Q-Switched Nd:YAG Treatment of Tattoos and Pigmented Lesions

MOSHE LAPIDOTH, MD – *Herzlia Medical Center, Herzlia, Israel*
ZHAN-CHAO ZHOU, MD – *The Hospital for Skin Diseases, Peking Union Medical College, Nanjing, China*

INTRODUCTION

Dating back to ancient times, tattoos have been a widespread phenomenon in many cultures, and their popularity has been growing in recent years. Tattoos are broadly divided into five categories – professional, amateur, cosmetic, medicinal and traumatic. The dyes used to create these tattoos differ in terms of origin, specific components, color, particle size, and concentration. Tattoo dyes are composed of insoluble, indigestible colored or reflective solid particles that may either be phagocytosed or remain free in the intercellular space at various depths up to 1.5 mm (for professional tattoos). The phagocytic cells are usually immobilized by a network of connective tissue, while the intercellular dye particles may have a greater degree of mobility. Chemical and conformational modifications of the dye particles, as well as their physical displacement, often lead to a duller, more blurred appearance of the tattoo with time.[1-2]

The changes over time in tattoo clarity and color intensity are incentives for tattoo removal, which along with other reasons for people's dissatisfaction with their tattoos, have created an increasing demand for this application. Traumatic and medicinal tattoos are naturally unwanted; moreover, it is estimated that more than half of the individuals with "intentional" tattoos eventually regret having been tattooed. Over the centuries, many techniques have been attempted for tattoo removal, including surgical excision, skin grafting, salabrasion, dermabrasion, chemical bleaching, and cryotherapy. Many of these methods are associated with significant pain, and often result in infection, inflammation, scar formation or pigmentary alterations. Carbon dioxide and argon lasers have also been employed for tattoo removal, but resultant scarring due to non-specific thermal damage has made this type of treatment inadequate as well.[2-3]

Q-SWITCHED LASERS

A major breakthrough in tattoo removal involves Q-switched lasers, which utilize a number of techniques to allow energy build-up in the laser up to a certain threshold. The released energy is concentrated into an intense nanosecond pulse with high peak powers in the multi-megawatt range.[3-4]

Q-switched lasers are well-suited to tattoo removal, as well as to treatment of benign pigmented lesions. Their nanosecond-short pulses and high energy outputs create a photoacoustic shock, which fragments the targeted lesion, particularly the more particle-dense tattoos. Cavitation bubbles may be formed around the particles, introducing further damage to the target. The fragmented particles are consequently eliminated via phagocytosis and lymphatic drainage. Sometimes the particles are not eliminated, but become invisible to the human eye as a result of being shifted to deeper dermal layers, being broken down to smaller pieces, or being covered by denser tissue. In addition to phagocytosis for clearing of residual pigment, a crust is usually formed over more superficial pigmented lesions, with subsequent exfoliation. Importantly, due to certain physical characteristics of the emitted light and its interaction with the target particles, collateral damage is generally avoided during Q-switched laser treatment. This leads to a lower complication rate and a shorter recovery period in comparison to other treatment modalities.[3,5]

In general, three types of Q-switched lasers are used – Q-switched neodymium-yttrium-aluminum-garnet (Nd:YAG) at 1064 nm or frequency-doubled at 532 nm, Q-switched ruby at 694 nm, and Q-switched alexandrite at 755 nm. Due to the different wavelengths of these lasers, each is compatible with different types and colors of tattoo dyes. The 1064 nm Q-switched Nd:YAG is best-suited for black and dark blue tattoos, the most common tattoo colors, and has also been shown to remove other colors. This laser's longer wavelength offers an additional advantage in its relatively reduced absorption by endogenous chromophores and its ability for deep dermal penetration, contributing to increased efficacy, especially with regard to treatment of deeper lesions.[1,5-7]

Q-SWITCHED ND:YAG TREATMENT MODALITY

A 1064 nm Q-switched Nd:YAG treatment head forms the core of a new modality for Lumenis' aesthetic multi-appliction platforms. Lightweight and ergonomically designed, all laser and Q-switching components are located in this compact treatment head (see Figure 1). The Q-switched module offers calibration capabilities and includes a double safety mechanism, which prevents accidental light emission from the treatment head. Various spot sizes, 2-5 mm in diameter, enable customization of treatment to various lesion characteristics. The laser operates at a fluence range of 2-12.7 J/cm^2 and a pulse duration of 6-8 ns.

Figure 1. The Q-switched Nd:YAG treatment head and disposable tip for the IPL™ Quantum platform.

The user may choose the 'single' or 'repeat' mode, the latter allowing a pulse rate of up to 5 Hz. The "Top-Hat" beam profile of the emitted light is indicative of homogenous energy distribution across the spot (see Figure 2), thereby enhancing treatment safety and efficacy. System operation is easily enabled via the software, which is displayed in a user-friendly interface.

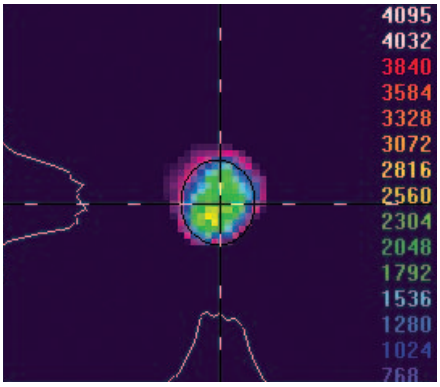

Figure 2. Simulation of the Q-switched Nd:YAG beam profile (Spiricon Beam Profiler).

PROCEDURE

Lumenis' Q-switched Nd:YAG treatment head is intended for the removal of dark blue/black tattoos and for the treatment of benign pigmented lesions. Prior to treatment, it is important to ascertain the patient's and lesion's suitability for the intended procedure, including the performance of test spots.[8-9]

The user should determine the appropriate fluence and pulse rate. It is recommended to begin treatment with the lowest possible fluence suitable for the condition of the target lesion, noting that the darker the lesion, the lower the fluence. Other factors, such as lesion's depth/location and the patient's skin type, should also be considered. Treatments should be performed (at an interval of at least 6 weeks) until complete clearance of the target or according to the physician's discretion and the patient's satisfaction. As the treatments proceed, the lesion usually becomes lighter and the fluence may be increased, unless safety concerns are raised.

The desired immediate response of tattoos (see Figure 3) is blanching (whitening) and epidermal elevation, normally resolving within several minutes and several days, respectively. The elevation is thought to result from rapid localized heating with steam or gas formation and the blanching from evaporation of epidermal water.[1] For pigmented lesions, color change, usually darkening, with subsequent crusting and exfoliation are generally observed (the latter mostly in superficial lesions).

Figure 3. Asian patient, skin type IV, undergoing treatment for removal of permanent eyebrows cosmetic tattoo. On right side of picture, eyebrow prior to treatment. On left, eyebrow immediately following treatment. Note blanching and slight epidermal elevation in treated tattoo area, a desired short-term response.

Case 1

Figure 4 depicts a 31-year-old Caucasian woman, skin type II, with a professional tattoo in black on her lower left abdomen. After a hypersensitive response to the tattoo particles was ruled out, this 7-year-old carbon-based tattoo received six treatments over a course of nine months. The first four treatments were administered using the 3.5 mm spot size at 4.2 J/cm^2. Due to visible clearing of the tattoo dye and the fact that no side effects were observed, the fluence was increased to 8.2 J/cm^2 at the two subsequent sessions. All treatments were carried out utilizing the "Repeat" mode at 2 Hz. The patient was most satisfied with this treatment modality and its outcome.

Case 2

A 28-year-old woman of Ethiopian origin, with relatively light skin type VI, requested removal of an ethnic amateur tattoo (a traditional cross within a circle) that she had had for 17 years. Located in the center of the patient's forehead, the charcoal-based tattoo was a faded black color, but still sufficiently darker than the surrounding skin. Following a test spot procedure, treatment was commenced with the 3.5 mm spot size and 4.2 J/cm^2 fluence level, using a 3 Hz pulse repetition rate. Blanching and epidermal elevation were observed over the tattoo, with subsequent lightening of the tattoo dye and no complications. As can be seen in Figure 5,

after only a single treatment, the tattoo cleared significantly, with no pigmentary or textural changes despite the patient's darker skin type.

Case 3

Figure 6 portrays a 38-year-old Caucasian male with skin type II. The patient presented with clusters of black lines, stretching across the left side of his face, primarily close to his eye. This traumatic asphalt-containing tattoo was the result of a motorcycle accident, which occurred 14 months prior to treatment. The chosen treatment parameters were 3.5 mm spot size, 4.2 J/cm^2 fluence, and 2 Hz pulse rate. Response to treatment was positive, and ten weeks later, an additional treatment was performed using the same parameters. Six months following this second treatment, it appears that most of the black pigment in the tattoo was cleared, and there was some improvement in the scars, adding further to the patient's satisfaction with the treatment results.

SUMMARY

Tattooing of all sorts remains prevalent and tattooing for decorative purposes has actually grown in popularity in recent years. However, many people eventually regret having been tattooed and experts even predict an increased interest in tattoo removal in the future.[10] For more than a decade now, Q-switched lasers, and Q-switched 1064 nm Nd:YAG in particular, have been described as the technology of choice for removal of unwanted dark blue/black tattoos and for the treatment of pigmented lesions, especially dermal ones.[6,11]

Several clinical examples of Q-switched Nd:YAG 1064 nm treatments were shown herein, including different skin types (II, IV, VI); they also depict several types of tattoos – professional, amateur, cosmetic and traumatic – composed of various substances and located on different body areas. High levels of safety and efficacy were achieved in all cases. The significant clearance is noteworthy, particularly given that only 1-2 treatments were performed in some cases. Finally, this preliminary report highlights part of the range of skin and lesion types that may be treated successfully with this new Q-switched Nd:YAG module.

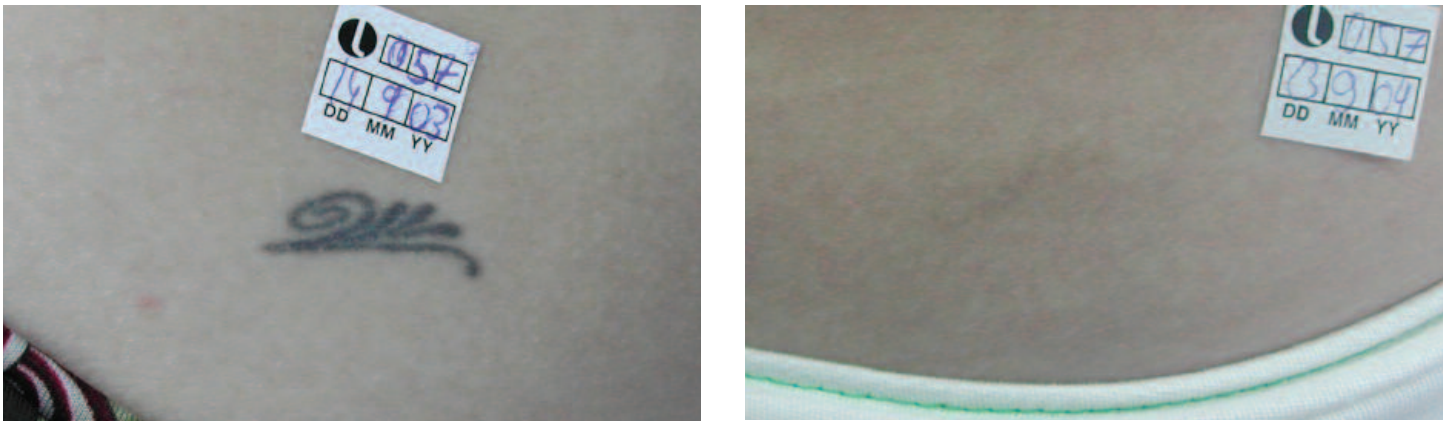

Figure 4. Case 1 - professional tattoo, skin type II, before (left) and four months after (right) six Q-switched Nd:YAG treatments.

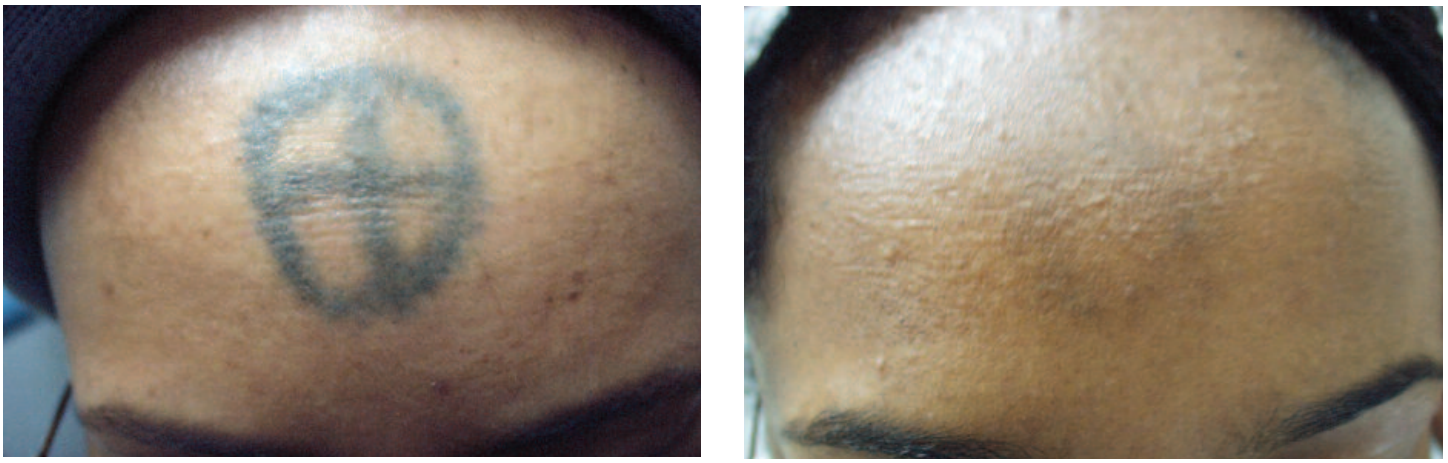

Figure 5. Case 2 - amateur tattoo, skin type VI, before (left) and six weeks after (right) one Q-switched Nd:YAG treatment.

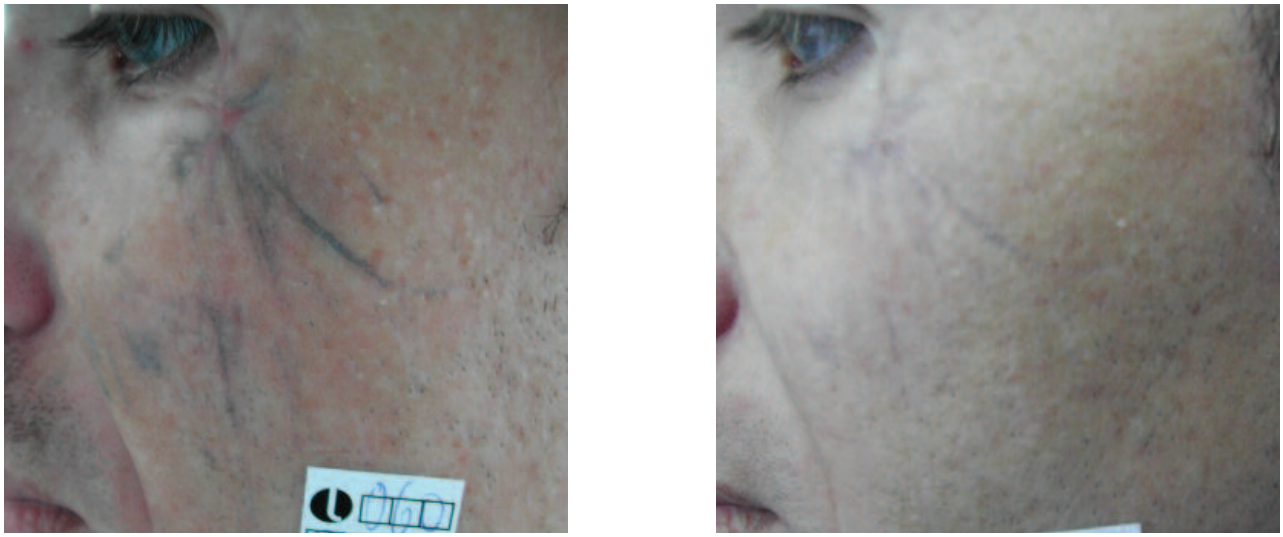

Figure 6. Case 3 - traumatic tattoo, skin type II, before (left) and six months after (right) two Q-switched Nd:YAG treatments.

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Santa Clara, CA 95051
USA
Tel. +1.408.764.3000
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800.505.1133

Lumenis (GERMANY) GmbH
Dreieich-Dreieichenhain,
Germany
Tel. +49.6103.8335.0
Fax. +49.6103.8335.300

Lumenis (UK) Ltd.
London, UK
Tel. +44.20.8324.4200
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Lumenis (JAPAN) Co. Ltd.
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Tel. +81.3.5789.8300
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Tel. +33.1.69.33.14.20
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Beijing, China
Tel. +86.10.6510.2620
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Lumenis (ITALY) Srl.
Formello (RM), Italy
Tel. +39.06.90.75.230
Fax. +39.06.90.75.269

Lumenis (HK) Ltd.
Hong Kong
Tel. +852.2174.2800
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