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Objective and subjective clinical effects of a Nd:YAG 532-nm frequency-doubled long-pulsed diode pumped laser system on photoaging of the face: A retrospective study on color signs, texture and rhytids

Marco Dal Canton & Eliana Modolo

BACKGROUND: Pulsed 532-nm lasers have been widely used in the treatment of vascular and pigmented conditions of aged skin. In addition to lesion clearance, many patients report color and texture improvements to the skin. These improvements are often difficult to appreciate from photographic analysis alone, but are significant to the patient’s impression of treatment success.

OBJECTIVE: To grade and compare objective and subjective results of treatments with a 532-nm frequency-doubled pulsed Nd:YAG laser using criteria of skin color, skin texture, and wrinkles based on a blinded retrospective analysis of photographs compared with results from patient questionnaires.

METHODS: Clinical before and after pictures from 20 patients (skin types I–IV) treated for diffuse vascular and pigmented lesions were selected for evaluation. A blinded grading was performed using criteria of skin color, skin texture, and wrinkles. Patients were asked to grade improvement using the same criteria. The results of the blinded and patient grading were reported and compared using a chi-squared analysis.

RESULTS: Clinical improvements recorded by blinded photographic evaluation and patient evaluation agreed with no statistically significant differences. Both the blinded observers and patients recorded remarkable improvement in the color signs of photoaging, slight to moderate improvement in skin texture and fine wrinkles, and negligible improvement of medium depth and deep wrinkles.

CONCLUSION: The 532-nm pulsed laser is a safe and effective device for the treatment of the visible signs of photoaging of skin types I–III. In addition to improvements in color defects, objectively and subjectively significant improvements in texture and fine wrinkles can be expected. Little to no improvement in medium to deep wrinkles can be anticipated.

Original Research

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Introduction

In the new age of rejuvenation, patient expectations are increasing. Patients are expecting ‘lunchtime’ procedures that produce visible skin improvements, with short or no downtime, and a low rate of undesirable effects. To date, a wide array of new and well-honored or re-interpreted technologies and procedures are available for this task.

The options available among lunchtime procedures include new cosmeceuticals and anti-aging drugs, superficial and very superficial chemical peels, microdermabrasion, intradermal and subcutaneous fillers, Botox®, various kinds of new and known lasers and intense pulsed light (IPL) devices, and, recently developed, radio frequency (RF) devices, alone or in combination with lasers or IPLs.

When choosing light sources, there are three main choices: (1) water-heating infrared devices (1320–1450 nm), coupled with efficient cooling systems to protect the epidermis to obtain skin tightening and toning; (2) visible light lasers and IPL sources to improve color signs and possibly superficial dermal structural defects; and (3) RF devices for dermal shrinkage, with or without combination with IPLs or lasers.

When the aged skin comprises mainly uneven pigmentation (mottling), diffuse age spots (ephelides, lentigines, flat pigmented seborrheic keratoses) and vascular changes, including telangiectasias, poikiloderma and erythematous rosacea, visible light sources such as 532-nm lasers, pulsed dye lasers (PDLs), and IPLs can be effective due to selective absorption by oxyhemoglobin and melanin. Indeed, the partial overlap of the spectral curves of oxyhemoglobin and melanin in the range of visible light, which can be unfavorable when dealing with discrete pure vascular lesions in darker skin types, is a precious advantage when treating the color signs of photoaged skin on lighter complexions, as commonly seen in Caucasian and Celtic skin types.

The effects of short-pulsed and long-pulsed dye lasers1 on collagen and dermal amorphous matrix have been documented on clinical, histological, biochemical and instrumental2 evidence. Various combinations of shorter and longer wavelength PDL lasers, the number and modality of passes3 and purpura or sub-purpura levels4 have been recently tested. These studies provide evidence that the PDL can improve the texture and, to some extent, rhytids of photodamaged skin, and that patients with greater dyspigmentation usually have more prominent results.5 It has also been shown that purpura-free PDL settings were less effective than those above the purpura threshold on low-density, small caliber and broader, denser vessels.4 However, these higher fluences and the presence of purpura result in unsightly and unacceptable, from a lunchtime procedure perspective, patient downtime.

The recent development of new diode-pumped, long-pulsed, frequency-doubled Nd:YAG 532 lasers was driven by interest in purpura-free selective photothermolysis of vascular lesions.5 This same desire for purpura-free treatment, combined with greater melanin absorption at 532 nm than with PDLs, makes these new 532-nm devices extremely interesting for treating the red and brown color signs of photoaging.

The combination of long pulse durations with selective vascular photothermolysis provides the theoretical rationale for an efficient thermal stimulation of the dermis by long-pulse 532-nm Nd:YAG lasers.

Background

In our mountainous area (the Dolomites), photoaging is widespread in all adult ages, due to the average fair complexion of local inhabitants (average skin type is I–III) in conjunction with weathering in outdoor workers as well as outdoor leisure at high altitudes (400–2500 m and more).

In our dermatology center we treat these common aesthetic problems with a 532-nm frequency-doubled long-pulsed Nd:YAG laser, which is FDA approved for the treatment of both vascular and pigmented benign lesions. We have been using this device extensively for more than 3 years.

Frequently, patients undergoing treatment for approved diffuse conditions (mainly telangiectasias, age spots and diffuse mottling) have reported not only (red and brown) color homogenization, but also some degree of textural improvement and improvement in the appearance of fine wrinkles.

Objective

To assess, document, score, and compare, on a retrospective basis, the objective and subjective effects of this 532-nm pulsed laser system on skin signs of photoaging in order to evaluate its suitability and limitations to perform elective photorejuvenation.

Materials and methods

Laser treatments were performed in a private practice setting, on an outpatient basis, with a 532-nm frequency-doubled, diode-pumped, long-pulsed (millisecond domain) Nd:YAG laser (DioLite 532®; Iridex Co., Mountain View, CA, USA). The device is equipped with interchangeable handpieces delivering treatment spot sizes of 200, 500, 700, 1000 and 1400 μm in diameter, and can deliver a treatment fluence from 0.1 to 950 J/cm² in pulses of 0–100 ms duration, at a repetition rate adjustable from 0 to 25 Hz.

Clinical before and after photographs from 20 patients treated with this system for diffuse vascular and pigmented lesions were selected for retrospective analysis. The selected 20 patients (13 F, seven M; 26–67 years of age: average 43 years), skin types I–IV, underwent three to five sessions (average 3, 47, 66 treatments in total), spaced 4–6 weeks apart (Table I). The selection criteria included the availability of representative and comparable before/after clinical photographs appropriate to undergo a ‘micro-details’ analysis. Only photographs that included a reliable
Effects of a Nd:YAG 532-nm laser system on photoaging of the face

Original Research

Table 1

<table>
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Table 1: Effects of a Nd:YAG 532-nm laser system on photoaging of the face

Comparison of reference points were considered. All photographs were taken using standardized routine digital photography under intense incident light. No digital processing was performed. The most comparable photographs taken before the treatment cycle and 1 month or longer after the third treatment session were selected. When available and consistent, photographs taken after intermediate sessions and at long-term follow-up visits were considered.

Photographs included in this retrospective study were from patients undergoing treatment for approved (vascular and pigmented) conditions with this device between April 2001 and March 2004. For the purpose of the study, we selected only patients treated for diffuse lesions, including telangiectasias, rosacea, poikiloderma, mottling, and dis-carded cases treated for only discrete lesions.

Patients included in the study were typically treated with the 700 μm and 500 μm spots, with settings of 14–19 J/cm² (18–25 ms) and 19–25 J/cm² (12–16 ms), respectively, for vascular lesions, and 12–14 J/cm² (15–18 ms) and 16–20 J/cm² (10–13 ms), respectively, for pigmented lesions. For selected conditions, the laser was used with a scanner (ScanLite® MedArt 910; Iridex) delivering a 700 μm spot at 0–25 Hz, with 0–40% spacing between spots within geometric patterns up to 1 cm² in area. The scanner was used with conservative settings of 10–18 J/cm², with 40% spot spacing for vascular lesions to avoid bulk tissue heating, and 7–16 J/cm² with 40–20% spacing for pigmented lesions. The repetition rate was set to the maximum allowed by the laser for the fluence settings selected (19–25 Hz).

Vessels and pigmented lesions were observed during treatment using a polarized lamp magnification system (Syris 600®; Syris Scientific, Gray, ME, USA). This system eliminates epidermal reflections of incident light and allows the improved visualization of the vascular field and details of pigmented lesions, permitting perfect tracing of both discrete lesions and less defined areas of vascularity or pigmentation. The small spot handpieces were used to target and trace vessels, with no or minimal overlap. The treatment endpoint was vessel disappearance without epidermal blanching. This endpoint was usually achieved in one to two passes. Diffuse fine vessels were treated with the scanner device with 40% spacing and 10–18 J/cm² fluences. Benign pigmented lesions, including ephelides, lentigines, flat seborrheic keratoses, and mottled areas were traced with 20% overlap, using low fluences to obtain a slight chromatic modification, without ‘popping’ and with minimal edema. Larger pigmented lesions and wide areas with diffuse pigmentation were traced in a crisscross fashion, or treated with the scanner with 20–40% spacing using low to conservative fluences (7–16 J/cm²).

The laser is not equipped with a built-in cooling system. The treatment sites were cooled prior to treatment using iced (4°C) gel packs (Flexi Temp gel pack®; Kimberly-Clark Co., GA, USA) for 2–4 min. The area was then covered with a thin (0.5–1 mm) layer of a 4°C water-based gel immediately prior to treatment. The cool gel packs were re-applied at the end of the treatment. The patients were dismissed with written instruction and prescribed wet cool packs BID-TID at home, integrated with repeated application of O/A soothing cream, as required, daily sunscreens and application of a Vaseline-based antibiotic ointment to any larger crusts.

Follow-ups were scheduled at 7–10 days after the first treatment, and 1 month after each session.

The treatment outcome 1 month after the third treatment was objectively evaluated and graded (when available, the progression of results was also recorded after the first and/or second and later treatments and long term) using a blinded retrospective analysis of clinical photographs, and subjectively graded by patient questionnaires. The blinded observer (EM) was first required to identify the before and after photographs. After the identification of before and after photographs, a grading was performed on
a three-point scale (none, slight to moderate, remarkable improvement) using the criteria of wrinkles (deep non-distensible; medium depth distensible; fine/superficial), texture and pores, and color. The grading was performed within selected comparable areas, identified by a rectangle. At least three identifiable areas were considered on each pair of photographs (Figure 1).

The same 20 selected patients were sent an anonymous questionnaire and were asked to grade their personal perception of the results using the same criteria and improvement scale used by the observer. Patients were also encouraged to describe the nature of improvements noted.

The outcomes of the observer and patients’ scoring were graphically described and compared using a chi-squared test (significance level $p<0.01$).

**Results**

The blinded observer correctly distinguished all before and after photographs. The observer’s and patients’ scoring of improvement in texture, color, fine superficial wrinkles, medium distensible wrinkles, and deep non-distensible wrinkles are reported in Table II and shown in Figure 2. Both the blinded observer and patients recorded a progressive remarkable improvement in the color signs of photoaging, slight to moderate improvement in skin texture and fine superficial wrinkles, and negligible improvement of medium depth and deep wrinkles: these observations were confirmed on later follow-ups. Although the patients’ scores were generally slightly higher than the observer scores, the chi-squared test did not reveal any statistically significant difference between the scores on each considered parameter.

In evaluating the nature of the texture improvement in their skin, patients used terms including ‘thicker’, ‘more compact’, ‘smoother’, and ‘more moisturized’.

Representative examples of before and after photographs (third treatment: follow-up at 1 month) used in this study are reported in Figures 3 and 4.

The side effects observed in this study were analogous to those observed in our more extensive experience with this Nd:YAG 532-nm laser, and included pinpoint micro-crusting (12 patients), slight to moderate transient edematous swelling (to a maximum of 24–48 h), long-lasting (>48 h) zygomatic swelling (one patient), transient focal hyperpigmentation (one patient: skin type IV), and no hypopigmentation, and no scarring.

While most patients were followed up at about 1 month after each treatment and at 6–12 months at the end of the scheduled treatment cycle, we were able to document three patients with visible improvement of color and texture persisting 12 months after the final treatment (Figures 5 and 6).

**Discussion**

Color signs of aged skin are usually early and prominent in lighter complexions, consequently it is debatable whether these epidermal signs should be spared in any rejuvenation procedure; on the other hand, the effects on dermal structure of visible light sources, due to the superficial penetration, are expected to be minor and distinctly difficult to document.

Partial overlap between oxyhemoglobin and melanin absorption curves is inversely proportional to wavelength in all-vascular lasers and shorter wavelengths, as 532 nm, can effectively act on both oxyhemoglobin and melanin.

Selective photothermolysis provided in combination with a long pulse duration is the basic principle explaining the specific purpura-free clearing of telangiectasias of long-pulsed Nd:YAG 532-nm lasers; additionally, the long-pulsed heat deposition specifically within the vascular target should generate a collateral stimulation of the surrounding dermal structures to produce deposition of newly formed collagen and matrix molecules.

These effects have already documented clinically and histologically with dye lasers, but should be theoretically best accomplished when adopting selective photothermolysis coupled with long pulse durations, as

![Figure 1](third treatment: follow-up at 1 month after first treatment.)

![Table 2](Blinded observer score)

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<table>
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with the Nd:YAG 532-nm ms pulsed laser. Further studies are required to assess this specific potential of the technology.

In this study, we tried to point out the subjective and objective results of the Nd:YAG 532-nm laser on distinct variables of photoaging. Even though quantitatively moderate and difficult to clinically document, these effects can be perceived in most cases independently by both patients and observers. The effects of the 532-nm pulsed laser in photorejuvenation have been recently ascertained by various authors.6–10

Progressive and cumulative results can be expected after multiple treatments: empirically we routinely suggest that our patients undergo at least three treatments spaced 4–6
weeks apart, but further evaluation is required of the potential influence on textural changes of tuning the number and the time frame between sessions. Based upon our observations of some patients treated 1 year or more before, the results of color and also texture should be long-lasting (Figures 4 and 5).

These improvements should be most advantageous when treating diffuse dyschromias in skin types I–III. In this sense, in this study we did not discriminate patients for the prevalence of red or brown chromophores; nevertheless, it is our conviction that a superior outcome on texture can be predicted when treating diffuse telangiectasias and redness than when dealing with irregular pigmentation, owing to the better absorption by oxyhemoglobin, the deeper location of the target and the higher fluences and pulse widths utilizable. Darker skin types and/or pigmented lesions require more conservative settings, possibly slowing down textural improvements.

Another issue is that visualization under polarized light magnification proved to be an indispensable implementation in routine practice with this laser, particularly useful not only when dealing with discrete lesions, helping collaterally to discriminate melanocytic from non-melanocytic lesions, but also when targeting fine details and subtle shades in pigment distribution and vascular pattern. This ‘look inside’ seems to be a new and invaluable tool in refining the treatment of color signs of aged skin with great speed and precision.11

The low rate of postoperative effects makes photo-rejuvenation with the Nd:YAG 532-nm long-pulsed laser a superior lunchtime procedure; nevertheless, in our opinion, undue long pulses and heating build ups when using the scanner device, which can be potentially harmful for the thinnest skin and in particular areas, such as over bony prominences, requiring appropriate and conservative settings. In our hands, treatment of pigmented lesions is particularly satisfactory, but requires a more watchful technique and settings due to pulse widths larger than the thermal relaxation time of the specific chromophores. Particularly, although the number of undesired effects is very low, darker skin types and/or tanned skin could be at greater risk for adverse events because of the competitive absorption by epidermal melanin.

A recent study published by Lee on 150 patients treated with a combination of 532-nm and 1064-nm lasers for non-invasive skin rejuvenation, reports a mild to moderate degree of improvement of rhytids, a moderate degree of restoration of skin toning and texture and great improvement of redness and pigmentation, also pointing out the
better efficacy of the 532-nm laser than the 1064-nm laser when used alone, and a better outcome when combining them.8,9 This study contributes to making clear the value of long-pulse Nd:YAG lasers on rejuvenation procedures, primarily of the 532-nm wavelength as an optimal choice for most color and superficial structural signs of photoaging. A more recent study substantiates the previous data, indicating the greatest improvements in dryness, roughness and uneven pigmentation, pointing out the efficacy and safety of 532-nm and 1064-nm lasers for non-ablative skin rejuvenation.10

In our study, some patients treated only with the Nd:YAG 532-nm pulsed laser perceived a greater improvement than the observer in superficial and medium wrinkles; this perception seems disproportionate and inconsistent with the objective and most important improvement of color changes and, in our eyes, could be due to the average better overall aspect of the skin surface, which has been described by patients mostly as smoother, thicker, more compact, brighter or more hydrated.

Undeniably, at the present time, although a slight to moderate improvement after Nd:YAG 532-nm treatment can be predicted on fine lines, results on medium depth distensible and deep non-distensible wrinkles are objectively modest; recent reports tend to confirm our observations.12

On the other hand, when color signs of photoaging are diffusely represented, as vastly seen in patients with fair skin looking for conservative rejuvenating procedures, we assume that the above description of subjective and objective improvement of the texture and of fine wrinkles after treatment of diffuse colored (red and brown) lesions with this laser system (i.e. Nd:YAG 532-nm FD laser + polarized light magnification + scanner device) supports it as a valuable tool for elective photorejuvenation in skin types I–III.

Acknowledgements

The authors claim no significant economic interest in any company mentioned in this paper. All photographs appearing in this study have been submitted after written permission from patients.

References
