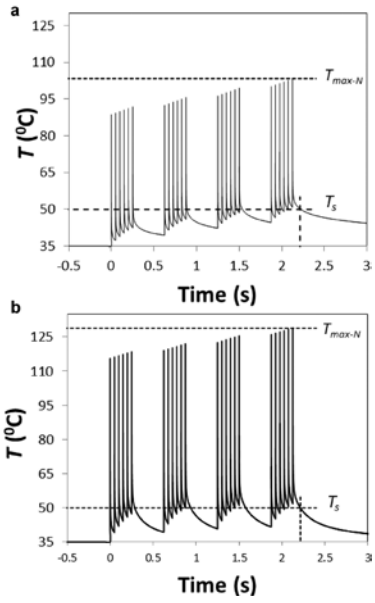
sequences (>5 seconds with higher pulse numbers) **produce deeper thermal remodeling** with minimal superficial effects. The study also shows that **patterned handpieces improve safety and efficacy** by enhancing lateral heat diffusion, allowing higher fluence delivery without exceeding pain thresholds. These findings explain why current clinical protocols in dermatology, gynecology, and ENT have been empirically optimized for **maximum regenerative effect with minimal risk**, supporting non-ablative Er:YAG resurfacing as a **safe and versatile alternative to more aggressive procedures.**



*(a) Calculated coagulation depths (zc) for three non-ablative sequence fluences F_s = 2.4, 4.8, and 7.2 J/cm2, as a function of the sequence duration t_s, for t_{sep} = 25 milliseconds (diamonds), 75 milliseconds (squares), and 125 milliseconds (circles). The lines are a visual guide for the eye; **(b)** Full lines represent calculated coagulation depths for different sequence durations at corresponding pain threshold fluences for without (F_p) and with topical anesthesia ($F_{p\text{-}EMLA}$), for t_{sep} of 25 milliseconds (diamonds), 75 milliseconds (squares), and 125 milliseconds (circles). Dashed lines represent calculated coagulation depths for ablation threshold fluences for t_{sep} = 100 and 50 milliseconds. Published measured coagulation depths are represented by the gray squares and the gray triangle.*



*Calculated short-exposure superficial damage for sub-resurfacing (gray symbols connected by dashed lines) and smooth-resurfacing (black and open symbols connected by full lines), as a function of the sequence duration t_s **(a)** or the number of pulses N **(b)**. Black and open symbols represent smooth-resurfacing with and without topical anesthesia, respectively. The calculated damage integrals are for pulse separation times t_{sep} of 25 milliseconds (diamonds), 85 milliseconds (squares), and 125 milliseconds (circles).*



*Calculated temporal profile of the skin surface temperature during a sequence of four SMOOTH® mode macro pulses each consisting of six micro pulses (resulting in N= 4 x 6= 24 micro pulses) for **(a)** F_s = 4.9 J/cm² with a full-beam handpiece (R11 with 7 mm spot size); and **(b)** F_s = 14.7 J/cm² with a patterned beam handpiece (PS03 with 0.85 mm micro spot size).*

Parameters for the New FRAC3® Nd:YAG Laser Skin Treatment Modality

Authors: Lukac, M., Sult, T., Zabkar, J., Gorjan, M., Vizintin, Z.
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Published in: Journal of the Laser and Health Academy, 2010

FRAC3®: A NOVEL THREE-DIMENSIONAL FRACTIONAL ND:YAG APPROACH

This study introduces FRAC3®, a non-ablative fractional laser modality using short-pulse 1064 nm Nd:YAG technology. Unlike conventional fractional treatments that create predefined surface patterns, **FRAC3® generates a self-induced three-dimensional distribution of thermal damage within the skin. The effect selectively targets microscopic imperfections and inhomogeneities**, allowing more precise treatment while preserving surrounding healthy tissue. This results in a minimally invasive approach with faster healing and improved safety.

SHORT PULSES ENABLE SELECTIVE HEATING OF SMALL STRUCTURES

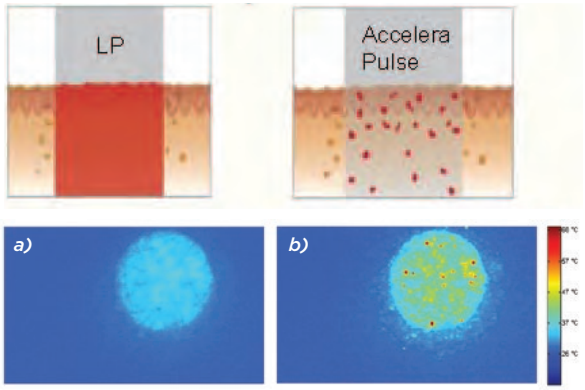
The method is based on using **very short pulse durations (0.1–1.0 ms), which are shorter than the thermal relaxation time of small skin structures.** This allows heat to remain confined within targets such as microvasculature, hair follicles, and minor skin imperfections, rather than diffusing into surrounding tissue. Shorter pulses produce higher localized temperature peaks, **significantly improving treatment selectivity and efficiency without increasing overall skin temperature.**

SELF-INDUCED FRACTIONAL HEATING IMPROVES SAFETY AND EFFICACY

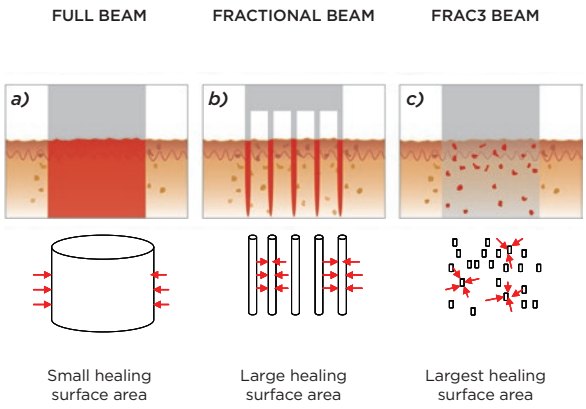
FRAC3® creates localized thermal “hot spots” distributed throughout the skin in three dimensions. **These microthermal zones act as healing centers, stimulating tissue regeneration while leaving surrounding areas intact.** Compared to traditional long-pulse treatments that produce uniform heating, this approach results in greater target-specific heating and reduced overall tissue heating, improving both treatment outcomes and safety.

CLINICAL APPLICATIONS AND TREATMENT OPTIMIZATION

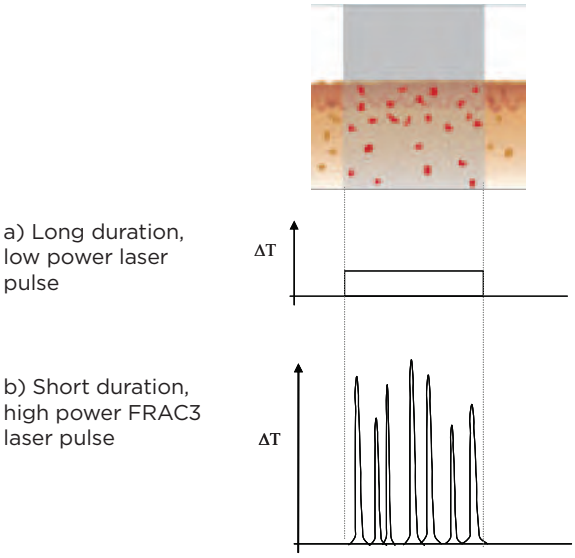
FRAC3® is effective for **skin rejuvenation, vascular treatments, acne therapy, and hair removal**, particularly for small structures with rapid thermal response. The approach typically uses high fluence, short pulse durations, and small spot sizes (around 3 mm) to maximize precision. Scanner-assisted delivery improves treatment uniformity and prevents overlap. Clinical results show **improved skin texture, collagen remodeling, and minimal side effects**, with only mild and temporary redness reported.



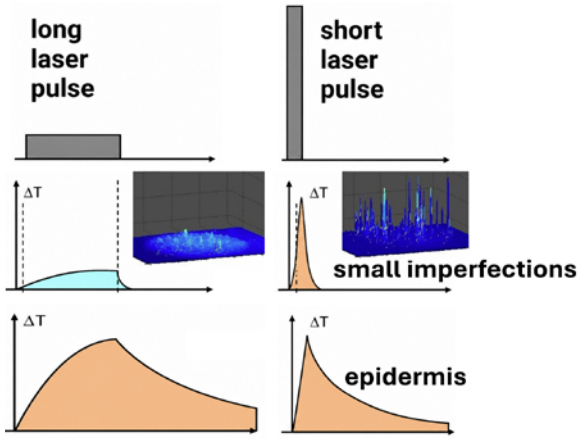
*Skin surface temperature thermal image following a 20 ms **(a)**, and a 0.3 ms **(b)** Nd:YAG laser pulse.*



*Laser induced damage islands as healing centers: **a)** standard uniform laser treatment; **b)** standard two- dimensional fractional treatment; and **c)** novel self-induced three-dimensional FRAC3® laser treatment. With the FRAC3® method the tissue is treated only where required, i.e. at skin imperfections. In addition, the healing area is the largest and the healing time is the fastest.*



***a)** Standard treatment. Small absorbers are not heated; heat diffusion into the surrounding tissue is too rapid; **b)** FRAC3® treatment. Small absorbers are heated very quickly and there is not enough time for diffusion to proceed.*



In FRAC3® treatments where $TRT_{epi} < TRT_{imp}$ situation applies, shortening the laser pulse duration improves treatment efficacy of small skin imperfections without endangering the bulk epidermis.

New Skin Treatment Possibilities with PIANO Mode on an Nd:YAG Laser

Authors: Lukac, M., Vizintin, Z., Pirnat, S., Nemes, K.

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Published in: Journal of the Laser and Health Academy, 2011

PIANO MODE: SUPER-LONG PULSE ND:YAG FOR HOMOGENEOUS DERMAL HEATING

This article introduces **PIANO mode**, a novel Nd:YAG laser modality characterized by **super-long pulse durations in the seconds range (0.3–60 s)**, far exceeding the thermal relaxation time of the epidermis and other skin structures. Unlike conventional short or long pulses designed for selective photothermolysis, PIANO mode is optimized for **homogeneous "bulk" heating of the dermis.** By avoiding rapid temperature peaks in the epidermis, it enables **deep, safe thermal delivery** for non-ablative treatments such as skin remodeling, tightening, and wound healing.

LONG PULSE DURATION ENABLES UNIFORM HEAT DISTRIBUTION IN THE SKIN

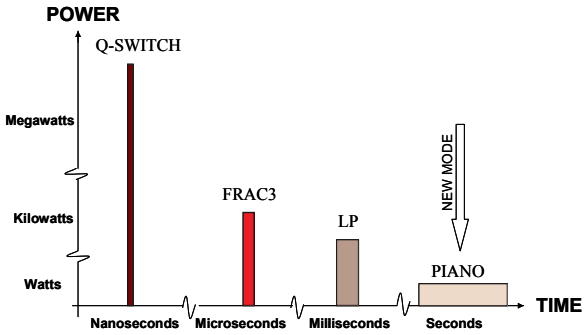
The study highlights that **pulse duration determines heat distribution** within tissue. Short pulses confine heat to specific targets, while long pulses allow **heat diffusion and uniform temperature distribution.** Since the epidermal thermal relaxation time is approximately **25–100 ms**, using second-range pulses ensures **effective dermal heating while minimizing epidermal damage.** This shift from selective to bulk heating allows for more controlled and consistent treatment outcomes.

DEEP DERMAL HEATING WITHOUT EPIDERMAL OVERHEATING

Experimental results confirm that PIANO mode achieves **effective dermal temperatures without high epidermal temperature spikes.** Compared to shorter pulses, super-long pulses significantly reduce peak temperature at the skin surface while maintaining sufficient heat in deeper layers. Additionally, temperature increase shows a **linear relationship with fluence**, allowing predictable and controlled treatments. This controlled heating induces a **heat shock response (around 50–55°C), which stimulates collagen remodeling** without causing thermal injury.

VERSATILE CLINICAL APPLICATIONS IN SKIN REJUVENATION AND HEALING

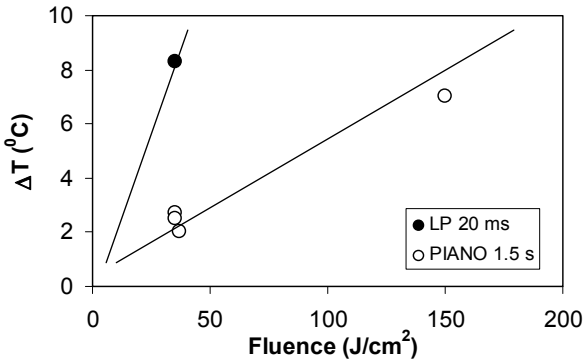
PIANO mode is highly effective for **non-ablative dermatological treatments**, including skin remodeling, tightening, and scar prevention. Controlled dermal heating promotes **collagen contraction and new collagen formation**, improving skin tone, elasticity, and texture. It is also suitable for **laser-assisted wound healing**, where **thermal stimulation enhances tissue repair and reduces scar formation.** The method can also be combined with fractional Er:YAG resurfacing for enhanced results.



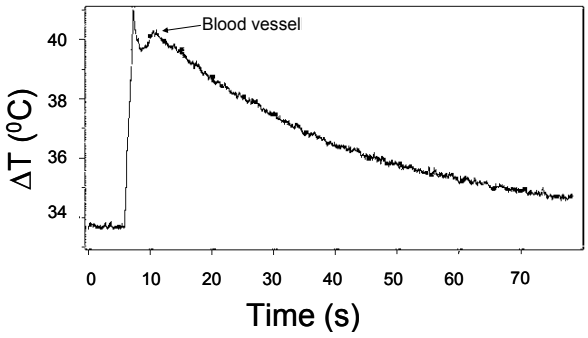
The new "super long pulse" PIANO mode enables pulse durations in the seconds regime, and exhibits less intensive pulse powers of several Watts.

	ΔT (at 35 J/cm²)	ΔT/Fluence
cheek	7.6 °C	0.22 °C cm²/J
beard	7.1 °C	0.20 °C cm²/J
forehead	12.7 °C	0.36 °C cm²/J
hand	2.7 °C	0.05 °C cm²/J

Skin temperature increase following a PIANO pulse (1.5 s) illumination on different parts of the body. Measurements were performed on a female patient of skin type II.



Measured dependence of the peak skin surface temperature increase for the PIANO mode Nd:YAG laser illumination of 1.5 s pulse duration. For comparison, a temperature increase with a shorter, 20 ms Nd:YAG pulse is also shown. Spot sizes were in the range of 10-20 mm. Diagonal lines in the chart are only a visual aid.



Temporal evolution of dorsal hand skin in the presence of an underlying blood vessel following an Nd:YAG PIANO pulse (1.5 s, 150 J/cm²). Heat diffusion from the underlying heated vessel results in a second skin surface temperature peak, with the time delay depending on the depth of the vessel within the skin.

Influence of tissue desiccation on critical temperature for thermal damage during Er:YAG laser skin treatments

Authors: Lukac, M., Kosir, J., Zel, T., Kazic, M., Savli, D., Jezersek, M.

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Published in: Lasers in Surgery and Medicine, 2024

TISSUE DESICCATION AS A KEY FACTOR IN ER:YAG LASER–INDUCED THERMAL DAMAGE

This study investigates the role of **tissue desiccation during Er:YAG laser skin treatments** and its **impact on thermal damage.** While desiccation is well known in hard tissues, it has been largely overlooked in soft tissue due to its higher water content. The authors demonstrate that even in skin, particularly in the **stratum corneum with relatively low water content**, **desiccation significantly influences thermal behavior.** The study focuses on how water evaporation during laser irradiation alters tissue properties and contributes to unexpected thermal effects.

DESICCATION PROLONGS COOLING TIME AND INCREASES THERMAL EXPOSURE

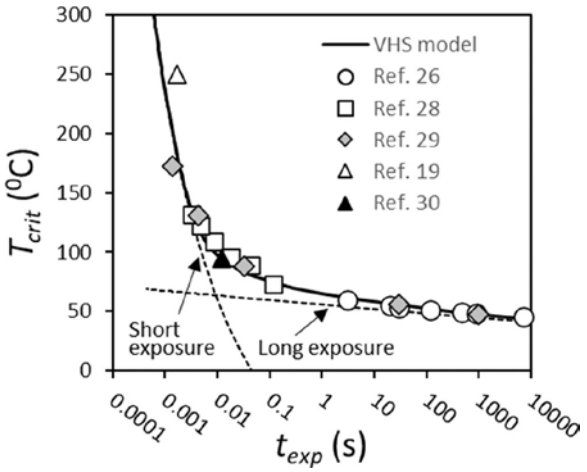
Using in vivo measurements with a fast thermal camera, the study shows that **temperature decay times increase significantly after Er:YAG irradiation**, especially at fluences approaching the ablation threshold. This effect is attributed to **evaporation of free water**, which **increases optical penetration depth and slows heat dissipation.** As a result, tissue remains at elevated temperatures for longer periods, increasing the **overall thermal exposure time**, a key determinant of thermal damage according to Arrhenius-based models.

LOW-TO-MEDIUM FLUENCES MAY CAUSE MORE DAMAGE THAN HIGHER FLUENCES

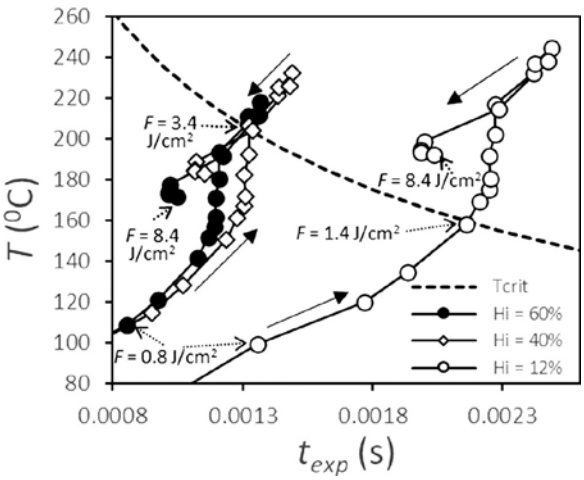
A critical and counterintuitive finding is that **low-to-medium fluences can result in greater thermal damage than higher fluences.** As desiccation increases, prolonged thermal exposure **reduces the critical temperature required for tissue damage**, meaning damage can occur at lower peak temperatures. The Variable Heat Shock (VHS) model demonstrates that intermediate fluence ranges may shift tissue into a thermal damage zone, whereas higher fluences may actually return conditions toward safer exposure levels.

SKIN HYDRATION AS A KEY CLINICAL FACTOR FOR SAFETY AND OUTCOMES

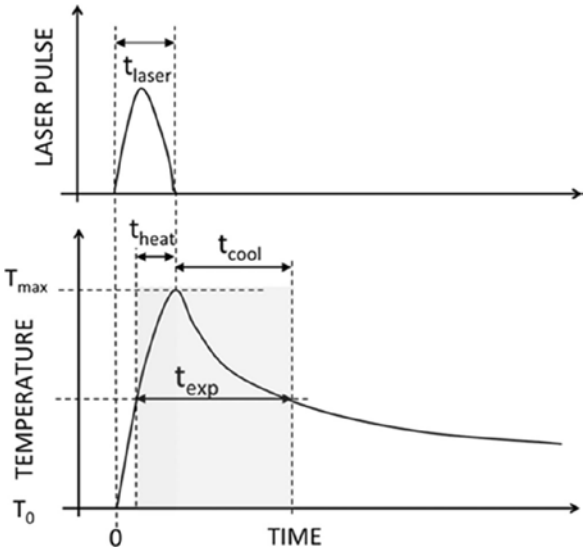
The study highlights **skin hydration as a critical modifiable factor** influencing treatment safety. **Higher initial hydration reduces the impact of desiccation**, shortens cooling times, and lowers the risk of thermal damage. Conversely, dry skin significantly amplifies desiccation effects, increasing exposure and risk. The authors conclude that **pre-treatment skin hydration can mitigate adverse thermal effects** and improve treatment outcomes, emphasizing the importance of hydration not only in ablative but also in non-ablative and sub-ablative Er:YAG procedures.



Dependence of the published measured critical (damage threshold) temperatures T_{crit} on the duration of thermal exposure t_{exp}, together with the fitted critical temperature curve according to the VHS model. The transition coef cient of the VHS curve is equal to p = 0.135. The short exposure and long exposure Arrhenius dotted lines represent the dependence of the critical temperatures on the exposure time for the long exposure process 1, characterized by A_1 = 3.0 x 10^{87} s^{-1} and E_1 = 5.5 x 10^8 J $kmol^{-1}$, and for the short exposure process 2 characterized by A_2 = 8.0 x 10^4 s^{-1} and E_2 = 1.85 x 10^7 J $kmol^{-1}$.



Trajectories of estimated thermal exposures relative to the variable heat shock (VHS) critical temperature curve (dashed line) for different initial skin hydration levels H_i = 12%, 40%, and 60%, as the Er:YAG laser pulse fuence is increased from F = 0.8 J/cm² to F = 8.4 J/cm². The arrows show the direction of the increasing laser pulse uence.



The duration of the thermal pulse texp is determined by the duration of the laser pulse and the duration of the cooling phase, during which the heated tissue cools down by means of the relatively slow heat conduction.

Objective monitoring of laser tattoo removal in human volunteers using an innovative optical technique: A proof of principle

Authors: Golmajer Zima, N., Verdel, N., Lukac, M., Majaron, B.

Published in: Lasers in Surgery and Medicine, 2023


CASE REPORT

Objective monitoring of laser tattoo removal in human volunteers using an innovative optical technique: A proof of principle

Neža Golmajer Zima MSc[1,2] | Nina Verdel PhD[1] | Matjaž Lukač PhD[1,2,3] | Boris Majaron PhD[1,2]

OPEN ACCESS

OBJECTIVE MONITORING OF LASER TATTOO REMOVAL USING OPTICAL TECHNIQUES

This study introduces a **non-invasive method for objectively monitoring laser tattoo removal** by combining **diffuse reflectance spectroscopy (DRS)** and **pulsed photothermal radiometry (PPTR)** with computational modeling. Traditional evaluation methods such as visual inspection are subjective, while histological analysis is invasive. This approach enables **quantitative assessment of tattoo properties**, including ink concentration and depth, allowing for more accurate and reproducible monitoring of treatment progress.

GRADUAL INK REDUCTION AND LAYER-BY-LAYER REMOVAL

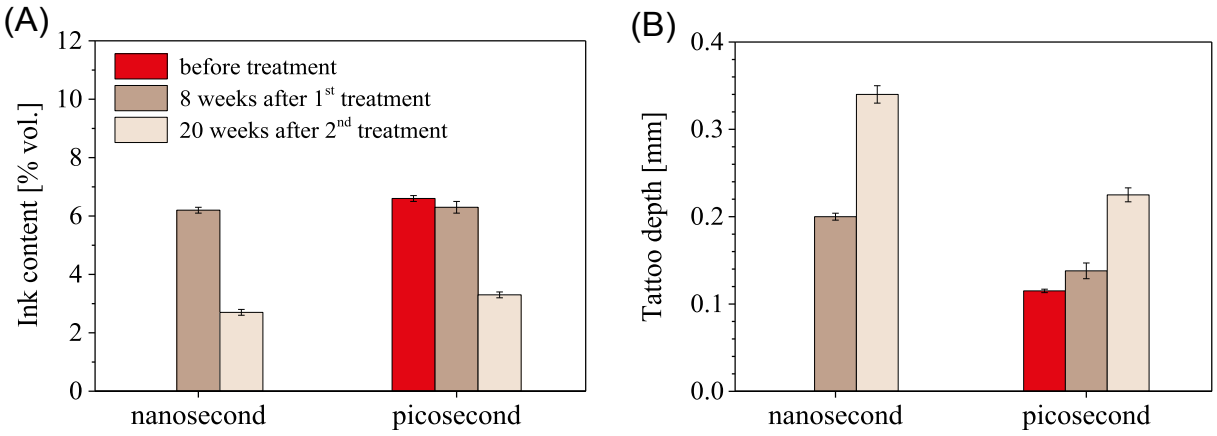
The results show a **progressive decrease in tattoo ink concentration** with repeated laser treatments, along with a **shift of the remaining pigment deeper into the skin.** This confirms that tattoo removal occurs in a **layer-by-layer process**, where superficial ink is removed first. The reduction in pigment is gradual and reflects both laser-induced fragmentation and biological clearance mechanisms over time.

EFFECT OF LASER PARAMETERS ON TREATMENT OUTCOME

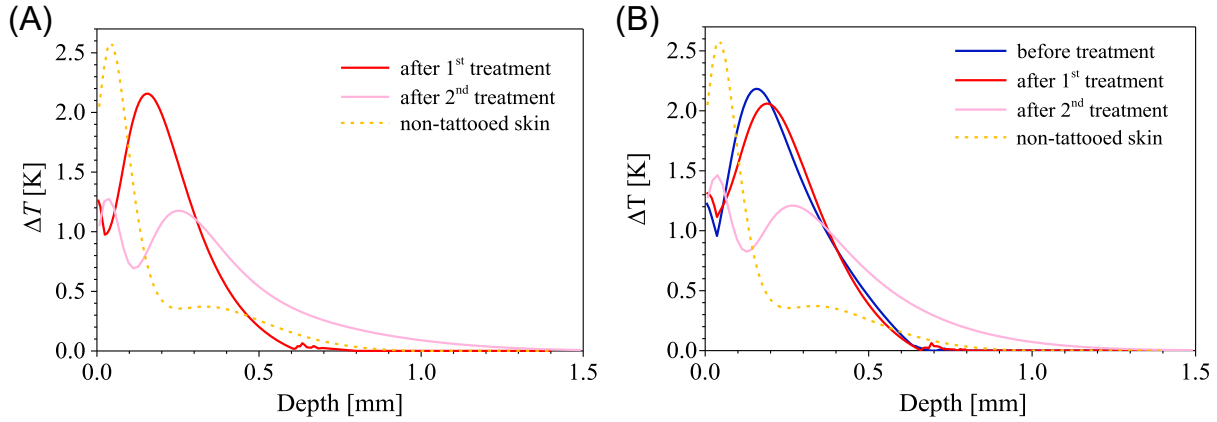
The study compares **nanosecond and picosecond laser pulses**, demonstrating that both can **effectively reduce tattoo pigment.** In this case, nanosecond pulses achieved slightly greater ink reduction, mainly due to higher delivered energy. Treatment success depends on **pulse duration, energy level, and number of sessions**, as well as delayed biological processes involved in pigment removal. Lower energy treatments tend to produce slower or less pronounced results.

IMPORTANCE OF TATTOO CHARACTERISTICS AND PERSONALIZED TREATMENT

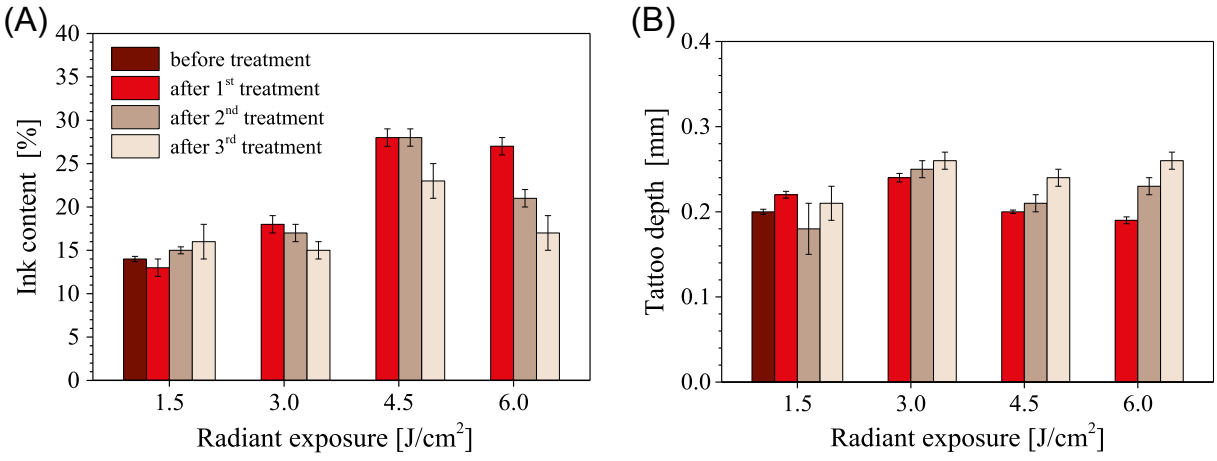
The study highlights that **tattoo characteristics significantly influence treatment response**, especially **ink density and depth.** Tattoos with higher pigment concentration or deeper placement are more difficult to remove and require more intensive treatment. **Increasing energy improves effectiveness**, while very low energy produces minimal changes. These findings support the need for **personalized treatment protocols** based on objective measurements rather than visual assessment alone.



(A) The assessed amount of black ink and (B) subsurface depth of the tattoo layer before and after the first and second treatment with the nanosecond or picosecond laser. The error bars represent standard deviations assessed from 5 IMC runs.



Temperature depth profiles reconstructed from the PPTR signals, indicating the energy deposition of 532 nm light in the tattooed test sites over the course of treatment with the (a) nanosecond, and (b) picosecond laser pulses. The result obtained from non-tattooed skin is presented for comparison. PPTR, pulsed photothermal radiometry.



(A) The assessed amount of tattoo ink and (B) the subsurface depth of the tattoo layer before and after the first, second, and third removal treatment with different radiant exposures. The error bars are standard deviations from 5 IMC runs.

Measurements of hair temperature avalanche effect with alexandrite and Nd:YAG hair removal lasers

Authors: Vella, D., Lukac, M., Jernejcic, U., Lukac, N., Klanecek, Z., Milanic, M., Jezersek, M.

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Published in: Lasers in Surgery and Medicine, 2023

AVALANCHE EFFECT IN LASER HAIR REMOVAL: A NONLINEAR THERMAL RESPONSE

This study investigates the **photothermal behavior of human hair during laser hair removal** using **Nd:YAG (1064 nm) and alexandrite (755 nm) lasers.** The authors identify a **nonlinear "avalanche effect"**, where hair temperature increases more rapidly than expected from linear energy absorption. This effect occurs when hair is exposed either to a **single high-fluence pulse or multiple low-fluence pulses**, leading to **enhanced heating efficiency.** These findings help explain why different clinical techniques, including both stamping and brushing methods, can effectively achieve hair reduction.

THRESHOLD-DEPENDENT TEMPERATURE AMPLIFICATION

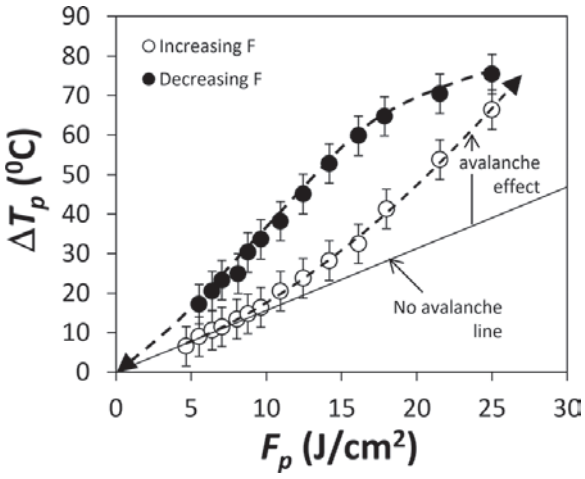
The study shows that hair temperature initially increases linearly with laser fluence, but **above a threshold fluence, the response becomes nonlinear and significantly amplified.** The avalanche threshold was identified at approximately **10 J/cm² for Nd:YAG and 2.5 J/cm² for alexandrite lasers**, reflecting differences in absorption. This effect becomes evident when hair temperature exceeds approximately **45°C**, after which subsequent laser pulses produce progressively greater temperature increases. This defines a critical transition point for efficient thermal targeting of hair.

MULTIPLE LOW-FLUENCE PULSES INCREASE TREATMENT EFFICIENCY

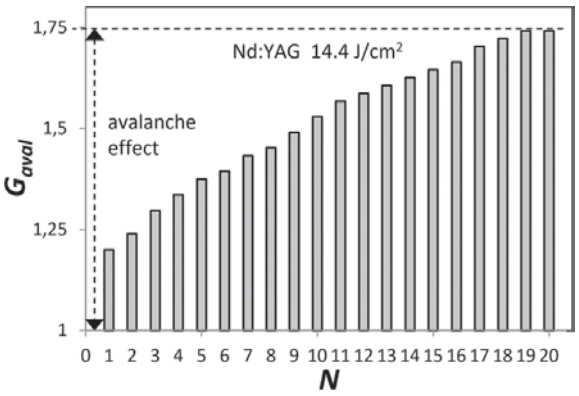
A key finding is that **repeated low-fluence pulses can achieve equal or greater heating compared to single high-fluence pulses.** The study shows that delivering up to 50 consecutive pulses significantly enhances the thermal response, with an avalanche gain greater than 2. This cumulative effect is attributed to **changes in the hair's optical and structural properties during heating**, which increase energy absorption over time. These findings support the effectiveness of **"in-motion" or brushing techniques**, where lower energy pulses are delivered repeatedly across the treatment area.

STRUCTURAL CHANGES IN HAIR DRIVE THE AVALANCHE EFFECT

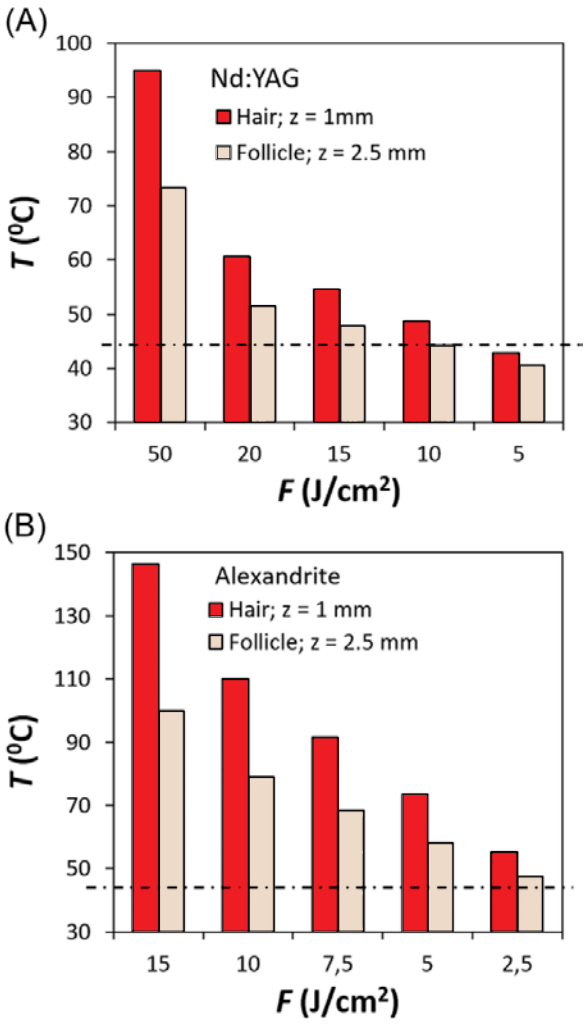
The avalanche effect is linked to **temperature-induced structural and optical changes in the hair shaft**, including increased absorption and surface alterations. At moderate temperatures (~50–90°C), changes are mainly limited to the outer layers, while higher temperatures (>200°C) lead to **significant structural degradation**, further increasing absorption. Simulations indicate that this effect also occurs in hair located within the skin, where **light scattering enhances energy retention in the follicle**, supporting the clinical relevance of the findings.



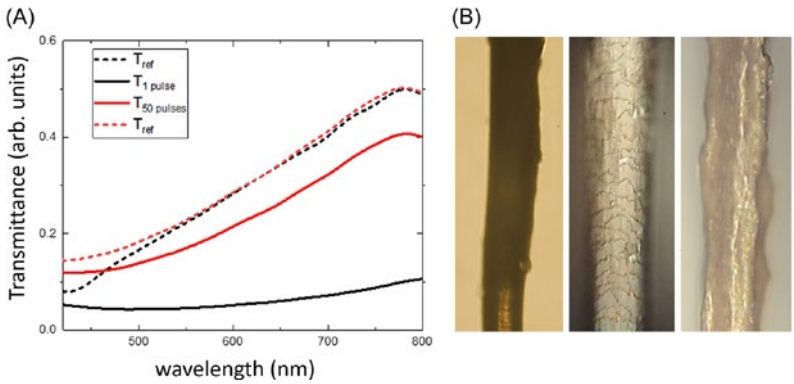
Temperature increase ΔT_p, of the same hair section following consecutive irradiation by individual Nd: YAG laser pulses. In the initial phase (represented by open circles), the pulse fluence of individual pulses (F_p) was increased from pulse to pulse, starting with the first pulse with F_p= 5J/cm², and ending with the final pulse with F_p = 25J/cm². In the subsequent phase (represented by closed circles), the individual pulse fluences (F_p) were decreased from pulse to pulse, starting with the first pulse with F_p = 25J/cm², and ending with the final 13th pulse with F_p = 6J/cm².



Gradual increase of the avalanche gain G_{aval} during the delivery of Nd:YAG pulses.



*Calculated elevated temperature of the hair (at z = 1 mm) and follicle (at z = 2.5 mm) as a function of the Nd:YAG **(A)** or alexandrite **(B)** single pulse laser uence. The dotted lines represent the temperature threshold for the avalanche effect.*



***(A)** Transmittance spectra of the hair following a single high uence (F_p = 12.5 J/cm²) alexandrite laser pulse (black solid line), and following 50 low fuence (F_p = 5 J/cm²) alexandrite laser pulses (red solid line). The corresponding reference measurements are represented by the dashed lines. **(B)** Optical images of the hair shaft, after irradiation with a single high uence alexandrite pulse (left panel), before irradiation (central panel) and after irradiation by 50 low fuence alexandrite laser pulses (right panel).*

Influence of skin type and light scattering on induced skin temperatures during Nd:YAG and Alexandrite laser treatments in dermatology

Authors: Kosir, J., Sharma, R., Lukac, M.

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Published in: Journal of the Laser and Health Academy, 2023

Influence of Skin Type and Light Scattering on Induced Skin Temperatures during Nd:YAG and Alexandrite Laser Treatments in Dermatology

OPEN ACCESS

INFLUENCE OF SKIN TYPE AND LIGHT SCATTERING ON LASER-INDUCED TEMPERATURES

This study investigates how **skin type and light scattering affect temperature distribution during Nd:YAG (1064 nm) and Alexandrite (755 nm) laser treatments.** As laser light penetrates the skin, scattering causes the beam to spread outward, **reducing the effective fluence reaching deeper targets.** The study uses thermal imaging to evaluate how these effects influence treatment outcomes across different Fitzpatrick skin types, highlighting the **importance of tissue optics in dermatological laser procedures.**

LARGER SPOT SIZES INCREASE EFFECTIVE HEATING

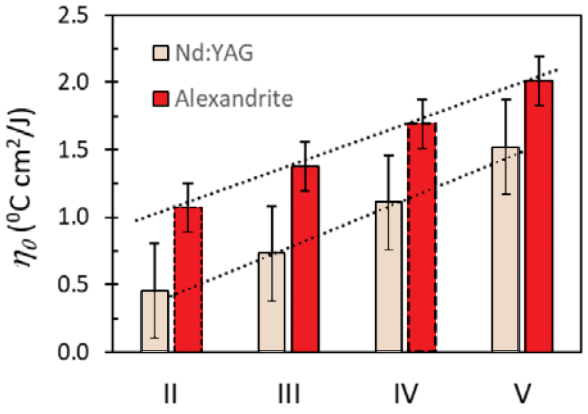
A key finding is that **skin surface temperature increases with larger laser spot sizes**, even when the same fluence is applied. This occurs because scattering spreads the beam by a relatively constant amount, meaning smaller beams lose a greater proportion of their energy. As a result, **larger spot sizes maintain higher effective fluence within the skin**, improving thermal efficiency and treatment effectiveness. This explains why larger spot sizes are often preferred in clinical laser treatments.

SKIN TYPE STRONGLY INFLUENCES HEATING AND SAFETY

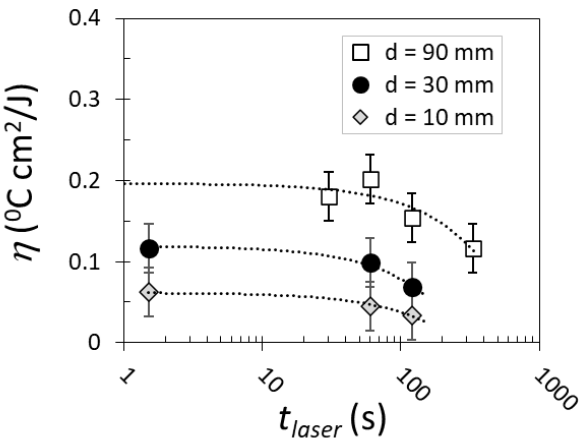
The study confirms that **skin type significantly affects laser-induced temperature distribution**, mainly due to differences in melanin absorption. Darker skin types show higher epidermal absorption, leading to increased surface heating and reduced energy penetration to deeper tissues. Lighter skin types allow deeper and more uniform heating. These differences impact both **treatment effectiveness and safety**, requiring careful adjustment of parameters for different skin types to avoid complications.

PULSE DURATION AND THERMAL EXPOSURE DETERMINE TISSUE RESPONSE

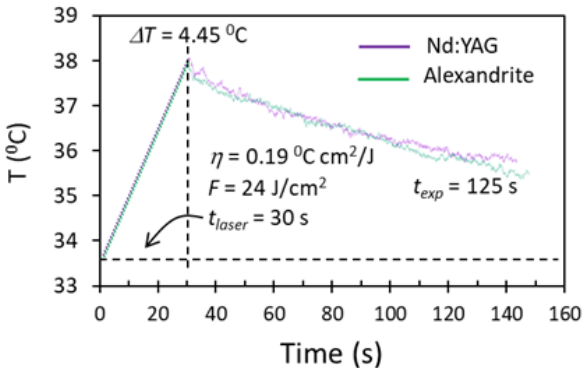
The study highlights that **pulse duration plays a critical role in thermal behavior.** Short pulses create rapid temperature peaks followed by fast and slow cooling phases, while long pulses allow more uniform heat distribution across tissue layers. Importantly, tissue response depends not only on peak temperature but also on **duration of thermal exposure**, consistent with the Arrhenius model. This emphasizes the need to control both **temperature and exposure time** for safe and effective treatments.



Heating coefficients η_0 (d = 30 mm) for Nd:YAG and Alexandrite laser wavelengths for pulse durations t_{laser} = 3 ms.



Dependence of the heating coefficient η on the "slow" (PIANO mode) pulse duration for Nd:YAG and Alexandrite laser wavelength, and for different laser spot sizes.



Comparison of the measured skin temperature evolutions following irradiation with the Nd:YAG or Alexandrite laser PIANO (t_{laser} = 30 s) pulse mode, with the same fluence of F = 24 J/cm². Both irradiations result in the same ΔT_{max} = 4.45 ^{0}C, and essentially the same temperature decay behavior.

Dry molecular cooling (DMC™) in laser aesthetics and dermatology

Authors: Kosir, J., Kukovic, J., Gerdovic, N., Kanduc, U., Lukac, M.

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Published in: Journal of the Laser and Health Academy, 2023

DRY MOLECULAR COOLING (DMC™): A NOVEL NON-CONTACT SKIN COOLING TECHNOLOGY

This study introduces **dry molecular cooling (DMC™)** as a new non-contact skin cooling method designed to improve safety and comfort during laser treatments in dermatology and aesthetics. Conventional cooling methods such as cryogen spray cooling (CSC) and cold air cooling (CAC) have limitations, including risk of overcooling, insufficient cooling efficiency, or lack of continuity. **DMC™ uses a digitally controlled, micro-pulsed fine water mist** that rapidly evaporates on the skin surface, **enabling efficient heat removal without forming a liquid barrier.** This approach allows effective cooling while maintaining optimal treatment conditions.

FASTER AND SELF-REGULATING COOLING COMPARED TO CONVENTIONAL METHODS

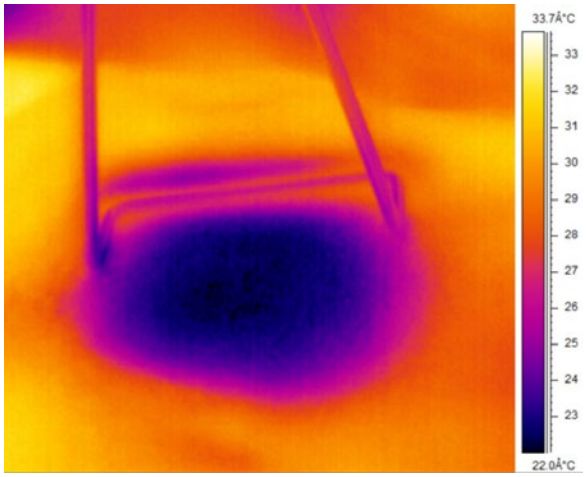
The study demonstrates that DMC™ provides a **significantly faster cooling rate than cold air cooling**, with approximately three times higher initial cooling efficiency. A key advantage is its **self-regulating mechanism**, where evaporation of micro-droplets limits the minimum skin temperature to around **16°C, preventing excessive cooling.** In contrast, CAC and CSC rely on very low temperatures and may lead to discomfort or cryo-injury. This controlled cooling behavior allows DMC™ to achieve effective epidermal protection while maintaining patient safety.

PROLONGED POST-COOLING IMPROVES THERMAL STABILITY AND CLINICAL OUTCOMES

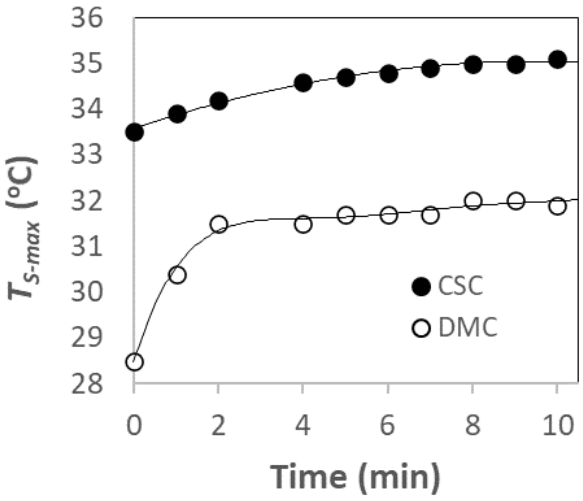
Unlike CSC, which provides only brief pre-cooling, DMC™ enables **continuous and prolonged post-cooling** due to the persistence of fine water droplets on the skin. This results in **sustained reduction of skin temperature over the entire treated area**, preventing the formation of post-treatment hot spots caused by heat diffusion from deeper layers. The prolonged cooling effect contributes to **reduced edema and erythema**, improving overall treatment outcomes and patient comfort compared to conventional cooling methods.

VERSATILE AND SAFE COOLING FOR MULTIPLE LASER APPLICATIONS

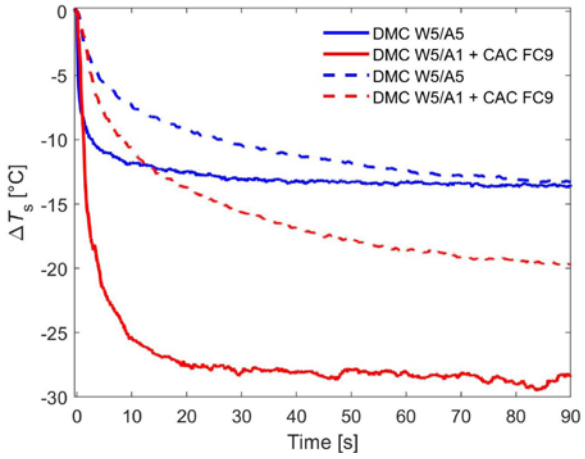
DMC™ is shown to be a **versatile and clinically effective cooling method** for various laser procedures, including **hair removal, vascular treatments, and skin rejuvenation.** It combines the advantages of rapid cooling and sustained thermal control without the risks associated with extreme temperatures. Additionally, DMC™ can be used alone or in combination with cold air cooling to further enhance performance. The technology enables **efficient, homogeneous cooling of large treatment areas**, supporting improved safety, consistency, and clinical results across different applications.



Thermal image of the DMC-cooled skin area of the LX/Nx-Runner scanning handpiece.



Temporal evolution of the maximal temperature over the treated area during the time following a hair removal treatment using either the DMC or CSC skin cooling method.



Comparison of the development of the average skin temperature decrease ΔT_s during skin cooling either under DMC W9/A5 alone, or under the combination of DMC W9/A5 and CAC FC9 cooling. The dashed lines represent temperatures obtained with the LX/Nx-Runner scanning handpiece, and full lines represent temperatures obtained with the R35 manual handpiece.

Skin reactions following a treatment, at 5 hours post treatment. A strong erythema can be observed on the CSC-cooled leg.

Numerical Study of Hyper-Thermic Laser Lipolysis With 1,064 nm Nd:YAG Laser in Human Subjects

Authors: Milanic, M., Muc, B. T., Lukac, N., Lukac, M.

-

Published in: Lasers in Surgery and Medicine, 2019

Numerical Study of Hyper-Thermic Laser Lipolysis With 1,064 nm Nd:YAG Laser in Human Subjects

Matija Milanic, PhD,[1,2*] **Blaz Tasic Muc,** MSc,[3,4] **Nejc Lukac,** PhD,[3,4] **and Matjaz Lukac,** PhD[2,3]
[1]*Faculty of Mathematics and Physics, University of Ljubljana, Jadranska 19, SI-1000, Ljubljana, Slovenia*
[2]*Department of Complex Matter, Jožef Stefan Institute, Jamova 39, Ljubljana, SI-1000, Slovenia*
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Background and Objectives: The aim of this study was to develop a numerical model for hyperthermic laser lipolysis in human subjects to improve understanding of the procedure and find optimal therapeutic parameters.
Study Design/Materials and Methods: A numerical model of hyperthermic laser lipolysis (HTLL) on human subjects was developed that is based on light and heat transport, including the effects of blood perfusion and forced air cooling. Tissue damage was evaluated using the Arrhenius model. Three irradiation scenarios were considered: single skin area irradiation without and with forced air cooling, and sequential heating of four adjacent skin areas in a cyclical manner. An evaluation of the numerical model was made by comparing the recorded skin surface temperature evolution during an experimental HTLL procedure performed on the abdomen of ten human volunteers using a 1,064 nm Nd:YAG laser irradiation.
Results: A good agreement was obtained between the simulated skin surface temperatures and that as measured during the HTLL procedure. The temperature difference between the simulations and experiments was in the range of 0.2–0.4°C. The model parameters, which were fitted to the experiment were the perfusion parameter (0.36–0.79 and 0.18–0.49 kg/m^3·s for dermis and subcutis) and the subcutaneous tissue absorption coefficient (0.17–0.21 cm^{-1}). By using the developed HTLL model and the determined parameters, temperature depth distributions and the resulting thermal injury to adipocytes were simulated under different treatment conditions. Optimal ranges of the HTTL treatment parameters were determined for different skin types, damaging adipocytes while preserving skin cells. The target subcutaneous temperatures were in the range of 43–47°C, which has been found to lead to programmed adipocyte death. The optimal treatment parameters were further used to define a range of recommended protocols for safe and effective multiarea cycled HTLL treatment of large body surfaces. Specifically, for the set of chosen optimal treatment parameters (4–5 treatment cycles, 1.2 W/cm^2 radiant exposure, and 60–130 W/cm^2 forced air heat-transfer coefficient) the threshold surface temperature during irradiation was found to be in the range of 31–38°C, depending on the skin type and heat-transfer coefficient.
Conclusions: The developed numerical model allows for the calculation of the temperature distribution and the resulting injury to adipocyte cells within deeper lying fatty tissues under different clinical treatment conditions. It is demonstrated that by measuring the temporal evolution of the skin surface temperature and by stopping the laser irradiation at predefined skin surface threshold temperatures, it may be possible to monitor and control the effects of the HTLL procedure deeper within the tissue. As such, the model provides a better insight into the HTLL, and may become a tool for defining the range of safe and effective HTLL treatment protocols for patients with different skin types.

Key words: laser fat reduction; non-invasive fat reduction; numerical modeling

INTRODUCTION

Traditional liposuction is a very effective and commonly performed cosmetic surgical procedure for fat reduction. It is, however, associated with a number of drawbacks, including blood loss, ecchymosis and skin laxity [1]. In order to address some of the drawbacks of traditional liposuction, a less invasive method of laser-assisted lipolysis was introduced [2], which consists of inserting an optical fiber through an incision and delivering laser energy directly into the subcutaneous adipose tissue. The absorbed laser energy within the tissue induces lipolysis, coagulates small blood vessels and contributes to new collagen formation. However, laser-assisted lipolysis is still a surgery which most patients would prefer to avoid.

Recently, transcutaneous delivery of laser energy to the adipose tissue has attracted significant attention

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DOI 10.1002/lsm.23124

NUMERICAL MODELING OF HYPERTHERMIC LASER LIPOLYSIS (HTLL)

This study develops a **numerical model of hyperthermic laser lipolysis (HTLL) using a 1,064 nm Nd:YAG laser to improve understanding and optimization of non-invasive fat reduction.** The model combines light transport, heat diffusion, and blood perfusion in a three-layer skin structure (epidermis, dermis, subcutaneous fat). It was validated with experimental data from human subjects, showing strong agreement between simulated and measured skin temperatures. The **primary goal of HTLL is to heat adipose tissue to 43–47°C, which induces programmed fat cell death (apoptosis) while preserving surrounding skin tissue.**

TEMPERATURE DISTRIBUTION AND THE ROLE OF COOLING

The study demonstrates that **cooling plays a critical role in controlling heat distribution** within tissue. Without cooling, surface and deep temperatures remain similar, limiting treatment selectivity. **With forced-air cooling, a larger temperature gradient is created, allowing higher temperatures in subcutaneous fat while maintaining lower skin surface temperatures.** This enables safer delivery of energy to deeper tissues. Additionally, after irradiation stops, a delayed temperature increase at the surface occurs due to heat diffusion from deeper layers.

IMPORTANCE OF TIME–TEMPERATURE RELATIONSHIP FOR FAT CELL DAMAGE

Thermal damage to adipocytes depends on both temperature and exposure duration, described by the Arrhenius damage model. Sustained exposure to moderate temperatures is more effective than short exposure to high temperatures. Even small increases in temperature significantly increase tissue damage, but also raise the risk of unwanted effects. Therefore, **controlled and prolonged heating within the optimal range is essential** to achieve apoptosis without causing necrosis or damage to surrounding tissues.

CYCLED TREATMENT PROTOCOLS FOR SAFE AND EFFECTIVE RESULTS

The study identifies **cycled irradiation protocols as an effective strategy for treating larger areas.** In this approach, multiple adjacent skin regions are heated sequentially, allowing heat to accumulate in deeper tissues while the surface cools between cycles. This **results in progressive temperature increase in subcutaneous fat without exceeding safe skin temperature limits.** Optimal protocols include multiple cycles, controlled energy delivery, and active cooling, achieving effective fat reduction at depths of approximately 0.3–2.5 cm while maintaining safety.

Short Drafts of Selected Scientific Publications

FOTONA4D®

Beyond Surface Improvement: Histological and Clinical Benefits of Combined 2940 nm and 1064 nm Laser Therapy

Authors: Shanina N.A., Patrushev A.V., Zorman A.

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Published in: Journal of Cosmetic Dermatology, 2021


ORIGINAL CONTRIBUTION

WILEY

Histological and immunohistochemical changes in facial skin treated with combined ablative and non-ablative laser therapy

Natalia A. Shanina MD[1] | Alexander V. Patrushev MD[1] | Anže Zorman MD[2]

OPEN ACCESS

EVALUATING HISTOLOGICAL EFFECTS OF COMBINED LASER REJUVENATION

This study aimed to evaluate the macroscopic, histological, and immunohistochemical changes in facial skin following combined ablative and non-ablative laser therapy. The objective was to determine whether dual-wavelength treatment can induce structural skin remodelling at both clinical and microscopic levels.

CLINICAL AND HISTOLOGICAL STUDY USING DUAL-WAVELENGTH PROTOCOL

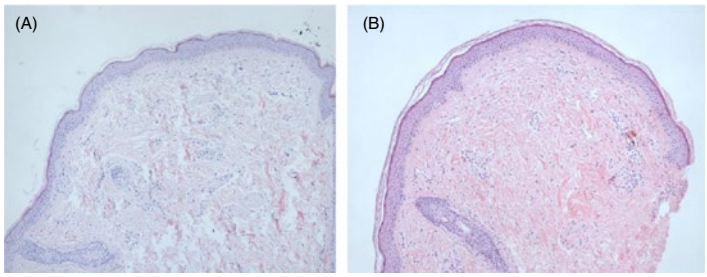
A clinical study included 14 patients with moderate to severe signs of facial aging. Treatments were performed using the SP Dynamis® system (Fotona, Slovenia) following a four-step protocol (Fotona4D®) combining 2940 nm Er:YAG and 1064 nm Nd:YAG lasers. Patients underwent two treatment sessions at 1-month intervals. Outcomes included clinical evaluation using an age-related skin index (IOVIKL), as well as histological and immunohistochemical analysis of skin biopsies taken before and 2 months after treatment.

SIGNIFICANT CLINICAL AND MICROSCOPIC SKIN IMPROVEMENTS

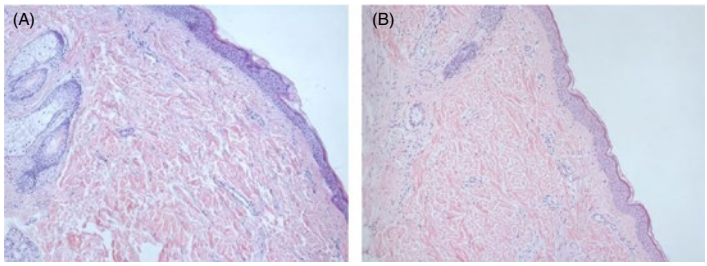
All patients showed significant clinical improvement, with reductions in wrinkles, pigmented lesions, pore size, and overall skin aging scores. Histological analysis demonstrated increased epidermal thickness, higher fibroblast activity, increased collagen fiber density, and enhanced connective tissue structure. Immunohistochemical findings confirmed increased collagen production and significant angiogenesis, evidenced by increased microvessel density and CD34 expression. These changes are illustrated in histology images showing denser collagen and vascular structures after treatment.

SYNERGISTIC MULTI-LAYER SKIN REGENERATION WITH HIGH SAFETY

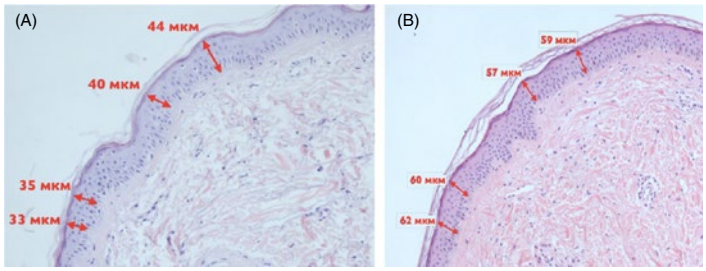
The combination of ablative and non-ablative laser modalities produces synergistic effects by targeting multiple layers and mechanisms of skin aging, including collagen remodelling and vascular regeneration. The treatment was well tolerated, with no significant adverse effects and minimal downtime. This dual-wavelength approach provides both visible clinical improvement and measurable histological regeneration, supporting its role as an effective and comprehensive facial rejuvenation strategy.



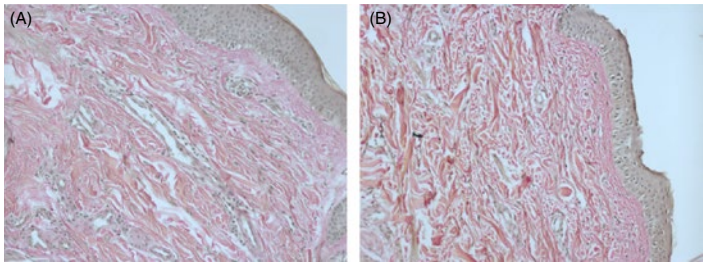
*Female patient. Light microscopy before **(A)** and after **(B)** laser treatment with more eosinophilic ground substance with increased connective tissue density (hematoxylin/eosin, 100x magnification).*



*Female Patient. Light microscopy before **(A)** and after **(B)** combined laser treatment with an increase in the number of fibroblasts and evidence of glomeruloid angiogenesis (hematoxylin/eosin, 100x magnification).*



*Female Patient. Light microscopy before **(A)** and after **(B)** combined laser treatment showing increased epithelial thickness (hematoxylin/eosin, 100x magnification).*



*Male patient. Light microscopy before **(A)** and after **(B)** laser treatment with an increase in the number and intensity of collagen fibers (Van Gieson's stain, 200x magnification).*

*Female Patient — before the procedure **(A)**, 1 month after second procedure **(B)**.*

Enhanced Facial Rejuvenation with Combined 1,064 nm and 2,940 nm Laser Treatment Compared with Single-Modality Therapy: A Randomized Split-Face Study

Authors: Song W., Tian Y., Tan W., Wang G., Gao L.

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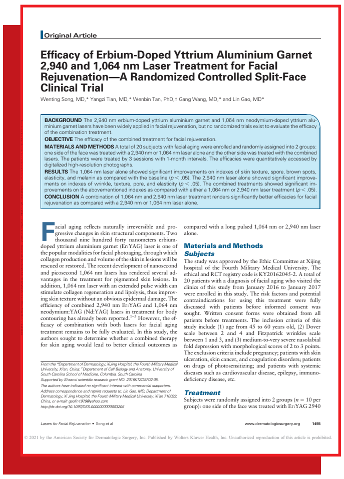
Published in: Dermatologic Surgery, 2021



Original Article

Efficacy of Erbium-Doped Yttrium Aluminium Garnet 2,940 and 1,064 nm Laser Treatment for Facial Rejuvenation—A Randomized Controlled Split-Face Clinical Trial

Wenting Song, MD,* Yangzi Tian, MD,* Wenbin Tan, PhD,† Gang Wang, MD,* and Lin Gao, MD*

BACKGROUND The 2,940 nm erbium-doped yttrium aluminium garnet and 1,064 nm neodymium-doped yttrium aluminium garnet lasers have been widely applied in facial rejuvenation, but no randomized trials exist to evaluate the efficacy of the combination treatment.
OBJECTIVE The efficacy of the combined treatment for facial rejuvenation.
MATERIALS AND METHODS A total of 20 subjects with facial aging were enrolled and randomly assigned into 2 groups: one side of the face was treated with a 2,940 nm or 1,064 nm laser alone and the other side was treated with the combined lasers. The patients were treated by 3 sessions with 1-month intervals. The efficacies were quantitatively accessed by digitalized high-resolution photographs.
RESULTS The 1,064 nm laser alone showed significant improvements on indexes of skin texture, spore, brown spots, elasticity, and melanin as compared with the baseline ($p < .05$). The 2,940 nm laser alone showed significant improvements on indexes of wrinkle, texture, pore, and elasticity ($p < .05$). The combined treatments showed significant improvements on the abovementioned indexes as compared with either a 1,064 nm or 2,940 nm laser treatment ($p < .05$).
CONCLUSION A combination of 1,064 nm and 2,940 nm laser treatment renders significantly better efficacies for facial rejuvenation as compared with a 2,940 nm or 1,064 nm laser alone.

Facial aging reflects naturally irreversible and progressive changes in skin structural components. Two thousand nine hundred forty nanometers erbium-doped yttrium aluminium garnet (Er:YAG) laser is one of the popular modalities for facial photoaging, through which collagen production and volume of the skin in lesions will be rescued or restored. The recent development of nanosecond and picosecond 1,064 nm lasers has rendered several advantages in the treatment for pigmented skin lesions. In addition, 1,064 nm laser with an extended pulse width can stimulate collagen regeneration and lipolysis, thus improving skin texture without an obvious epidermal damage. The efficiency of combined 2,940 nm Er:YAG and 1,064 nm neodymium:YAG (Nd:YAG) lasers in treatment for body contouring has already been reported.[1–3] However, the efficacy of combination with both lasers for facial aging treatment remains to be fully evaluated. In this study, the authors sought to determine whether a combined therapy for skin aging would lead to better clinical outcomes as compared with a long pulsed 1,064 nm or 2,940 nm laser alone.

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http://dx.doi.org/10.1097/DSS.0000000000003205

Materials and Methods

Subjects

The study was approved by the Ethic Committee at Xijing hospital of the Fourth Military Medical University. The ethical and RCT registry code is KY20162045-2. A total of 20 patients with a diagnosis of facial aging who visited the clinics of this study from January 2016 to January 2017 were enrolled in this study. The risk factors and potential contraindications for using this treatment were fully discussed with patients before informed consent was sought. Written consent forms were obtained from all patients before treatments. The inclusion criteria of this study include (1) age from 45 to 60 years old, (2) Dover scale between 2 and 4 and Fitzpatrick wrinkles scale between 1 and 3, and (3) medium-to-very severe nasolabial fold depression with morphological scores of 2 to 3 points. The exclusion criteria include pregnancy; patients with skin ulceration, skin cancer, and coagulation disorders; patients on drugs of photosensitizing; and patients with systemic diseases such as cardiovascular disease, epilepsy, immunodeficiency disease, etc.

Treatment

Subjects were randomly assigned into 2 groups ($n = 10$ per group): one side of the face was treated with Er:YAG 2940

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COMBINING ER:YAG AND ND:YAG LASERS FOR FACIAL REJUVENATION

This study aimed to evaluate the efficacy of combined 2940 nm Er:YAG and 1064 nm Nd:YAG laser treatment for facial rejuvenation. The objective was to determine whether a multi-modality approach provides superior improvement in skin aging features compared to either laser used alone.

RANDOMIZED SPLIT-FACE CLINICAL TRIAL DESIGN

A randomized controlled split-face study included 20 patients with facial aging. Treatments were performed using the SP Dynamis® system (Fotona, Slovenia), where one side of the face received either Er:YAG or Nd:YAG monotherapy, and the contralateral side received combined treatment. Patients underwent three sessions at one-month intervals. Outcomes were assessed using high-resolution imaging (VISIA system) for wrinkles, texture, pores, and brown spots, as well as instrumental measurements of skin elasticity and melanin levels, alongside blinded clinical evaluation and patient satisfaction scoring.

SUPERIOR MULTI-PARAMETER IMPROVEMENT WITH COMBINATION THERAPY

Both monotherapies demonstrated significant improvements compared to baseline, but with modality-specific strengths. Er:YAG alone showed greater improvement in wrinkles and skin texture, while Nd:YAG alone was more effective in improving pigmentation, pores, elasticity, and melanin levels. However, the combined treatment produced significantly greater improvements across multiple parameters, including wrinkles, texture, pores, brown spots, elasticity, and melanin. Quantitative VISIA analysis confirmed superior overall skin rejuvenation with combination therapy.

SYNERGISTIC AND SAFE APPROACH FOR COMPREHENSIVE REJUVENATION

The combination of 2940 nm Er:YAG and 1064 nm Nd:YAG lasers provides a synergistic effect by targeting multiple aspects of skin aging simultaneously, resulting in enhanced overall clinical outcomes. Treatments were well tolerated, with only mild and transient side effects such as erythema, edema, and temporary pigmentation changes. This multi-modality approach represents an effective and safe strategy for comprehensive facial rejuvenation.

FOTONA4D®

Three-Dimensional Imaging of Dynamic Changes After Nd:YAG/Er:YAG Laser Skin Tightening: A Prospective Study.

Authors: Qi J., Wang Q., Huang L., Zhang L.

-

Published in: Lasers in Surgery and Medicine, 2026

FOTONA4D® MEN

Fotona4D®Men - Rejuvenation for Men.

Author: Gaspar A.

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Published in: Journal of the Laser and Health Academy, 2021

HONEYCOMB®

How I Do It - A non-invasive approach to facial and neck rejuvenation.

Author: Osterc Diwersy T.

-

Published in: THE PMFA JOURNAL, 2025

SMOOTHEYE® AND PERIOCULAR REJUVENATION

Non-Ablative Er:YAG SmoothEye® Treatment Produces Clinically Significant Improvements in Periorbital Wrinkles, Elastosis, and Skin Laxity

Authors: Badawi A., Sobeih T., Vesel J.

-

Published in: Lasers in Medical Science, 2022

EVALUATING NON-ABLATIVE ER:YAG LASER FOR PERIOCULAR REJUVENATION

This study aimed to evaluate the safety and efficacy of non-ablative long-pulse 2940 nm Er:YAG laser for the treatment of periorbital wrinkles and skin laxity. The objective was to provide a minimally invasive alternative to ablative resurfacing procedures by stimulating collagen remodeling while minimizing downtime and adverse effects.

PROSPECTIVE STUDY USING SMOOTH™ ER:YAG LASER TECHNOLOGY

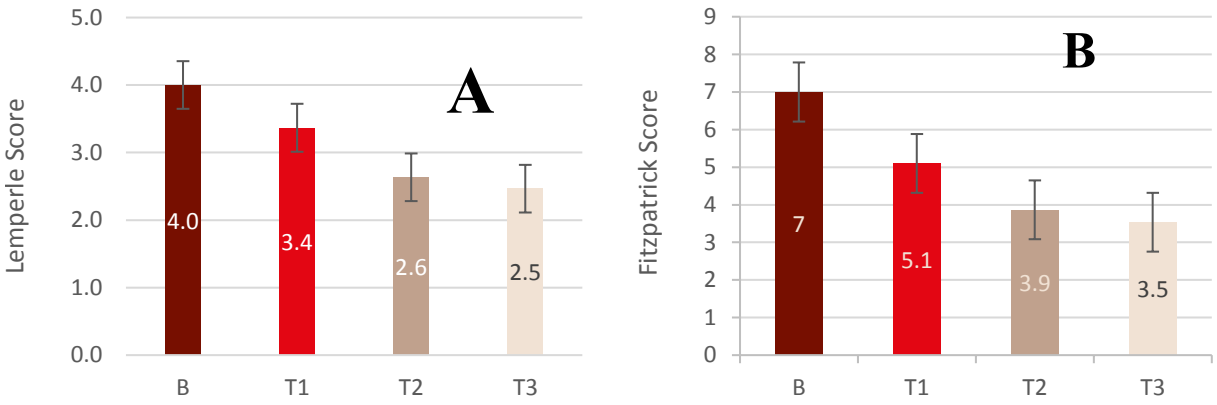
A prospective clinical study included 30 patients with varying degrees of periorbital wrinkles treated with three laser sessions at 4-week intervals. Treatments were performed using the SP Dynamis® system (Fotona, Slovenia) with non-ablative Fotona SMOOTH® mode. Outcomes were assessed using validated wrinkle scales (Lemperle and Fitzpatrick), blinded photographic evaluation, patient satisfaction questionnaires, and safety monitoring, with follow-up extending to 12 months.

SIGNIFICANT AND SUSTAINED IMPROVEMENT IN WRINKLES

The study demonstrated statistically significant improvement in wrinkle severity and skin quality, with reductions in both Lemperle and Fitzpatrick scores after each treatment session. Improvements were maintained at 12 months, indicating long-term efficacy. Blinded evaluators correctly identified pre- and post-treatment images in all cases, confirming visible clinical improvement. Adverse effects were mild and transient, including short-lived erythema, edema, and superficial peeling, with no long-term complications reported. Patient satisfaction was high, with most patients reporting moderate to excellent improvement.

SAFE, MINIMALLY INVASIVE TREATMENT WITH LONG-TERM BENEFITS

Non-ablative Er:YAG SMOOTH™ laser treatment appears to be a safe and effective option for periocular rejuvenation, providing durable improvements with minimal downtime. This approach offers a valuable alternative to ablative procedures, particularly for patients seeking less invasive treatments with sustained results.



(A) Mean values of Lemperle Score and (B) Fitzpatrick Score at baseline, after 1st, 2nd, and 3rd sessions. B—baseline, T1—after 1st session, T2—after 2nd session, T3—after 3rd session.

	After session 1 ($N=30$)	After session 2 ($N=30$)	12 months after session 3 ($N=28$)
Satisfaction			
– 1: worsening	0	0	3.6%
0: no improvement	0	0	0
1: mild improvement	6.7%	3.3%	7.1%
2: moderate improvement	46.7%	46.7%	42.9%
3: excellent improvement	46.7%	50.0%	46.4%
Mean patient satisfaction score (SD)	2.4 (±0.6)	2.5 (±0.6)	2.3 (±0.9)

Patient evaluation of treatment outcome.

Improvement of periorbital wrinkles: (A) before treatment; (B) 12 months after the 3rd treatment.

SMOOTHEYE® AND PERIOCULAR REJUVENATION

Fox eyes lift - A new protocol for eyebrow elevation with laser Fotona.

Authors: Burmann, T. G., Duarte, F. B., Akaishi, P. M. S.
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Published in: Journal of Cosmetic Dermatology, 2024

Reduction of the Volume and Wrinkles under the Eyes using Non-Ablative 2940 nm Er:YAG Laser on the Lower Eyelid Palpebral Conjunctiva.

Authors: Jong-Gu K., Zorman A.
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Published in: Journal of the Laser and Health Academy, 2018

VECTORLIFT®

Fotona VectorLift™ Technique for Eyebrow Tail Elevation and Upper Eyelid Rejuvenation with hyperstacking of Smooth Mode pulses.

Author: Gaspar A.
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Published in: Journal of the Laser and Health Academy, 2022

LIPLASE® AND INTRAORAL REJUVENATION

Improved Vermillion Border Definition with Fotona's LipLase Er:YAG Lip Enhancement Protocol.

Authors: Vélez, N. C., Vélez Ocampo, J. C., Vélez Ocampo, S.

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Published in: Journal of the Laser and Health Academy, 2024

The effect of intraoral 2,940nm non-ablative Erbium: YAG laser on the rejuvenation of the upper lip: A pilot study.

Authors: Gaón, N., Binfa, F.

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Published in: Surgical & Cosmetic Dermatology, 2017

Maximizing Results, Minimizing Downtime: A Dual-Phase Er:YAG Approach to Full-Face Skin Resurfacing

Authors: Mani N., Pajk F., Vizintin Z.

-

Published in: Journal of Cosmetic Dermatology, 2021

ORIGINAL CONTRIBUTION

WILEY

Full-face skin resurfacing using a combination of fractional and full spot ablative 2940 nm erbium laser

Nasrin Mani MD[1] | Franja Pajk PhD[2] | Zdenko Vizintin BSEE, MSc[3]

Abstract

1 | INTRODUCTION

EVALUATING COMBINED ER:YAG LASER FOR FULL-FACE RESURFACING

This study aimed to evaluate the safety and efficacy of a combined fractional and full-spot ablative 2940 nm Er:YAG laser approach for full-face skin resurfacing. The objective was to achieve results comparable to full-field ablative treatments while reducing downtime and adverse effects associated with aggressive resurfacing.

RETROSPECTIVE STUDY USING DUAL-PHASE ER:YAG PROTOCOL

A retrospective study included 109 patients, predominantly females over 50 years old, treated using a two-phase protocol with the SP Dynamis® system (Fotona, Slovenia). The treatment combined full-spot Er:YAG ablation (5 J/cm^2, three passes) followed by fractional Er:YAG ablation (132 J/cm^2, 5% coverage, three passes). Most patients received a single treatment session. Outcomes included time to re-epithelialization, duration of erythema, side effects, blinded photographic evaluation (GAIS), and patient satisfaction.

HIGH PATIENT SATISFACTION WITH CONTROLLED DOWNTIME

The majority of patients (78%) showed clinical improvement based on blinded evaluation, with 24% rated as very much improved. Patient satisfaction was high, with 97% satisfied and 67% very satisfied. Re-epithelialization occurred within approximately 6.4 days on average, and erythema lasted about 13.8 days.

COMBINED APPROACH BALANCING EFFICACY AND SAFETY

Blinded evaluation of standardized clinical photographs demonstrated improvement in 78% of patients, as assessed GAIS, with high inter-rater reliability. Side effects were rare (3.7%) and included isolated cases of hyperpigmentation, infection, hypopigmentation, and ulceration, all resolving without complications. These findings indicate that the combined approach provides effective clinical improvement with a favorable safety profile.

Multiple fractional erbium: yttrium-aluminum-garnet laser sessions for upper facial rejuvenation: clinical and histological implications and expectations.

Authors: El-Domyati, M., Abd-El-Raheem, T., Medhat, W., Abdel-Wahab, H., & Al Anwer, M.

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Published in: Journal of Cosmetic Dermatology, 2014

Periorbital rejuvenation with fractional 1,550-nm ytterbium/erbium fiber laser and variable square pulse 2,940-nm erbium:YAG laser in Asians: a comparison study.

Authors: Wattanakrai, P., Pootongkam, S., Rojhirunsakool, S.

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Published in: Dermatologic Surgery, 2012

MICRO LASER CORING

Micro laser coring: A cutting-edge approach to skin rejuvenation

Authors: Osterc Diwersy T.

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Published in: THE PMFA JOURNAL, 2025

SUPERSMOOTH™

SuperSMOOTH™: a Novel Hybrid Er:YAG Laser Modality for Fast, Effective, and Minimally Invasive Skin Rejuvenation – a Clinical Case Series.

Authors: Osterc Diwersy, T., Murovec Misigoj, N., Hreljac, I., Lukac, M.

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Published in: Journal of the Laser and Health Academy, 2025

PERIORAL REJUVENATION

Comparative analysis of erbium: glass 1550 nm and combined erbium: YAG & Nd: YAG lasers for perioral rejuvenation: a prospective study.

Authors: Mohamadi, F., Pourgholi, E., Vahabi, S. M., Hosseini, F., Mahmoudi, H., Ehsani, A., Etesami, I.

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Published in: Lasers in Medical Science, 2025

FRACREVIVE®

How I Do It - FracRevive - holistic skin rejuvenation with a combination of full beam and fractional Q-switched Nd:YAG laser.

Author: Choong, L. C. L.

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Published in: THE PMFA JOURNAL, 2022

Effective Acne Scar Improvement with High-Energy Fractional Q-Switched Nd:YAG Laser

Authors: Mani N., Zorman A.

Published in: Journal of Cosmetic Dermatology, 2021

EVALUATING FRACTIONAL Q-S ND:YAG LASER FOR ACNE SCARS

This study aimed to evaluate the efficacy and safety of a high-energy fractional nanosecond 1064 nm Q-switched Nd:YAG laser for the treatment of acne scars. The objective was to determine whether higher fluence fractional delivery could improve scar outcomes while maintaining minimal downtime and reducing the risk of adverse effects associated with traditional ablative treatments.

RETROSPECTIVE STUDY USING FRACTIONAL ND:YAG LASER

A retrospective study included 46 patients with acne scars treated using the StarWalker® MaQX laser system (Fotona, Slovenia) equipped with a fractional 1064 nm handpiece FS20A. Treatments were performed using high energy levels (30–75 mJ per pixel) with multiple passes depending on scar severity. Patients underwent 1 to 4 sessions, with intervals based on healing time. Outcomes were assessed through blinded evaluation of standardized photographs and patient satisfaction scores.

SIGNIFICANT CLINICAL IMPROVEMENT WITH MINIMAL DOWNTIME

Most patients (75%) were rated as improved or very improved by blinded evaluators, demonstrating clear clinical benefit. The average number of sessions was low (approximately 1.7), indicating efficient treatment. Healing was rapid, with re-epithelialization occurring within approximately 2–3 days and erythema resolving within about 9 days. No serious adverse effects, including hyperpigmentation, hypopigmentation, or scarring, were reported. Patient satisfaction was high, with the majority reporting satisfaction or high satisfaction with treatment outcomes.

EFFECTIVE, SAFE, AND LOW-DOWNTIME TREATMENT APPROACH

High-energy fractional nanosecond Q-switched Nd:YAG laser appears to be a safe and effective treatment for acne scars, offering meaningful clinical improvement with minimal downtime and good tolerability. The fractional delivery allows controlled ablation and collagen remodeling while preserving surrounding tissue, contributing to a favorable safety profile across Fitzpatrick skin types II–IV.

Blinded evaluation	*N* = 12	
1-Exceptional improvement	0	0%
2-Very good improvement	3	25%
3-Improvement	6	50%
4-No change	3	25%
5-Worsening	0	0%

Scar improvement graded by 3 blinded assessors (GAIS).

Patient satisfaction	*N* = 20	
3-Very satisfied	5	25%
2-Satisfied	12	60%
1-Somewhat satisfied	3	15%
0-Not satisfied	0	0%

Patient satisfaction.

Before and 2 weeks after the second procedure.

Before and 4 months after a single procedure.

Before and 1 months after a single procedure.

Fractional Erbium-YAG Laser and Platelet-Rich Plasma as Single or Combined Treatment for Atrophic Acne Scars: A Randomized Clinical Trial.

Authors: El-Taieb, M. A., Ibrahim, H. M., Hegazy, E. M., Ibrahim, A. K., Gamal, A. M., Nada, E. A.
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Published in: Dermatology and Therapy, 2019

Resurfacing of Facial Acne Scars With a New Variable-Pulsed Er:YAG Laser in Fitzpatrick Skin Types IV and V.

Authors: Chathra N., Mysore V.
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Published in: Journal of Cutaneous and Aesthetic Surgery, 2018

Laser-Induced Optical Breakdown - Acne Scars Treatment.

Author: Santos P. A.
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Published in: Journal of the Laser and Health Academy, 2018

Fractional Erbium-Doped Yttrium Aluminum Garnet Laser Versus Microneedling in Treatment of Atrophic Acne Scars: A Randomized Split-Face Clinical Study.

Authors: Osman, M. A., Shokeir, H. A., Fawzy, M. M.

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Published in: Dermatologic surgery, 2017

Evaluation of effectiveness of erbium:yttrium–aluminum–garnet laser on atrophic facial acne scars with 22-MHz digital ultrasonography in a Turkish population.

Authors: Engİn, B, Kutlubay, Z., Karakuş, Ö., Yardimci, G., Doğan, Z., Tüzün, Y., Serdaroğlu, S.

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Published in: Journal of Dermatology, 2012

Treatment of punched-out atrophic and rolling acne scars in skin phototypes III, IV, and V with variable square pulse erbium:yttrium-aluminum-garnet laser resurfacing.

Authors: Wanitphakdeedecha, R., Manuskiatti, W., Siriphukpong, S., Chen, T. M.

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Published in: Dermatologic Surgery, 2009

Treatment of Scars Combining Er:YAG and Nd:YAG using the SP Dynamis Laser.

Authors: Vélez Ocampo, S., Vélez Ocampo, J. C.
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Published in: Journal of the Laser and Health Academy, 2021

HYPERTROPHIC SCARS

Hypertrophic Scar Outcomes in Fractional Laser Monotherapy Versus Fractional Laser-Assisted Topical Corticosteroid Delivery: A Randomized Clinical Trial.

Authors: Manuskiatti, W., Kaewkes, A., Yan, C., Ng, J. N., Glahn, J. Z., Wanitphakdeedecha, R.
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Published in: Acta Dermato-Venereologica, 2021

KELOID SCARS

Laser-assisted topical steroid application versus steroid injection for treating keloids: A split side study.

Authors: Abd El-Dayem, D. H., Nada, H. A., Hanafy, N. S., Elsaie, M. L.
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Published in: Journal of Cosmetic Dermatology, 2020

Safety and Efficacy of Long-pulsed Nd:YAG Laser for the Treatment of Keloids – A Prospective Study of 39 Keloids.

Authors: Mysore V., Mhatre M.
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Published in: Journal of the Laser and Health Academy, 2015

Comparative Study Between the efficacy of LongPulsed Neodymium- YAG Laser and Fractional Co2 Laser in the Treatment of Striae Distensae.

Authors: Hendawy, A. F., Aly, D. G., Shokeir, H. A., Samy, N. A.
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Published in: Journal of Lasers in Medical Sciences, 2021

LINELASE™

Optical Coherence Tomography-Assisted Evaluation of Fractional Er:YAG Laser Versus Fractional Microneedling Radiofrequency in Treating Striae Alba.

Authors: Nada, H. A., Sallam, M. A., Mohamed, M. N., Elsaie, M. L.
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Published in: Lasers in Surgery and Medicine, 2021

A pilot study of treatment of striae distensae with variable square pulse Erbium: YAG laser resurfacing.

Authors: Wanitphakdeedecha, R., Meeprathom, W., Manuskiatti, W.
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Published in: Journal of Cosmetic Dermatology, 2017

Efficiency of ablative fractional Er:YAG (erbium: yttrium-aluminum-garnet) laser in the treatment of benign epidermal and dermal skin lesions: A retrospective study.

Authors: Koc, E., Yeniay, Y., Yeşil, H., Caliskan, E., Açıkgöz, G.

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Published in: Turkderm: Archives of the Turkish Dermatology and Venerology, 2014

Comparative study of the efficacy of Fractional Er: YAG 2940 nm laser and Q-switched Nd: YAG 1064 nm laser in keratosis pilaris.

Authors: Al-Dhalimi, M. A., Al-Hilo, A. M.
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Published in: Journal of Cosmetic Dermatology, 2022

Innovative 1064-nm Nd:YAG Laser Significantly Improves Keratosis Pilaris, A Randomized, Double-Blind, Sham-Irradiation-Controlled Trial.

Authors: Maitriwong, P., Tangkijngamvong, N., Asawanonda, P.
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Published in: Lasers in Surgery and Medicine, 2020

The Efficacy and Safety of a Variable Square Pulse (VSP) Erbium:YAG Laser for Treatment of Enlarged Pores in Asians.

Authors: Park, K. Y., Ko, E. J., Seo, S. J., Hong, C. K.

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Published in: Lasers in Surgery and Medicine, 2021

Short-pulsed and Q-switched ND-YAG laser with topical carbon versus fractional CO2 laser in the treatment of enlarged facial pores: A split-face comparative study.

Authors: Wanitphakdeedecha, R., Eimpunth, S., Manuskiatti, W., Manonukul, J.

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Published in: Lasers in Surgery and Medicine, 2021

Comparable Efficacy of Nd:YAG and Pulsed Dye Laser for Acne Vulgaris: A Split-Face Randomized Study

Authors:
Chalermsuwiwattanakan N., Rojhirunsakool S., Kamanamool N., Kanokrungsee S., Udompataikul M.

Published in: Journal of Cosmetic Dermatology, 2021

ORIGINAL CONTRIBUTIONS

WILEY

The comparative study of efficacy between 1064-nm long-pulsed Nd:YAG laser and 595-nm pulsed dye laser for the treatment of acne vulgaris

Napith Chalermsuwiwattanakan MD[1] | Saline Rojhirunsakool MD, MSc[2] | Nantcha Kamanamool MD, PhD[2] | Sitada Kanokrungsee MD[1] | Montree Udompataikul MD[1]

Abstract

Background: The popularity of laser therapy in acne treatment has been increasing recently due to its safety, effectiveness, and convenience. Both 595-nm pulsed dye laser (PDL) and 1064-nm long-pulsed neodymium:yttrium-aluminum-garnet laser (Nd:YAG) have been successful in treating inflammatory acne lesions. However, clinical data from controlled comparative studies are still lacking.

Aims: To compare the clinical efficacy of 1064-nm Nd:YAG with 595-nm PDL for the treatment of acne vulgaris.

Methods: Thirty-four participants with mild to moderate facial acne were enrolled and then randomized to receive three, 2-week interval treatments with 1064-nm Nd:YAG on one side of the face and 595-nm PDL on the other side. Clinical assessments including acne lesion counts, acne erythema grading, and erythema index were performed at baseline, 2nd, 4th, and 8th week. Participants' satisfaction, preference, and adverse effects were recorded.

Results: As compared with baseline, the significant reduction of mean inflammatory acne lesion counts, acne erythema grading, and erythema index was demonstrated on 595-nm PDL-treated sides and 1064-nm Nd:YAG-treated sides. However, there were no significant differences between both sides. The participants were satisfied with both laser treatments, but the participants preferred 1064-nm Nd:YAG over 595-nm PDL treatment. The adverse effects were less on 1064-nm Nd: YAG-treated sides.

Conclusions: 1064-nm Nd:YAG and 595-nm PDL treatments are equally effective in reducing inflammatory acne lesions and acne erythema in mild to moderate facial acne vulgaris.

KEYWORDS

595-nm Pulsed dye laser, 1064-nm Long-pulsed Nd:YAG laser, Acne erythema, Acne vulgaris

COMPARING ND:YAG AND PDL FOR ACNE TREATMENT

This study aimed to compare the clinical efficacy and safety of 1064 nm long-pulsed Nd:YAG laser and 595 nm pulsed dye laser (PDL) for the treatment of mild to moderate facial acne vulgaris. The objective was to determine whether one modality offers superior reduction of inflammatory lesions and erythema, while maintaining a favourable safety profile.

SPLIT-FACE RANDOMIZED CLINICAL STUDY DESIGN

A prospective, randomized split-face clinical trial included 34 patients treated with both modalities on opposite sides of the face. The 1064 nm Nd:YAG treatments were performed using the Dualis SP® system (Fotona, Slovenia), while the contralateral side received 595 nm PDL treatment. Patients underwent three treatment sessions at 2-week intervals, with follow-up assessments including lesion counts, erythema index, acne severity grading, patient satisfaction, pain scores, and adverse effects.

BETTER TOLERABILITY AND FEWER ADVERSE EFFECTS WITH ND:YAG LASER

Both laser modalities demonstrated significant reductions in inflammatory acne lesions, erythema index, and acne severity scores compared to baseline, with no statistically significant difference between the two treatments. However, Nd:YAG treatment demonstrated significantly lower pain scores and fewer adverse effects compared to PDL. Additionally, Nd:YAG demonstrated a trend toward more sustained improvement and less rebound in noninflammatory lesions, while PDL showed slightly faster but less durable responses.

ND:YAG AS A PREFERRED OPTION FOR SAFETY AND PATIENT COMFORT

Both 1064 nm Nd:YAG and 595 nm PDL are safe and moderately effective treatments for inflammatory acne and associated erythema. However, Nd:YAG may be preferable, particularly in patients with darker skin types, due to lower risk of adverse effects, reduced discomfort, and higher patient preference.

Multimodal laser treatment for active acne with Nd:YAG and Er:YAG Laser.

Authors: Vélez Ocampo, S., Vélez Ocampo, J. C.

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Published in: Journal of the Laser and Health Academy, 2020

Treatment of Acne Vulgaris with 1064 nm Nd:YAG Laser.

Authors: Ganceviciene, R., Meskauskas, R., Berzanskyte, A.

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Published in: Journal of the Laser and Health Academy, 2015

Visible Hair Regrowth with Non-ablative Er:YAG Laser: A Clinical Observation in Androgenetic Alopecia

Authors: Zhang Q., Yang E., Cong L., Yang X., Ye J., Zhao W., Hu G., Talaber I.

-

Published in: Dermatologic Therapy, 2025

NON-ABLATIVE ER:YAG LASER AS A NOVEL OPTION FOR ANDROGENETIC ALOPECIA

This clinical observational study evaluated the effectiveness and safety of non-ablative Er:YAG laser treatment in patients with androgenetic alopecia (AGA). The aim was to assess whether minimally invasive laser therapy could provide visible improvement in hair appearance and patient satisfaction as a non-pharmacological treatment option for both male and female patients with early to advanced AGA.

A COMPREHENSIVE EVALUATION OF NON-ABLATIVE ER:YAG LASER TREATMENT

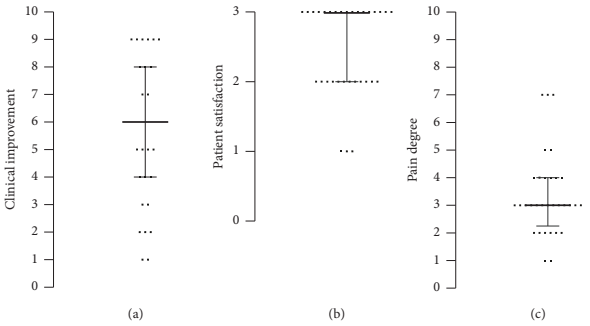
The clinical study enrolled 32 patients (22 men and 10 women) who received 2940 nm Er:YAG laser therapy using the XS Dynamis® system (Fotona, Slovenia). The treatment protocol consisted of six biweekly sessions using non-ablative Fotona SMOOTH® mode, with multiple laser passes over the affected scalp regions and controlled thermal delivery. Treatment efficacy was evaluated using clinical improvement scores, blinded assessment of standardized global photographs, patient satisfaction questionnaires, and pain scores.

VISIBLE HAIR IMPROVEMENT IN 72% OF PATIENTS WITH HIGH SATISFACTION

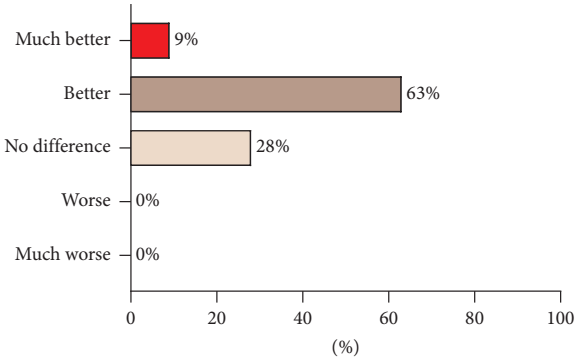
Clinical evaluation revealed a median improvement score of 6 on a 0–10 scale, indicating moderate to marked improvement. Blinded assessment of global photographs showed that hair appearance at 1-month follow-up was better in 63% of patients and much better in an additional 9%, resulting in visible improvement in 72% of treated patients. Patient satisfaction was high, with a median satisfaction score of 3 (very satisfied). Treatment efficacy was consistent across genders and independent of patient age or duration of AGA. The treatment was well tolerated, with a median pain score of 3 on a 0–10 scale, indicating mild discomfort. No serious adverse events were reported.

NON-ABLATIVE ER:YAG LASER IS A SAFE AND EFFECTIVE AGA TREATMENT OPTION

The study concludes that non-ablative Er:YAG laser therapy is a safe and effective treatment modality for androgenetic alopecia, producing visible improvement in hair appearance and high patient satisfaction. As a stand-alone, minimally invasive treatment, it represents a promising alternative or adjunct to pharmacological therapies, particularly for patients seeking non-drug-based options.

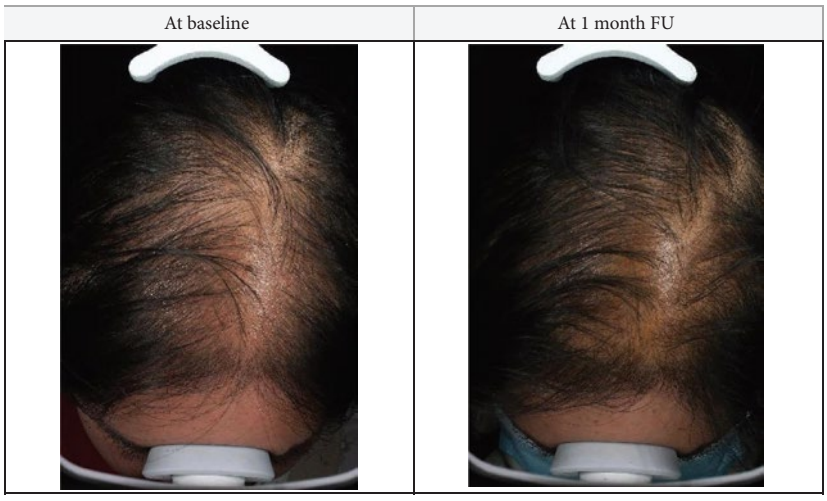


*Outcome measures presented with a frequency distribution, where a single data point on a chart represents a single patient. Black line and bars represent the median and interquartile ranges in **(a)** clinical improvement, **(b)** patient satisfaction, and **(c)** pain degree.*



Blind evaluation of hair appearance at the 1-month FU compared with the baseline. Shown is the percentage of patients receiving a specifc score on a scale from (-2) to (+2), corresponding to improvement in a range of much worse to much better.

Representative global photographs of the treated male patients at the baseline (left) and 1-month FU (right).



Representative global photographs of the treated female patients at the baseline (left) and 1-month FU (right).

Safe, Effective, and Well-Tolerated: Non-Ablative Er:YAG Laser for Hair Regrowth in AGA

Authors: Day D., McCarthy M., Talaber I.

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Published in: Journal of Cosmetic Dermatology, 2022

EVALUATING NON-ABLATIVE ER:YAG LASER FOR ANDROGENETIC ALOPECIA

This study aimed to evaluate the effectiveness and safety of non-ablative Er:YAG laser therapy in patients with androgenetic alopecia (AGA), used either as monotherapy or in combination with adjunctive treatments such as platelet-rich plasma (PRP), topical minoxidil, and nutraceuticals. The objective was to assess clinical improvement across different stages of AGA and determine overall patient outcomes.

RETROSPECTIVE STUDY USING ER:YAG SMOOTH™ LASER THERAPY

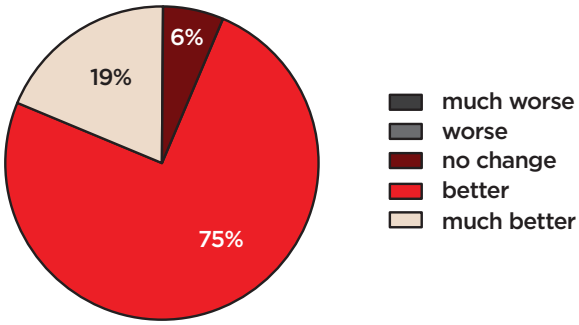
A retrospective clinical study included 16 patients (7 male, 9 female) with varying stages of AGA. All patients underwent eight treatment sessions using the SP Dynamis® system (Fotona, Slovenia) with non-ablative Fotona SMOOTH® Er:YAG mode at two-week intervals. Ten patients additionally received PRP injections, while several patients continued topical minoxidil and oral nutraceutical therapies during the study. Treatment efficacy was assessed using Ludwig and Norwood-Hamilton AGA grading scales, blinded evaluation of standardized global photographs, patient satisfaction questionnaires, pain scores, and safety monitoring.

HIGH RATE OF HAIR QUALITY IMPROVEMENT AND PATIENT SATISFACTION

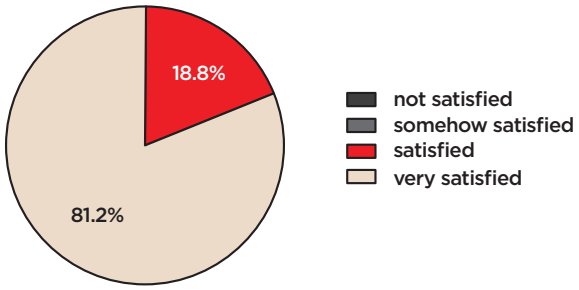
Blinded evaluation demonstrated improvement in hair quality in 93% of patients, with 75% rated as “better” and 19% as “much better,” while only one patient showed no visible change. A reduction in AGA grade was observed in 64% of patients overall, with statistically significant improvement detected in female patients. Patient satisfaction was high, with 81% of patients reporting the highest satisfaction score. Treatments were well tolerated, with low pain levels (median VAS score 2), and no adverse effects were reported during treatment or follow-up. Clinical photographs demonstrated visible improvement in hair appearance and scalp coverage following therapy.

SAFE AND EFFECTIVE TREATMENT WITH OR WITHOUT COMBINATION THERAPY

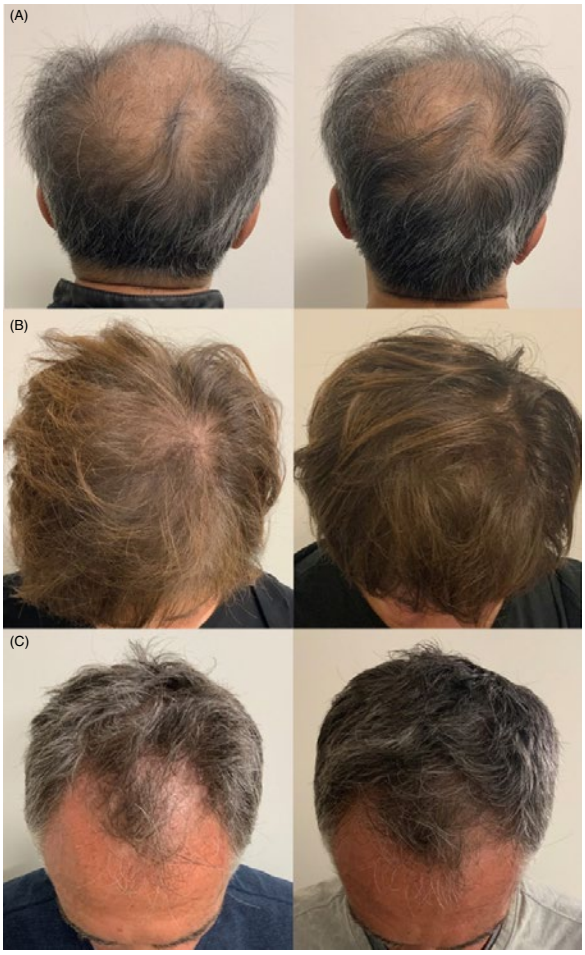
Non-ablative Er:YAG laser therapy SMOOTH® mode appears to be a safe and promising treatment for androgenetic alopecia, producing consistent improvements in hair quality and high patient satisfaction with minimal discomfort, either as monotherapy or in combination with PRP and adjunctive therapies. Results were comparable whether used alone or in combination with PRP and other therapies, suggesting broad clinical applicability.



Hair quality after treatment as assessed by the blind evaluation of global photographs.



Patient satisfaction.



*Representative before and after photographs of three patients. **(A)** Patient 6, treated with laser monotherapy. AGA stage improved from N- H stage 6 to 5 (North- Hamilton stage), and hair quality was assessed as better by blind evaluation after treatment; **(B)** patient 9, treated with laser combined with PRPb. AGA stage improved from grade 2 to 1 (Ludwig scale), and hair quality was assessed as better by blind evaluation after treatment; **(C)** patient 15, treated with laser combined with PRPa. AGA stage improved from N- H stage 3 to 2, and hair quality was assessed as much better by blind evaluation after treatment.*

Hair regrowth and maintenance in alopecia universalis patient treated with nonablative Er:YAG laser.

Authors: McCarthy, M., Day, D., Talaber, I.

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Published in: Clinical case reports, 2021

ROSACEA TELANGIECTATICA

Precision Vascular Treatment: Long-Pulse Nd:YAG Laser for Rosacea Redness

Author: Kozarev J.

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Published in: Journal of the Laser and Health Academy, 2011

EVALUATING LONG-PULSE ND:YAG LASER FOR ROSACEA TELANGIECTATICA

This study aimed to evaluate the efficacy and safety of long-pulse 1064 nm Nd:YAG laser for the treatment of rosacea telangiectatica, specifically targeting superficial facial blood vessels. The objective was to assess the degree of telangiectasia clearance and determine treatment tolerability.

CLINICAL STUDY USING LONG-PULSE ND:YAG LASER

A clinical study included 23 female patients with Fitzpatrick skin types I–III. Treatments were performed using the Dualis SP II® system (Fotona, Slovenia). Patients received one to three treatment sessions at 6-week intervals, with parameters adjusted based on vessel size and depth. Outcomes included percentage clearance of telangiectasia, patient-reported pain scores (VAS), and monitoring of adverse effects.

HIGH CLEARANCE RATES WITH GOOD TOLERABILITY

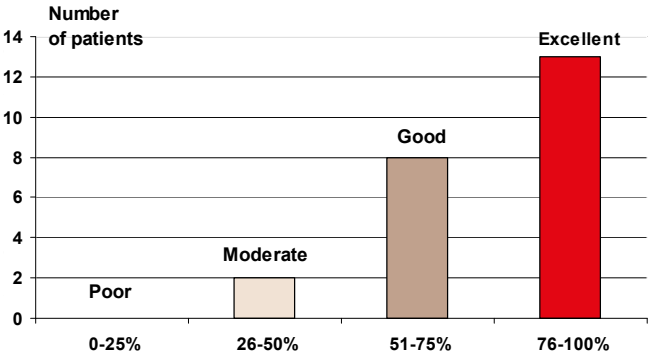
All patients demonstrated clinical improvement in telangiectasia appearance. The majority achieved good to excellent clearance, with 13 patients showing excellent results, 8 good, and 2 moderate clearancesafter treatment. Pain was generally moderate and well tolerated, with most patients rating it as "unpleasant" Transient side effects included mild erythema, edema, one case of prolonged erythema and three cases of hyperpigmentation, all resolving without long-term complications.

EFFECTIVE AND SAFE OPTION FOR VASCULAR LESIONS

Long-pulse Nd:YAG laser appears to be safe and effective treatment for rosacea-associated telangiectasia, particularly for vessels up to 2 mm in diameter. The treatment allows for parameter customization based on vessel characteristics, enabling effective targeting without anypermanent skin changes reported in this study. It is well tolerated without the need for anesthesia and allows patients to resume normal activities immediately.

Rosacea telangiectatica on the patient of skin type II before and 3 months after the treatment.

Excellent clearance of Erythematotelangiectatic type rosacea.



Three months after the last executed session 13 patients achieved excellent clearance, 8 good and 2 moderate.

Single Session of Long-Pulse Nd:YAG Laser for Treatment of Facial Rosacea.

Author: Wong, Y. S.
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Published in: Journal of the Laser and Health Academy, 2023

SUPERFICIAL VASCULAR LESIONS

Using long-pulsed KTP (532 nm) VERDE mode for vascular indications.

Author: Fratnik Florijancic U.
-
Published in: Journal of the Laser and Health Academy, 2018

TELANGIECTASIAS

Laser Treatment for Leg Telangiectasias.

Author: Wing Jian F.
-
Published in: Journal of the Laser and Health Academy, 2023

PORT-WINE STAIN

CASE REPORT: Laser Treatment of PWS using a Combination of Q-s KTP and Long-Pulse Nd:YAG Lasers.

Authors: Volovec, M., Volovec, L., Korosec, B.

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Published in: Journal of the Laser and Health Academy, 2015

FACIAL EPHELIDES (KTP)

Superior Clearance of Facial Ephelides with 532 nm Q-Switched Nd:YAG Laser Compared to Tranexamic Acid

Authors: Sayed K.S., Tuqan S., Hilal R.F.

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Published in: Lasers in Surgery and Medicine, 2021

Q-Switched Nd:YAG (532 nm) Laser Versus Intra-Dermal Tranexamic Acid for Treatment of Facial Ephelides: A Split Face, Randomized, Comparative Trial

Khadiga S. Sayed, Sonar Tuqan, and Rana F. Hilal

Department of Dermatology, Faculty of Medicine, Cairo University, Cairo, Egypt

COMPARING QS ND:YAG LASER AND TRANEXAMIC ACID FOR EPHELIDES

This study aimed to compare the efficacy and safety of 532 nm Q-switched Nd:YAG laser versus intradermal tranexamic acid (TXA) injections for the treatment of facial ephelides (freckles). The objective was to determine which modality provides superior pigment clearance and overall clinical improvement.

SPLIT-FACE RANDOMIZED COMPARATIVE STUDY DESIGN

A randomized split-face clinical trial included 30 female patients with bilateral facial ephelides. One side of the face was treated with intradermal TXA injections, while the other side received 532 nm Q-switched Nd:YAG laser using the QX MAX system (Fotona, Slovenia). TXA was administered every 2 weeks for 2 months, while the laser was delivered in one or two sessions depending on response. Outcomes included pigmentation severity index (PSI), melanin index (MI), erythema index (EI), blinded investigator assessment, patient satisfaction, and safety evaluation.

SUPERIOR PIGMENT REDUCTION WITH QS ND:YAG LASER

The Q-switched Nd:YAG laser demonstrated significantly greater improvement compared to TXA injections. Pigmentation severity (PSI) decreased by approximately 66.5% after treatment and 69.4% at follow-up on the laser-treated side, compared to 15.4% and 26.1% on the TXA side. Melanin index reduction was also significantly greater with laser treatment. Blinded evaluators and patient satisfaction scores consistently favored the laser-treated side. TXA showed modest depigmenting effects, primarily improving overall skin tone rather than removing ephelides.

LASER AS MORE EFFECTIVE OPTION WITH MANAGEABLE RISKS

Q-switched 532 nm Nd:YAG laser is a more effective treatment for facial ephelides compared to intradermal TXA injections, providing superior pigment clearance and higher patient satisfaction. TXA may play a complementary role in improving skin tone and treating cases with post-laser hyperpigmentation. Both treatments were generally well tolerated, and adherence to sun protection is essential to maintain results and prevent recurrence.

EPHELIDES AND LENTIGO

Case report: StarWalker VERDE for treatment of ephelides and lentigo.

Author: Chua, C. Y.

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Published in: Journal of the Laser and Health Academy, 2020

SOLAR LENTIGO

Effective and Safe Solar Lentigo Treatment with Frequency-Doubled Nd:YAG (532 nm) Laser – Our Experiences.

Authors: Kecelj Leskovec, N., Kecelj, B.

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Published in: Journal of the Laser and Health Academy, 2020

CAFÉ-AU-LAIT

The treatment of infantile giant café au lait spot using golden parameter therapy with a high fluence 1064-nm Q-switched Nd: YAG laser.

Authors: Hur, H., Baek, J. O., Joo, J. S., Jung, H., Kim, Y. R., Choi, S. J., Shim, D. T.

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Published in: Journal of Dermatological Treatment, 2024

The new treatment of cafe au lait spot using dr. hoon hur's golden parameter therapy with a high fluence 1064nm q-switched nd: yag laser.

Authors: Hur, H., Kim, J. H., Park, I. J., Park, C. H., Shim, D. T., In, S. I., Lee, G. H., Kim, P. S., Hyun, D. N., Kang, S. G., Shin, H. C., Park, J. I., Hong, J. S., Kim, S. H., Lee, S. Y., Park, N. J., Lee, J. S., Lee, D. S.

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Published in: International Journal of Current Research, 2018

High-fluence 1064-nm Q-switched Nd:YAG laser: Safe and effective treatment of café-au-lait macules in Asian patients.

Authors: Baek, J. O., Park, I. J., Lee, K. R., Ryu, H. R., Kim, J., Lee, S., Kim, Y. R., Hur, H.

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Published in: Journal of Cosmetic Dermatology, 2018

Comparable Efficacy with Improved Tolerability: Low-Fluence Nd:YAG Laser for Melasma

Authors: Bosseila M., Ghonim N., Mostafa P.

Published in: Lasers in Medical Science, 2022

Efficacy and safety of different low fluences of Q-switched Nd:YAG laser in treatment of melasma: a split-face clinical and dermoscopic comparative study

EVALUATING LOW-FLUENCE ND:YAG LASER FOR MELASMA

This study aimed to compare the efficacy and safety of different low-fluence 1064 nm Q-switched Nd:YAG laser protocols for the treatment of melasma. The objective was to compare treatment parameters that achieve pigment reduction while minimizing adverse effects, and to assess the role of dermoscopy in monitoring treatment response.

SPLIT-FACE COMPARATIVE STUDY DESIGN

A split-face randomized clinical study included 38 women with bilateral melasma. Treatments were performed using the QX MAX system (Fotona, Slovenia). One side of the face was treated with 3 J/cm^2 using two passes, while the other side received 1.5 J/cm^2 using four passes. Patients underwent six sessions at two-week intervals, with follow-up one month after the final treatment. Outcomes included melasma severity index (MSI), melanin index (MI), erythema index (EI), dermoscopic evaluation, pain scores, and safety assessment.

SIMILAR EFFICACY WITH DIFFERENT SAFETY AND TOLERABILITY PROFILES

Both treatment protocols resulted in significant improvement in melasma severity, with reductions in MSI, MI, and EI scores and no statistically significant difference between the two approaches. Dermoscopic analysis showed a decrease in superficial pigmentation patterns, while deeper perifollicular pigmentation became more visible. However, the higher fluence protocol (3 J/cm^2) was associated with significantly greater pain and longer-lasting erythema, whereas the lower fluence protocol (1.5 J/cm^2) was better tolerated by patients.

LOW-FLUENCE APPROACH AS A PREFERRED TREATMENT STRATEGY

Low-fluence Q-switched Nd:YAG laser is an effective treatment for melasma, producing meaningful improvement without complete clearance. While both protocols are clinically effective, lower fluence with more passes offers a better safety and comfort profile, making it a preferred approach. Strict photoprotection is essential to prevent recurrence.

Dual-Mode 1064 nm Nd:YAG Laser for Melasma: Improved Short-Term Outcomes and Reduced Relapse

Authors: Wu X., Cen Q., Lin X., Shang Y., Wang X., Zhang Z.

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Published in: Scientific Reports, 2025

EVALUATING DUAL-MODE ND:YAG LASER FOR MELASMA

This study aimed to evaluate the efficacy and safety of a dual-mode 1064 nm Q-switched Nd:YAG laser approach combining low-fluence (LFQS) and microsecond pulse width (MPW) modes for melasma treatment. The objective was to determine whether targeting both pigmentation and vascular components improves clinical outcomes and reduces relapse compared to standard LFQS monotherapy.

PROSPECTIVE SPLIT-FACE CLINICAL TRIAL DESIGN

A prospective, evaluator-blinded split-face study included 28 patients, with 21 completing full follow-up. Treatments were performed using the Fotona QX MAX system (Fotona, Slovenia). One side of the face received LFQS alone, while the other side received combined LFQS + MPW treatment. Patients underwent 5–10 sessions at monthly intervals, with follow-up at 1, 3, 6, and 12 months. Outcomes included Melasma Area and Severity Index (MASI), melanin index (MI), VISIA imaging analysis (pigmentation and red area indices), patient-reported outcomes, relapse rates, and safety assessment.

IMPROVED SHORT-TERM OUTCOMES AND REDUCED RELAPSE WITH DUAL-MODE THERAPY

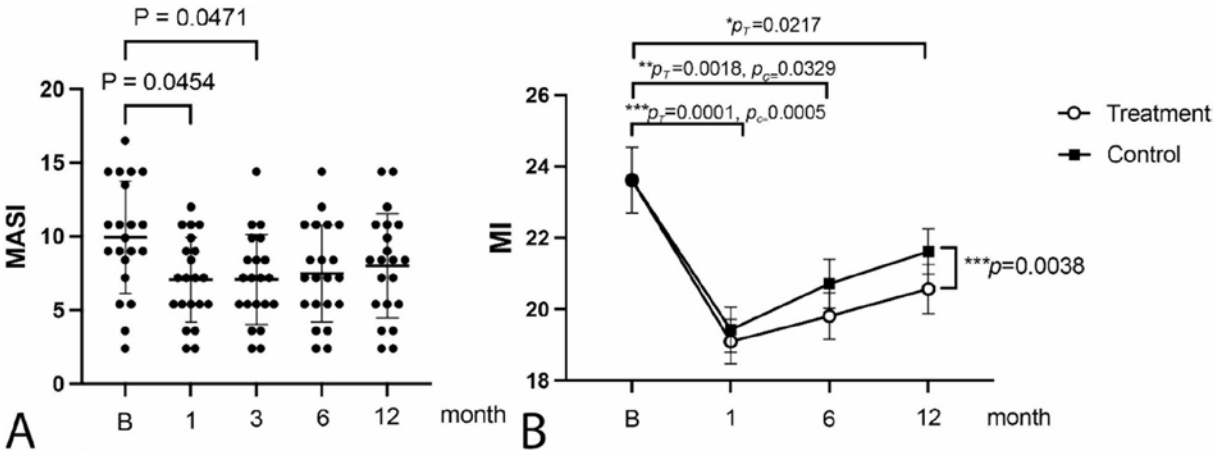
Both treatment approaches resulted in significant short-term improvements, with MASI and melanin index decreasing at early follow-ups. However, the combination therapy demonstrated superior outcomes, including greater reduction in melanin index and improved control of erythema, as confirmed by VISIA analysis. Importantly, relapse rates at 3 months were significantly lower on the combination-treated side (4.8%) compared to LFQS alone (23.8%). Although relapse increased over time, the combination therapy consistently showed better maintenance of results and slower pigment recurrence.

SAFE, MULTI-TARGET APPROACH WITH ENHANCED CLINICAL BENEFIT

The combination of LFQS and MPW 1064 nm Nd:YAG laser provides a safe and effective treatment for melasma by addressing both pigment and vascular components of the disease. The dual-mode approach enhances efficacy and reduces short-term relapse without increasing adverse effects, offering a valuable non-invasive alternative for patients seeking laser-based treatment.

		1 month	3 months	6 months	12 months
GAIS score*	1	3	3	3	2
	2	14	14	11	9
	3	4	4	7	10
	≥4	0	0	0	0
Patient self-assessment of bilateral appearance differences ($n=21$)	LFQS + MPW > LFQS	4	5	7	3
	LFQS + MPW = LFQS	17	16	14	18
	LFQS + MPW < LFQS	0	0	0	0
Relapse (sides, $n=42$)	LFQS + MPW ($n=21$)	0	1 (4.8%)	5 (23.8%)	11 (52.4%)
	LFQS ($n=21$)	0	5 (23.8%)	6 (28.6%)	12 (57.1%)
			$p=0.047$*	$p=0.63$	$p=0.66$
			Chi-squared test		

*Patient follow-up data at different time points after the last treatment. *GAIS scoring criteria: 1 = ≥ 75% improvement (very significant), 2 = 50–75% improvement (significant), 3 = 25–50% improvement (moderate), 4 = < 25% improvement (mild), 5 = no improvement.*



Average MASI and MI scores at different follow-up time points. ***(A)*** *The average MASI score showed a significant reduction at 1 and 3 months post-treatment compared with baseline (p = 0.043).* ***(B)*** *The bilateral MI score showed a significant decrease at 1 and 6 months post-treatment, and the treatment side maintained a significantly lower MI score at 12 months (p < 0.05).*

Female, 42 years old, with a 4-year history of melasma. ***(G–I)*** *show baseline images;* ***(J–L)*** *show the 1-month follow-up after seven treatment sessions. The left side was treated with LFQS mode (8 mm, 1.4–1.6 J/cm²) and the right side with LFQS (8 mm, 1.4–1.6 J/cm²) + MPW mode (8 mm, 10 J/cm²). The GAIS score was 1 (very much improved), indicating better efficacy on the right (combination) side. The MASI score decreased from 15.6 to 7.5. The melanin index decreased from 34 to 28 on the LFQS side and from 36 to 26 on the LFQS + MPW side.*

Q-Switched Laser Treatment of Pigmented Lesions in Asian Skin.

Authors: Desai, A., Desai, G., Hur, H., Fan, L., Vesel, J., Ku Shaari, K. S. B., Choong, L. C. L., Pham, M. T., Wahyudi, N., Thibroni, N., Leo, R. S., Yang, S. A., & Vizintin, Z.

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Published in: Journal of the Laser and Health Academy, 2024

Combining Low Power Fractional CO_2 With QS-NdYAG Toning in the Treatment of Melasma Reduces the Incidence of Punctate Leukoderma.

Authors: Esmat, S., Z Elramly, A., Shahin, D., Hilal, R. F.

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Published in: Lasers in Surgery and Medicine, 2021

Low-fluence Q-switched Nd:YAG laser for the treatment of melasma in Asian patients.

Authors: Choi, J. E., Lee, D. W., Seo, S. H., Ahn, H. H., Kye, Y. C.

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Published in: Journal of Cosmetic Dermatology, 2018

Q-switched Nd: YAG laser alone or with modified Jessner chemical peeling for treatment of mixed melasma in dark skin types: A comparative clinical, histopathological, and immunohistochemical study.

Authors: Saleh, F., Moftah, N. H., Abdel-Azim, E., Gharieb, M. G.

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Published in: Journal of Cosmetic Dermatology, 2018

MELASMA - MAQX CLEAR®

New Protocol for Long-Term Results With a Multi-Pulse Nd:YAG Laser for Melasma Treatment: A Descriptive Cohort Study.

Authors: Ocampo, J. C. V., Ocampo, S. V., Vélez, N. C., Braun, M.

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Published in: Journal of Drugs in Dermatology, 2021

Reducing Treatment Sessions in Tattoo Removal with Combined FracTAT® method and Multipass Delivery

Authors: Marini L., Marini S., Cutlan J., Hreljac I.

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Published in: Lasers in Medical Science, 2022

EVALUATING A COMBINED Q-S LASER STRATEGY FOR TATTOO REMOVAL

This study aimed to evaluate the safety and efficacy of a combined Q-switched (Q-S) laser approach using photo-acoustic fractional micro-drilling followed by multipass full-beam laser treatment for tattoo removal. The objective was to improve pigment clearance efficiency while reducing the number of treatment sessions required compared to conventional single-pass techniques.

CASE SERIES USING FRACTIONAL MICRO-DRILLING AND MULTIPASS LASER

A case series included 10 patients with 13 tattoos, treated using the StarWalker® MaQX laser system (Fotona, Slovenia). The protocol consisted of an initial fractional Q-S 1064 nm micro-drilling pass, followed by two full-beam Q-S 1064 nm passes spaced 5 minutes apart, with additional 532 nm passes when needed for red pigments. Treatments were performed at 2–3 month intervals until clearance. Outcomes included photographic assessment of pigment clearance, side effects, pain scores, and patient satisfaction.

HIGH PIGMENT CLEARANCE WITH FEWER TREATMENT SESSIONS

The combined technique achieved an average pigment clearance of approximately 97% after a mean of 4.85 sessions, representing about 40% fewer sessions compared to traditional single-pass Q-S laser estimates. The micro-drilling step enabled deeper pigment removal and improved laser penetration by releasing gas bubbles that typically limit multipass efficiency. Side effects were minimal, with low rates of transient erythema and pigmentary changes, and overall patient satisfaction was very high.

EFFICIENT AND SAFE SINGLE-SYSTEM TATTOO REMOVAL APPROACH

The combination of FracTAT® and multipass full-beam laser treatment appears to be a safe and highly efficient approach for tattoo removal. The ability to perform all treatment steps using a single laser system enhances practicality and reduces procedural complexity. Additionally, tissue remodelling effects may improve skin texture after treatment.

Example of a split-tattoo treatment performed prior to this study. Preliminary micro-drilling performed with a 2940-nm Er:YAG laser in ablative fractional mode immediately before two 1064-nm Nd:YAG full beam laser passes spaced 20-min apart on the left half of tattoo. Two 1064-nm Q-S full beam passes spaced 20-min apart on the right side. ***A*** *Pre-treatment virgin tattoo;* ***B*** *After 2 passes of Q-S 1064-nm Nd:YAG laser, left side pre-treated by 2940-nm Er:YAG laser ablative fractional micro-drilling mode; right half treated by two full beam Q-S 1064-nm Nd:YAG laser passes only — note the difference between sub-epidermal gas retaining skin properties after preliminary ablative laser micro-drilling (left) and without micro-drilling (right);* ***C*** *4 months after 2 treatments — left half showing markedly better clearance. Complete clearance was achieved after 5 sessions using the FracTAT® technique on both sides.*

Tattoo No	Clearing estimate 4 evaluator median (range)	Side effect score 4 evaluator median (range)	No. of sessions to clearance	Kirby-Desai estimate	Pain during treatment (0–10)	Patient satisfaction (1–5)
1	100% (90–100)	0.5 (0–1)	5	8	2	5
2	100% (100–100)	1 (1–1)	6	8	2	5
3	100% black (100–100) 50% green (20–70)	1 (1–2)	6	8 black 10 green	1	4
4	100% (90–100)	1.5 (0–2)	5	9	2	4
5	100% (90–100)	1.5 (1–2)	4	8	2	5
6	90% (80–90)	1 (1–2)	5	9	3	5
7	100% (100–100)	1 (0–1)	3	7	1	5
8	100% (100–100)	0 (0–0)	7	8	2	5
9	90% (80–90)	0 (0–1)	6	9	1	5
10	100% (100–100)	0 (0–0)	5	6	1	5
11	90% (90–90)	1 (1–2)	5	9	2	5
12	100% (90–100)	0 (0–0)	3	8	1	5
13	100% (100–100)	0 (0–0)	3	7	1	5
∑mean ± SD	97% ± 4	0.65 ± 0.54	4.85 ± 1.19	8	1.62 ± 0.6	4.85 ± 0.35

Parameters evaluated from 13 tattoos participating to this case series. Kirby-Desai estimates were done prior to treatment. Pigment clearing percentages were estimated by 4 independent dermatologists who were also responsible for the evaluation of side effects. Both values for each patient are presented as a median (range) of those taken by all the evaluators. Pain scores and overall treatment satisfaction were estimated by each patient at the end of each treatment session and once the final clearing results were obtained.

Professional monochromatic black tattoo located on the upper chest of a 30-year-old female patient. ***A*** *Before the laser procedure;* ***B*** *Immediately after 1064-nm Q-S micro-drilling — pin-point capillary bleeding clearly visible;* ***C*** *Immediately after the first full beam Q-S 1064-nm laser pass — note the fragmented, whitish sub-epidermal discoloration representing the Q-S micro-drilling modified pop-corn effect;* ***D*** *Immediately after the second Q-S 1064-nm full-beam laser pass;* ***E*** *Clinical result 1 month after the first laser session;* ***F*** *Complete tattoo clearance after four laser sessions — a 100% pigment clearance score and side effect score of 1.5 were confirmed by all dermatologists asked to evaluate the case.*

Effective Tattoo Removal with Q-Switched Nd:YAG Laser: Clinical Outcomes and Treatment Predictability

Authors: Gorsic M., Bacak I., Ahcan U.G., Topcic V.H.

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Published in: Journal of the Laser and Health Academy, 2013

EVALUATING Q-SWITCHED ND:YAG LASER FOR TATTOO REMOVAL

This study aimed to evaluate the efficacy and safety of Q-switched Nd:YAG laser for tattoo removal and to assess the accuracy of the Kirby-Desai scale in predicting the number of treatment sessions required. The objective was to confirm the effectiveness of laser-based tattoo removal and improve treatment planning and patient expectations.

CLINICAL STUDY USING MULTI-WAVELENGTH Q-S LASER

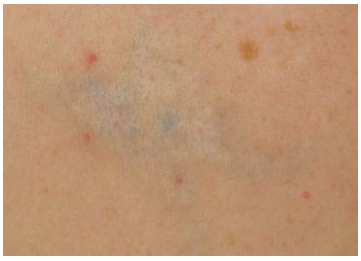
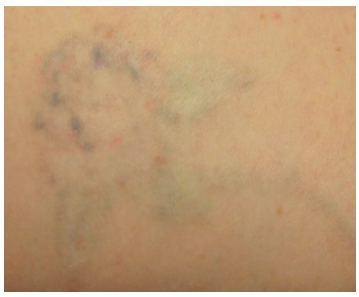
A clinical study included 10 patients with a total of 13 tattoos treated using the QX MAX Q-switched Nd:YAG laser system (Fotona, Slovenia). Multiple wavelengths were used depending on pigment color, including 1064 nm for dark pigments, 532 nm for red and orange, 650 nm for green, and 585 nm for blue tones. Treatments were performed with nanosecond pulses over multiple sessions, and outcomes included tattoo clearance, number of treatments, patient satisfaction, side effects, and correlation with Kirby-Desai score predictions.

COMPLETE TATTOO REMOVAL WITH HIGH PATIENT SATISFACTION

All tattoos were successfully removed after multiple treatment sessions, with an average of approximately 6 sessions required. The correlation between predicted and actual number of treatments was strong (r = 0.74), indicating that the Kirby-Desai scale is a useful tool for treatment planning. Patient satisfaction was high, with strong scores for treatment outcomes and number of sessions. Side effects were mild and transient, including erythema, edema, and occasional temporary hypopigmentation.

Q-SWITCHED LASER AS GOLD STANDARD WITH PREDICTABLE OUTCOMES

Q-switched Nd:YAG laser is a safe and effective gold-standard treatment for tattoo removal across different pigment types. Although multiple sessions are required, outcomes are predictable and can be reliably estimated using the Kirby-Desai scale, helping to align patient expectations. The treatment demonstrates high efficacy with minimal adverse effects, supporting its continued use in clinical practice.

	Before	After	Number of Treatments	Assessed No. of Tx by Kirby-Desai Score
Case 1			5	6
Case 6			5	10
Case 11			10	10
Case 13			10	10

Before and after photos, actual no. of treatments and assessed no. by Kirby-Desai score.

Satisfaction with tattoo removal	5.2
Satisfaction with the no. of treatments	4.9
Unwanted side effects	1.3
Pain	3.8

Average scores of general satisfaction with tattoo removal on a scale from 1 to 6 (1 – minimum, 6 – maximum).

Persistent eschar-like wound healing after Q-switched 1064 nm hybrid nanosecond-picosecond laser monochromatic tattoo removal: management and evolution.

Authors: Mitrofanoff, L., Marini, S., Marini, L.

-

Published in: Lasers in Medical Science, 2024

Case report: Treatment of a traumatic facial tattoo.

Authors: Shanina, N., Patrushev, A. V., Makhonya, D. V., Zorman, A.

-

Published in: Journal of the Laser and Health Academy, 2020

Tattoo removal by Q-switched Nd:YAG laser: an objective evaluation using histometry.

Authors: El-Domyati, M., Hosam, W., Nasif, G., Abdel-Aziz, R. T. A., Raouf, Y.

-

Published in: Journal of Cosmetic and Laser Therapy, 2019

Fractional Er:YAG Skin Conditioning for Enhanced Efficacy of Nd:YAG Q-Switched Laser Tattoo Removal.

Authors: Marini, L., Kozarev, J., Grad, L., Jezersek, M., Cencic, B.

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Published in: Journal of the Laser and Health Academy, 2012

CLEARSTEP

Improved Onychomycosis Clearance with Two-Stage Long-Pulsed Nd:YAG Laser Therapy

Authors: Zhong S., Lin G., Zhao J.

-

Published in: Evidence-Based Complementary and Alternative Medicine, 2019

EVALUATING TWO-STAGE ND:YAG LASER THERAPY FOR ONYCHOMYCOSIS

This study evaluated the efficacy and safety of a two-stage long-pulsed Nd:YAG 1064-nm laser treatment protocol for onychomycosis. The objective was to determine whether extending laser therapy beyond an initial intensive treatment phase could improve mycological clearance and clinical efficacy in patients with chronic fungal nail infections.

TWO-STAGE TREATMENT USING LONG-PULSED ND:YAG 1064-NM LASER

A prospective clinical study included 100 affected nails (88 toenails and 12 fingernails) from 22 patients with clinically and mycologically confirmed onychomycosis. Treatments were performed using a long-pulsed Nd:YAG 1064-nm laser (Dualis SP, Fotona, Slovenia) with fluences of 35–40 J/cm^2, 35 ms pulse duration, 4 mm spot size, and 1 Hz repetition rate. The treatment protocol consisted of a first stage with weekly sessions for 8 weeks, followed by a second stage with one session every 4 weeks for an additional 16 weeks. Mycological assessment, fungal cultures, clinical evaluation, pain assessment, and photographic documentation were performed throughout treatment and follow-up.

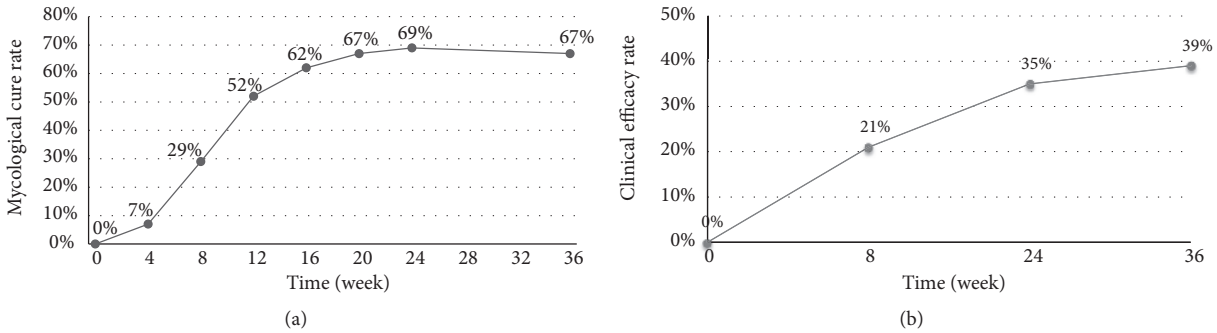
IMPROVED MYCOLOGICAL CLEARANCE AND CLINICAL EFFICACY AFTER SECOND-STAGE TREATMENT

Two-stage laser therapy significantly improved both mycological clearance and clinical efficacy compared with the initial treatment phase alone. The mycological cure rate increased from 29% after the first treatment stage (week 8) to 69% after completion of the second stage (week 24), remaining stable at 67% during follow-up at week 36. Clinical efficacy similarly improved from 21% at week 8 to 35% at week 24 and 39% at week 36.

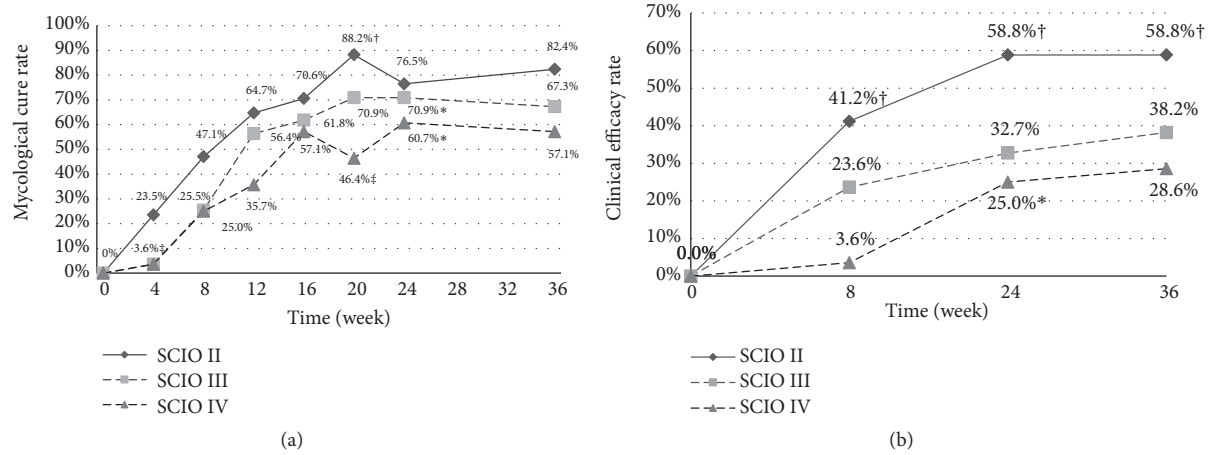
Treatment efficacy was influenced by disease severity and nail characteristics. Nails with lower SCIO severity grades demonstrated significantly better outcomes than more severe cases, while nails with hyperkeratosis below 1 mm showed superior response compared with thicker nails. Most patients reported moderate treatment discomfort, although no intolerable pain or treatment-related adverse effects were observed. Clinical photographs demonstrated progressive cosmetic improvement and nail regrowth throughout treatment and follow-up.

SAFE AND EFFECTIVE LASER APPROACH FOR ONYCHOMYCOSIS

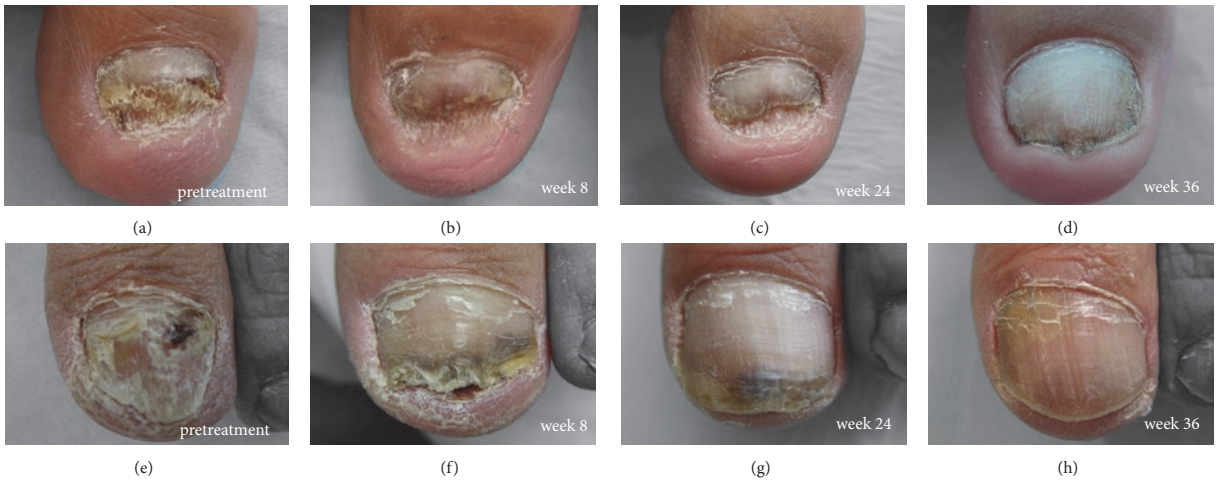
Two-stage long-pulsed Nd:YAG 1064-nm laser therapy appears to be a safe and effective treatment approach for onychomycosis, producing improved mycological clearance and progressive clinical nail improvement with extended treatment duration. The authors concluded that longer treatment courses and individualized treatment strategies based on disease severity may improve laser-treatment outcomes.



***(a)** Mycological cure rate and **(b)** Clinical efficacy rate of nails that received laser treatment. There was a significant improvement in both rates at week 24, compared to week 8.*



***(a)** Mycological cure rate of SCIO II, SCIO III, and SCIO IV during laser treatment. *p ‹ 0.05, comparing week 24 to week 8. †p < 0.05, comparing week 20 to week 8. ‡p < 0.05, comparing SCIO IV to SCIO II at both week 4 and week 20. **(b)** Clinical efficacy rate of SCIO II, SCIO III, and SCIO IV during laser treatment. *p < 0.05, comparing week 24 to week 8. †p < 0.05, comparing SCIO IV to SCIO II at week 8, week 24, and week 36.*



*Representative photographs of the nails before and after laser treatment from two patients. Patient 1: **(a)** pretreatment, **(b)** week 8, **(c)** week 24, and **(d)** week 36. Patient 2: **(e)** pretreatment, **(f)** week 8, **(g)** week 24, and **(h)** week 36.*

A randomised comparative study of 1064 nm Nd:YAG laser and Urea occlusion therapy with topical miconazole for the treatment of onychomycosis.

Authors: Cai Q., Meng L., Liu X., Gao Z., Ren H., Tan J., Yang L.

-

Published in: Lasers in Medical Science, 2025

Efficacy and safety of 1064-nm Nd:YAG laser in treatment of onychomycosis.

Authors: Wanitphakdeedecha, R., Thanomkitti, K., Bunyaratavej, S., Manuskiatti, W.

-

Published in: The Journal of Dermatological Treatment, 2016

A comparative clinical and mycological study of Nd-YAG laser versus topical terbinafine in the treatment of onychomycosis.

Authors: El-Tatawy, R. A., Abd El-Naby, N. M., El-Hawary, E. E., Talaat, R. A.

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Published in: The Journal of Dermatological Treatment, 2015

Minimizing Intervention, Maximizing Results: Wart Removal Without Anesthesia Using Nd:YAG Lase

Authors: Zorman A., Koron N.

-

Published in: Journal of Cosmetic Dermatology, 2021

EVALUATING ND:YAG LASER WART REMOVAL WITHOUT ANESTHESIA

This study aimed to evaluate the safety, efficacy, and tolerability of long-pulse 1064 nm Nd:YAG laser for wart removal without the use of topical or infiltrative anesthesia. The objective was to determine whether effective wart clearance can be achieved while avoiding anesthesia-related complications.

RETROSPECTIVE STUDY USING LONG-PULSE ND:YAG LASER

A retrospective study included 85 patients with 174 warts treated over a 3-year period. Treatments were performed using the SP Dynamis® system (Fotona, Slovenia) with long-pulse 1064 nm Nd:YAG laser. No chemical anesthesia was used; instead, cooling methods such as ice and cold air were applied to improve tolerability. Patients underwent repeated sessions at approximately 7 week intervals until clearance. Outcomes included number of sessions required, treatment success rate, pain scores (VAS), and adverse effects.

HIGH CLEARANCE RATES WITH MINIMAL SIDE EFFECTS

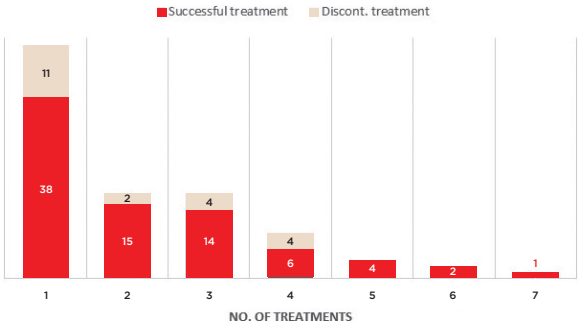
Among patients who completed treatment, high clearance rates were achieved, with most warts resolving after a mean of 2.2 sessions. Approximately 47% of patients achieved clearance already after a single session. Pain during treatment was moderate (mean VAS score of 6), but generally tolerable (only 5% of patients listed pain as the reason for discontinuation). Side effects were minimal and transient, including occasional short-term discomfort and rare cases of blistering, with no reported scarring or pigmentary changes.

SAFE, EFFECTIVE, AND PRACTICAL APPROACH WITHOUT ANESTHESIA

Long-pulse 1064 nm Nd:YAG laser without anesthesia appears to be a safe and effective treatment for warts, offering high clearance rates with minimal risk of complications. Avoiding anesthesia may allow real-time patient feedback to optimize treatment delivery and reduce tissue damage. In this study, long-pulse 1064 nm Nd:YAG laser treatment of warts was successful irrespective of wart location, patient age, and disease duration, with response rates similar to or higher than those reported for conventional therapies.

No. of treatments	No. of patients	% of patients	Cumulative clearance rate (%)
1	32	47	47
2	13	19	66
3	12	18	84
4	5	7.4	91
5	3	3.5	96
6	2	2.9	99
7	1	1.5	100

No. of treatments required to achieve complete clearance (n = 68). 17 patients discontinued their treatment.



Treatment success rate. Results are presented as the percentage of patients who either successfully completed the treatment or discontinued the therapy after a specified number of treatment sessions (n = 85).

5 days after the treatment.

6 weeks after the treatment.

20 days after the treatment.

6 months after the treatment.

Hair Reduction for darker skin types with Short-Pulse Nd:YAG Laser: Effective Results with Minimal Discomfort

Authors: Jane S.D., Mysore V.

-

Published in: Journal of Cosmetic Dermatology, 2018

ORIGINAL CONTRIBUTION

WILEY

Effectiveness of short-pulse width Nd:YAG in laser hair reduction

Subodh D. Jane MD, FRGUHS | Venkataram Mysore DVD, MD, DNB, DipRCPath(Lond), FRCP, FISHRS

Summary

Introduction: Laser hair reduction (LHR) is a safe and effective way of reducing unwanted hairs over body. Long-pulse Nd:YAG laser has over the years, been proven to be particularly safe and effective in darker skin types. While conventionally, long-pulse Nd:YAG laser has been used, recently short-pulse width Nd:YAG laser of 0.6-1.6 ms which is 10-50 times less than the standard method (long-pulse) of Nd: YAG LHR, has become available.

Objectives: To study the effectiveness of short-pulse width Nd:YAG laser in LHR in Indian patients.

Material and methods: This was a prospective observational study conducted over a period of 1 year. Fifty female patients with fitzpatrick skin type 3-5 were included. Patients underwent four sessions of LHR, with an interval of 6 weeks and then follow up was done for 6 months after the last session.

Results: The mean age of patient was 29.92 years ranging from 17 to 48 years. After finishing four sessions of LHR procedure 58%, 24%, 6%, and 2% of the patients showed excellent, good, moderate, and poor improvement respectively. No complications were seen during the treatment and after follow-up. Statistical analysis by paired t test showed the results to be statistically significant.

Conclusion: Hair reduction using unique short-pulse width Nd:YAG laser is easy to use, safe, and effective in Indian skin.

KEYWORDS

laser hair reduction, Nd:YAG laser, short-pulse width

1 | INTRODUCTION

EVALUATING SHORT-PULSE ND:YAG FOR HAIR REDUCTION

This study aimed to evaluate the effectiveness and safety of short-pulse width Nd:YAG laser for laser hair reduction (LHR) in patients with darker skin types. The objective was to determine whether significantly shorter pulse durations could provide effective hair reduction with reduced pain while maintaining safety.

PROSPECTIVE STUDY USING SHORT-PULSE ND:YAG LASER

A prospective observational study included 50 female patients with Fitzpatrick skin types III–V undergoing facial hair reduction. Eight patients had polycystic ovarian disease and six patients were on oral isotretinoin. Patients received four treatment sessions at 6-week intervals, followed by 6 months of follow-up. Treatments were performed using the XP Dynamis® laser system (Fotona, Slovenia) with short pulse widths of 0.6–1.6 ms. Outcomes included percentage hair reduction, pain scores, patient satisfaction, and safety assessment.

HIGH EFFICACY WITH LOW PAIN AND EXCELLENT SAFETY

The treatment demonstrated high efficacy, with 92% of patients achieving more than 50% hair reduction and 58% achieving excellent improvement after four sessions. Results were statistically significant, and improvements increased progressively with each session. Pain levels were low, with a mean score of 1.7, and patient satisfaction was high. No significant adverse effects were reported, apart from transient perifollicular erythema and edema, which are expected treatment endpoints.

EFFECTIVE AND PATIENT-FRIENDLY APPROACH FOR DARKER SKIN TYPES

Short-pulse width Nd:YAG laser represents a safe, effective, and well-tolerated approach for hair reduction in darker skin typesThe authors proposed that the mechanism of action of short-pulse Nd:YAG laser involves high peak power, vascular targeting, and heat diffusion, which may contribute to effective follicular damage and hair reductionwith minimal pain and a strong safety profile.

Clinical efficacy and safety of Nd:YAG laser in hair reduction.

Authors: Abdelrazek, W., Moftah, N., Hamdy, A

-

Published in: Minia Journal of Medical Research, 2023

Evaluation of Safety, Comfort and Efficacy of “Avalanche” Method of DMC-Assisted Alexandrite Laser Hair Removal.

Authors: Kukovic, M., Lukac, M., Jezersek, M., Milanic, M., Zanecek, M.

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Published in: Journal of the Laser and Health Academy, 2023

Noninvasive Fat Reduction and Skin Tightening with Combined Nd:YAG and Er:YAG Laser Therapy

Authors: Vas K., Besenyi Z., Urbán S., Badawi A., Pávics L., Erős G., Kemény L.

-

Published in: Journal of Biophotonics, 2019

EVALUATING COMBINED ND:YAG AND ER:YAG LASERS FOR BODY SHAPING

This study evaluated the safety and efficacy of combined long-pulse 1064 nm Nd:YAG and 2940 nm Er:YAG laser therapy for non-invasive lipolysis and skin tightening. The objective was to determine whether dual-wavelength laser treatment could reduce localized adipose tissue while improving skin firmness and body contour.

PROSPECTIVE STUDY USING TIGHTSCULPTING® LASER THERAPY

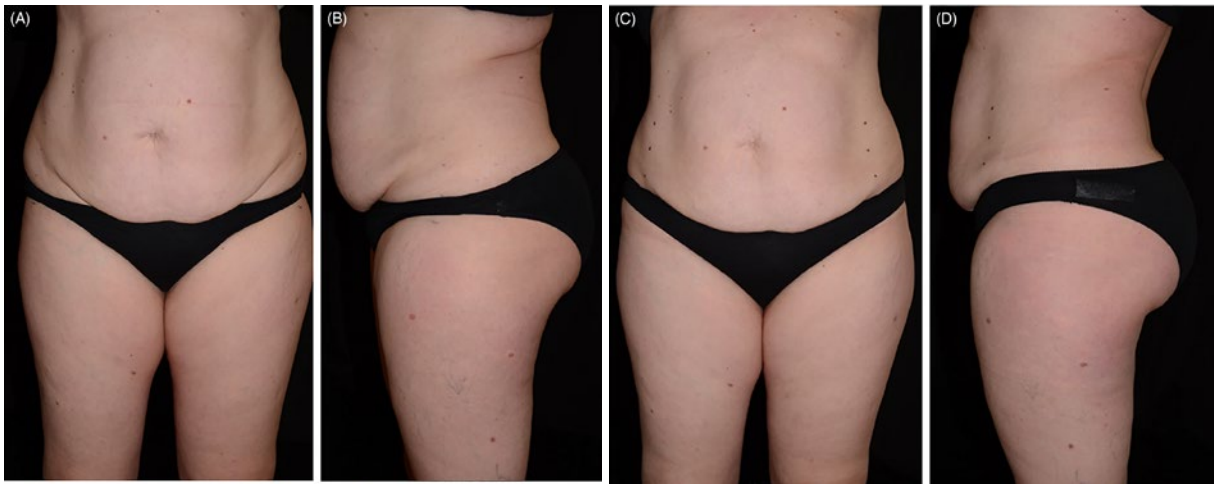
A prospective clinical study included 10 female participants with visible excess fat on the waist or lower abdomen. Patients underwent four combined laser treatment sessions at two-week intervals using the Fotona SP Dynamis® system with TightSculpting® PIANO Nd:YAG and SMOOTH® Er:YAG modes. The 1064 nm Nd:YAG laser was applied first for deep homogeneous tissue heating, followed by non-ablative 2940 nm Er:YAG laser treatment for superficial skin tightening. Outcomes were assessed using standardized photography, waist circumference measurements, bioelectric impedance body-fat analysis, ultrasonography, shear wave elastography, and low-dose CT imaging.

SIGNIFICANT WAIST REDUCTION, FAT THICKNESS DECREASE, AND IMPROVED SKIN STIFFNESS

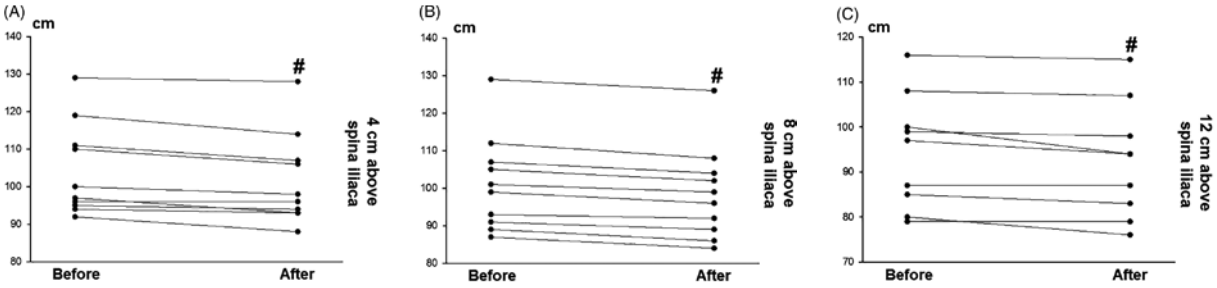
Combined laser treatment resulted in visible improvement in abdominal contour and significant reduction in waist circumference at all measured locations. Total body fat decreased significantly. Ultrasonography demonstrated a statistically significant reduction in subcutaneous fat thickness, while shear wave elastography showed increased tissue stiffness and tightening in the treated regions of all participants. Low-dose CT imaging demonstrated moderate reduction in subcutaneous fat volume in 6 of 10 participants, although these CT-based changes were not statistically significant overall. Treatments were well tolerated, with participants reporting only minimal warmth during procedures and no treatment-related complications or adverse effects.

SAFE AND PROMISING NONINVASIVE BODY CONTOURING APPROACH

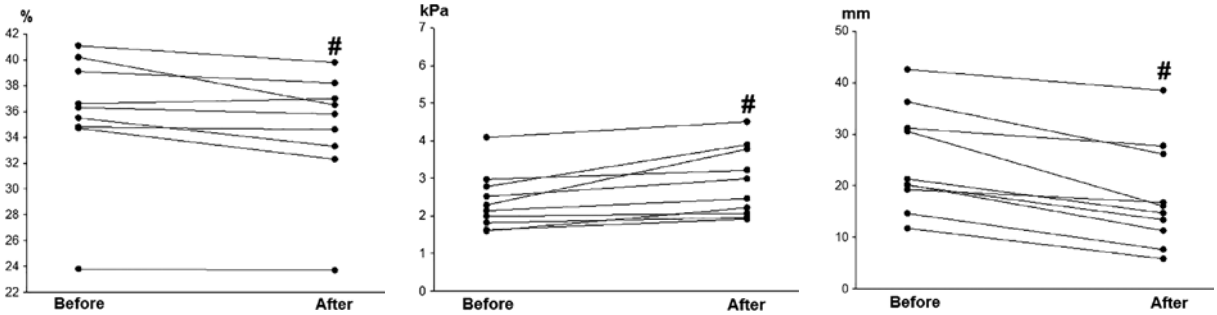
Combined 1064 nm Nd:YAG and 2940 nm Er:YAG laser therapy appears to be a safe, comfortable, and promising noninvasive approach for simultaneous fat reduction and skin tightening. The authors proposed that deep homogeneous heating with long-pulse Nd:YAG laser may support adipose-tissue reduction through bulk thermal effects, while nonablative Er:YAG SMOOTH® mode may contribute to skin tightening through controlled superficial heating and collagen remodeling. Objective measurements confirmed reductions in waist circumference and subcutaneous fat thickness together with increased tissue stiffness after treatment.



Comparative photographs of participant before and after the treatments. ***A)*** *The participant before the 1st combined laser treatment from frontwise.* ***B)*** *The participant before the 1st combined laser treatment from side view.* ***C)*** *The participant 2 weeks after the 4th treatment from frontwise.* ***D)*** *The participant 2 weeks after the 4th treatment from side view.*



Findings of waist circumference measurements."Before" values represent the status before the 1st laser treatment while"after" values were determined 2 weeks after the last treatment. Data of participants are depicted separately. Circumference values are given in cm. ***A, B*** *and* ***C*** *demonstrate measurement points 4, 8 and 12 cm above the spina iliaca anterior superior, respectively. #, difference between"before" and "after" values is statistically significant.*



Total body fat. "Before" and "after" values demonstrate baseline values and the values measured 2 weeks after the 4th laser treatment, respectively. Data of participants are depicted separately. Total body fat values are given in percentage. #, difference between "before" and"after" values is statistically significant.

Subcutaneous fat tissue stiffness determined by means of shear wave elastography."Before" values represent the status before the 1st laser treatment while"after" values were determined 2 weeks after the last treatment. Data of participants are depicted separately. Stiffness values are given in kPa. #, difference between "before" and"after" values is statistically significant.

Mean subcutaneous fat measured with two-dimensional B-mode ultrasonography. "Before" values were determined before the 1st laser treatment while"after" values demonstrate the fat thickness 2 weeks after the 4th laser treatment. Data of participants are depicted separately. Fat thickness values are given in mm. #, difference between"before" and"after" values is significant.

TENSORTIGHT™

Smooth resurfacing by hyper stacking of Er:YAG laser pulses: A histological and clinical study.

Authors: Gaspar, A., Tettamanti, M., Korosec, B., Lukac, M.

-

Published in: Journal of the Laser and Health Academy, 2022

Non-Invasive Abdominal Body Shaping with StarFormer® Magnetic Stimulation: Improved Muscle Tone and Reduced Waist Circumference

Author: Valdivia R.

Published in: Journal of Cosmetic Dermatology, 2022

EVALUATING HIGH-INTENSITY MAGNETIC STIMULATION FOR BODY SHAPING

This study aimed to evaluate the safety and effectiveness of high-intensity magnetic stimulation (HITS™) for non-invasive abdominal body shaping. The objective was to determine whether repeated magnetic muscle stimulation can improve abdominal muscle tone, strength, and overall body contour without affecting body weight.

CASE SERIES USING STARFORMER MAGNETIC STIMULATION

A prospective case series included 8 participants (4 male, 4 female) who underwent 10 treatment sessions of high-intensity magnetic stimulation using the StarFormer® system (Fotona, Slovenia). Treatments were performed three times per week over 3.5 weeks, with each 30-minute session delivering progressively increased intensity based on patient tolerance. Outcomes included blinded evaluation of standardized photographs using the Global Aesthetic Improvement Scale (GAIS), patient satisfaction questionnaires, waist circumference measurements, and body weight assessment.

IMPROVED MUSCLE TONE AND REDUCED WAIST CIRCUMFERENCE

Blinded evaluators identified visible improvement in abdominal appearance in all patients, with an average GAIS score of 1.38 ± 0.52, indicating visible enhancement. Patient satisfaction was high with mean scores of 4.13/5 for abdominal body shape improvement and 4.38/5 for perceived muscle strength enhancement, suggesting strong ratings for both muscle strength and aesthetic improvement. Objective measurements showed a significant reduction in waist circumference at multiple measurement points, while body weight remained unchanged. Average waist reduction was 2.81 cm below the anterior superior iliac spine (ASIC), 2.6 cm at the ASIC level, and 3.19 cm above the ASIC level (all $p < 0.001$), while average body weight change was minimal and not statistically significant (-0.32 kg; $p = 0.53$) suggesting visible contour changes despite stable body weight.

SAFE AND EFFECTIVE NONINVASIVE BODY SHAPING METHOD

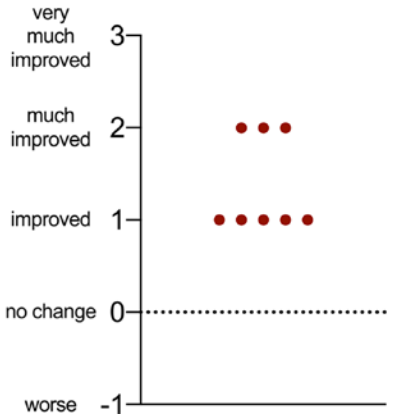
High-intensity magnetic stimulation using the StarFormer® system appears to be a safe, comfortable, and promising noninvasive method for abdominal body toning. The treatment was associated with visible improvement in abdominal appearance and perceived muscle strengthand improves body contour without downtime or adverse effects. The results support its role as a non-invasive body shaping option.

Patient #	Weight change (kg)	Waist circumference change (cm)		
		ASIC−3cm	ASIC	ASIC+3cm
1	0.3	−0.6	−1.3	−1.7
2	0.4	−3.2	−4.8	−5.5
3	1.7	−1.5	3−2.6	−2.2
4	−1.8	−3.3	−2.9	−2.5
5	−1.8	−3.3	−2	−3.5
6	0.8	−1.5	−1.6	−1.4
7	−1.9	−5.9	−4.1	−5.5
8	−0.2	−3.2	−1.5	−3.2
Average	−0.32	−2.8125	−2.6	−3.1875
Paired *t*-test	$p = 0.53$	$p < 0.001$***	$p < 0.001$***	$p < 0.001$***

Note: The Student's t-test was used to compare follow- up to baseline values; p-value lower than 0.05 was considered statistically significant. The paired Student's t-test was used to evaluate statistical significance.

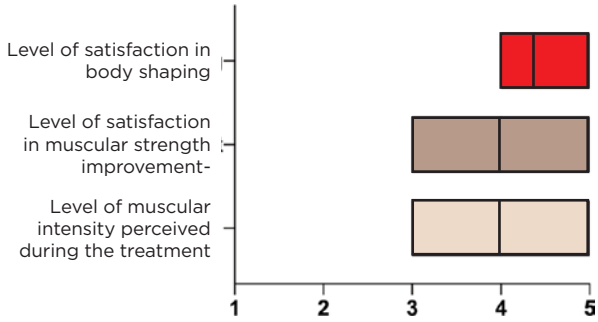
Weight and waist circumference change.

Blind evaluation of aesthetic improvement using GAIS scale

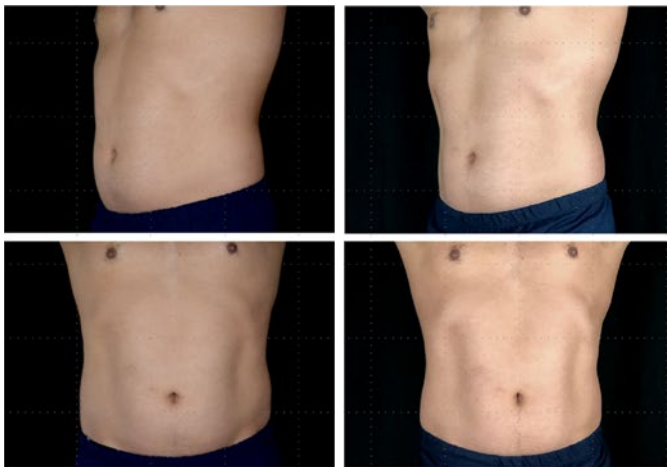


Median interevaluator scores from five blinded expert evaluators.

Patient satisfaction questionnaire



Patient satisfaction questionnaire. The graph shows box plots with mean, minimum, and maximum.



Before (left) and after (right) digital photographs. The patient was highly satisfied with the results, and the five blinded evaluators have also evaluated the after image as much improved (median interevaluator GAIS of 2).

Notes

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