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Evaluation of the Efficacy of Tattoo-Removal Treatments with Q-Switch Laser

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ABSTRACT

Laser therapy is the gold standard for tattoo removal. With laser removal, tattoo pigment particles can be selectively destroyed without harming the surrounding tissue by means of selective photothermolysis. This requires the correct choice of laser parameters, including wavelength, radiant exposure, and pulse duration of the applied laser. Q-switch Nd:YAG lasers are very effective in the treatment of tattoos; for effective and safe clearance, the laser system must be able to deliver nanosecond pulses with very high pulse energy and a uniform beam profile.

In our study 10 patients requesting tattoo removal were treated using Fotona's QX MAX Q-switch Nd:YAG laser, which offers four different wavelengths in a single system; 1064 nm Nd:YAG was used to treat and remove dark pigments, 532 nm KTP for red, purple and orange tattoo inks, 650 nm dye for green tattoo inks and 585 nm dye for sky-blue colored inks.

Being aware that multiple treatments are needed for successful tattoo removal, we predicted the number of required treatments using Kirby-Desai scores and evaluated the efficacy of the prediction of the required number of sessions by comparing the Kirby-Desai score assessment with the real number of required sessions. We also propose a version of assessment method of tattoo removal efficacy after treatment with a visual decrement scale. Satisfactory tattoo removal of all tattoos was achieved. We were able to provide a good assessment of the number of treatments required to achieve complete tattoo removal, thus matching patient expectations and establishing realistic goals.

In conclusion, our study showed that Q-switched lasers successfully remove tattoo ink, however, multiple treatments are required for satisfactory tattoo removal.

Key words: tattoo removal, Q-switch laser, selective photothermolysis

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I. INTRODUCTION

Many examples of tattooing in ancient cultures have been found, the oldest of which dates back to the Bronze Age. Tattooing has been practiced for centuries in many cultures and spread throughout the world. Tattoos, or "stigmata" as they were called in ancient Greek and Roman times, functioned to identify criminals and slaves or those belonging to particular religious sects [1-2]. Since the 1970s, tattoos have become a mainstream part of Western fashion with current estimates of over 20 million to 30 million people in the western world having at least one tattoo. Some estimates show that approximately 10% of men in the US already have at least one tattoo [3, 4].

However patient surveys have shown that these tattoos are sometimes obtained impulsively, when patients were young, and it is no surprise that many have eventually come to regret their decision. These patients may report feelings of embarrassment, low self-esteem, and stigmatization associated with their tattoos, and many will seek removal [2]. The various motivating reasons behind tattoo regret include social stigmatization, family pressure, a desire to improve career opportunities, and maturity-related factors. On average, tattoo removal is initiated after 14 years of remorse, however in some cases it occurs within months [3, 4].

Over time, different methods for tattoo removal have been explored including various mechanical, chemical and thermal techniques such as salabrasion, dermabrasion, and surgical excision of the skin containing tattoo pigments, the use of caustic chemicals (tannic acid and silver nitrate) and the use of an infrared coagulator or liquid nitrogen. Unfortunately most of these techniques not only destroyed the tattoo but also the skin which contained it and resulted in considerable scarring [4-6, 9].

The discovery of selective photothermolysis has enabled the targeted destruction of tattoo pigments with only minimal damage to the surrounding tissue and limited risk of adverse effects, which contrasts with previously used nonspecific methods. This

treatment modality requires laser pulses of short durations (nanoseconds) and high intensities. Laser therapy is now days considered as the gold standard for tattoo removal [3, 9].

With laser removal, tattoo pigment particles can be selectively destroyed without harming the surrounding tissue by means of selective photothermolysis. This requires the correct choice of laser parameters, including wavelength, radiant exposure, and pulse duration of the applied laser [9,10]. The only laser system that provides satisfactory results is the so called quality-switched or Q-switched laser system [5].

It is a known fact that one treatment is insufficient for successful tattoo removal. Patients should engage in the process with full awareness of the potential success of tattoo removal so it is important to assess number of treatments that the patient would receive.

The Kirby-Desai scale was proposed to assess the potential success and number of treatments necessary for laser tattoo removal, assuming the medical practitioner is using a quality-switched Nd:YAG or Alexandrite laser incorporating selective photothermolysis with 6 to 8 weeks between treatments. This scale can be used by the physician during pre-consultation to determine the number of treatments required for tattoo removal, decreasing the uncertainty of the laser-removal process [12].

In our study we evaluated the efficacy of prediction of the number of sessions required by comparing the Kirby-Desai scale assessment with the real number of required sessions.

II. MATERIALS AND METHODS

From March 2008 through January 2011, 10 patients requesting tattoo removal had been treated. One of the patients had three tattoos and one had two, thus we treated 13 tattoos altogether. All patients were treated with Fotona's QX MAX quality-switched Nd:YAG (Fotona, Slovenia) laser which offers four wavelengths in a single system; 1064 nm Nd:YAG was used to treat and remove dark pigments, 532 nm KTP for red, tan-colored, purple and orange tattoo inks, 650 nm dye for green tattoo inks and 585 nm dye for sky-blue colored inks.

Exclusion criteria for the initiation of laser treatment included a history of keloidal scarring, pregnancy, lactating mothers and the administration of photosensitive drugs. Treatments were administered by manually scanning the treatment area with the laser in an even motion throughout the entire treatment area with a 3–6 mm spot size, depending on the size and the type of the tattoo (in most cases a 5 mm spot size was used). Treatments were performed using different frequencies ranging from 1–10 Hz (on average 2 Hz), and fluences ranging from 2 J/cm2 up to 9 J/cm2 (average 6 J/cm2) and a 5 ns pulse duration. Initially, lower fluences were used and were usually progressively increased on each subsequent laser treatment.

High-resolution photographs were taken prior to the first treatment and after every subsequent treatment. After the completed treatments, patients were given a questionnaire to assess their satisfaction rate (satisfaction with tattoo removal, satisfaction with the number of treatments, unwanted side effects and pain during treatment). The results of laser tattoo removal was graded with grades from 1 to 6, 1 – being the minimum and 6 – the maximum.

A Kirby-Desai score was recorded for each tattoo based on the patient's history and photographs taken prior to the initiation of the laser tattoo-removal treatments. In the Kirby-Desai scale, numerical values are assigned to six parameters: skin type, location, color, amount of ink, scarring or tissue change, and layering. Parameter scores are then added to yield a combined score that will show the estimated number of treatments needed for successful tattoo removal. Scale parameters for the Kirby-Desai score were applied as follows: skin type = 1 to 6 based on the Fitzpatrick skin type; location = 1 to 5; color = 1 to 4; amount of ink = 1 to 4; scarring = 0 to 5; layering = 0 to 2 [12].

A Pearson correlation coefficient between Kirby-Desai scores and the number of actual tattoo treatments performed in the subject group was calculated.

III. RESULTS

The results of the study revealed that complete removal of all the tattoos in 10 patients was achieved in our subject group.

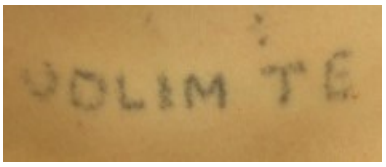
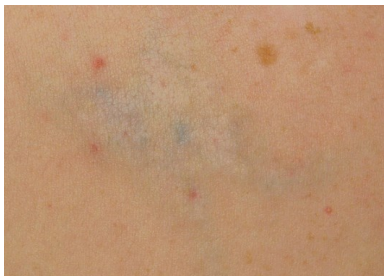
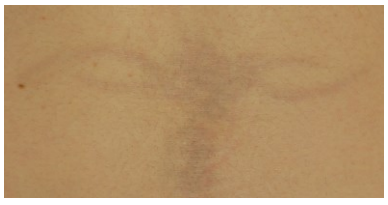
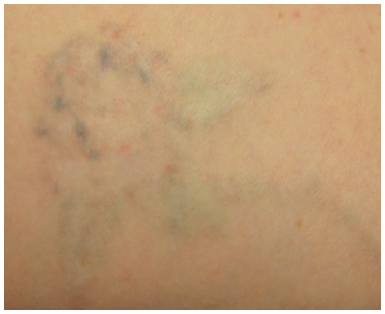
According to the results from the questionnaires, we can conclude that patients were very satisfied with the success and the number of treatments needed for tattoo removal. The unwanted effects were very mild to nonexistent and the pain was moderate (see Table 1).

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

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

Table 8: Before and after photos, actual no. of treatments and assessed no. by Kirby-Desai score, for cases of tattoo removal with Q-switched Nd:YAG laser (QX MAX, Fotona d.d.).

	Before	After	Number of Treatments	Assessed No. of Tx by Kirby-Desai Score
Case 1			5	6
Case 2			6	9
Case 3			9	8
Case 4			6	10
Case 5			4	7
Case 6			5	10

	Before	After	Number of Treatments	Assessed No. of Tx by Kirby-Desai Score
Case 7			4	4
Case 8			3	4
Case 9			3	5
Case 10			3	5
Case 11			10	10
Case 12			10	9
Case 13			10	10

A Kirby-Desai score was assessed for each tattoo and the actual required number of treatments was recorded. Photographs were taken prior to the initiation of laser tattoo-removal treatments. In table 2, we can see images of all tattoo cases before and after the treatment, the actual required number of treatments and the assessed number of treatments according to the Kirby-Desai scale.

The average number of treatments required was 6 treatments (6±2.68). This result correlates with the average Kirby-Desai score of 7.46 with a standard deviation of ±2.03. A good correlation coefficient r = 0.743 was found between the Kirby-Desai score and the number of laser tattoo-removal treatments.

Most of our patients had common but mild side effects. In every case a localized mild edema and erythema were observed, which usually disappeared within 2–3 days. Crusting usually went away after 5-6 days and after 7-10 days the skin completely healed. One of our patients had very strong edema, which appeared within 24 hours after treatment, but also subsided without any consequence within 48 hours. In two cases (Case 4 and 6) slight hypopigmentation also occurred.

Fig 1. Case 1 before and immediately after the first treatment of tattoo removal. Whitening results in an optical shield that prevents subsequent pulses from reaching the remaining underlying pigments. The third image shows the same tattoo after five treatments.

IV. DISCUSSION

It is well established that with Q-switch lasers tattoo pigment particles can be selectively destroyed via selective photothermolysis without harming the surrounding tissue [12].

Our study clearly shows that the Q-switched laser is an optimal choice for tattoo removal. All tattoos were successfully removed with multiple treatments ranging from 3-11 treatments. A questionnaire showed that patients were satisfied with the number of treatments.

Side effects of the treatments were mild and transient as expected. In two cases a slight hypopigmentation occurred.

In the study by Kirby et al., they notice hypopigmentation in 8% of patients and hyperpigmentation in 22% of patients with darker skin types. Many of the undesired pigment alternations were transient [13]. Prior to the beginning of treatment with a Q-switch laser, patients seeking the tattoo removal should be informed that that temporary or possibly even permanent (though rare) pigment changes may occur.

It is known that multiple treatments are needed for removal of a tattoo. The Kirby-Desai scale was previously proposed to assess the potential success and number of treatments necessary for a given patient [12]. By using Kirby-Desai scores, we attempted to assess the number of treatments and compare the real number of treatments to the Kirby-Desai score. We were able to provide a good assessment of the number of treatments required to achieve complete tattoo removal. The correlation between the estimated number of treatments and the real number was good (0.74). The average real number of tattoo removal sessions was 6 treatments, which was lower than estimated number of 7.5. This kind of estimation is positive for a patient because it exceeds patient expectations and does not over promise, but also does not scare off the patient with an overly pessimistic prediction (a too high number of possible treatments).

In general, amateur tattoos require fewer treatment sessions than professional tattoos, although amateur tattoos are less predictable. Tattoos on distal extremities are more difficult to treat, presumably due to decreased lymphatic drainage of phagocytosed pigment. Older tattoos in most cases responded more favorably, due to decreased density of pigment from its natural migration. More treatments were also required when treating multi-colored tattoos. In particular, purple, yellow, and green tones turned out to be therapeutically more challenging [5].

V. CONCLUSIONS

In our study we have confirmed that high power Q-switch laser is optimum tool for removal of black and colored tattoos of different quality. As expected several treatments were needed, however, we were able to predict the number of treatments by obtaining Kirby-Desai scores that correlated to the real number of treatments very well. It is very important to estimate the required number of treatments to establish realistic patient goals.

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