Q-switched laser tattoo removal

Odstranjevanje tetovaž s Q-switched laserjem

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Ključne besede:
Nd YAG laser, pigment, potemnitev tetovaže, brazgotinsko tkivo, fototermoliza

Key words:
Nd YAG laser, pigment, tattoo darkening, scar tissue, photothermolysis

Citirajte kot/Cite as:
Zdrav Vestn 2013; 82: 552–63

Prispelo: 8. nov. 2012, Sprejeto: 20. maj 2013

* Raziskava ni bila sponzorirana s strani kateregakoli proizvajalca medicinske opreme ali kateregakoli drugega podjetja. Smo pa pri raziskavi uporabljali Q-switched laser QX MAX, ki ga proizvaja Fotona d. d., Slovenija.

Izvleček

Izhodišča: V devetdesetih letih prejšnjega stoletja je postalo tetoviranje kot oblika okraševanja človeškega telesa vse bolj popularno, predvsem v zahodnem svetu. Po nekaterih ocenah je v Združenih državah Amerike tetoviranih že vsaj 10 % moških. Novejše raziskave pa kažejo tudi, da v Združenih državah Amerike 17 % vseh tetoviranih in več kot 50 % odraslih po 40. letu starosti razmišlja o odstranitvi tetovaže. Enak trend v zadnjih letih opažamo tudi pri nas. Odstranjevanje tetovaž z laserjem je danes zlati standard. Ponudb laserskega odstranjevanja tetovaž je v Sloveniji veliko. Ponujajo ga številne zasebne klinike in kozmetični saloni. Različne ustanove uporabljajo različne laserje, čeprav vsi laserji niso primerni za odstranjevanje tetovaž, uporaba napačnega laserja pa lahko povzroči številne trajne neželene stranske pojave.

Metode: Zaradi želje po odstranitvi tetovaže smo obravnavali 11 bolnikov (2 moška, 9 žensk). Za odstranjevanje tetovaž smo uporabili laser Q-switched QX MAX Nd:YAG (Fotona, Slovenija), ki nudi štiri različne valovne dolžine v enem sistemu; 1064 nm Nd:YAG smo uporabili pri odstranjevanju temnih pigmentov, 532 nm KTP za rdeče, vijolične, oranžne in kožne barve barvila, 650 nm za zeleno obarvane tetovaže in 585 nm za svetlo modro barvilo.

Rezultati: Pri vseh bolnikih smo tetovaže odstranili z dobrim estetskim rezultatom. Zadovoljive rezultate pri odstranjevanju tetovaž smo dosegli pri vseh obravnavnih. Število obravnav, potrebnih za popolno odpravo tetovaže, je bilo od 3 do 21 (povprečno 7). Povprečna ocena zadovoljstva bolnikov nad končnim rezultatom pa je znašala 5,2 (na lestvici od 1 do 6).

Zaključki: S Q-switched laserjem lahko uspešno odstranimo barvilo v koži. Vendar pa je tudi pri laserju Q-switched za popolno odstranitev tetovaže potrebnih več obravnav.

Abstract

Background: Decorative tattooing gained popularity in many western countries throughout the 1990s. Some estimates show that approximately 10 % of men in the United States already have tattoos. However, tattoos often become a personal regret. As recent surveys suggest, 17 % of people that have obtained a tattoo and more than 50 % of adults over the age of 40 in the United States of America consider having them removed. The same trend can be observed in our country as well. Laser therapy is the gold standard for tattoo removal. In Slovenia, laser tattoo removal therapy is available and widely accessible. There is a wide range of facilities offering laser tattoo removal, ranging from different private clinics to beauty salons. Different facilities use different lasers, but not all lasers, however, are optimal for successful and complete tattoo removal, as inappropriate use can cause many unwanted side effects.

Methods: Eleven (11) patients (2 men and 9 women) requesting tattoo removal were treated in our department. When treating our patients, we used Fotona's QX MAX quality-switched 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, tan-colored, purple and orange tattoo inks, 650 nm dye for green tattoo inks and 585 nm dye for sky-blue colored inks.

Results: Satisfactory tattoo removal was achieved in all patients treated. Patients were very satisfied with the success and the number of treatments needed for tattoo removal. There were mild unwanted side effects and the pain was moderate. The average number of treatments required for complete tattoo removal was less than 7, rang-

This research was not sponsored by any manufacturer of medical equipment or any other company. Q-switched QX MAX laser system used in our research is produced by Fotona d. d., Slovenia.

ing from 3 to 21 treatments. Patients' satisfaction with tattoo removal was estimated at 5.2 (on a scale from 1 to 6).

Conclusions: Our study showed that Q-switched lasers successfully remove tattoo ink, however several treatments are required for satisfactory tattoo removal.

Background

Tattoos are an ancient art form with origins that trace back to Neolithic times (12,000 BC)[1-3] and have remained popular throughout time and across many cultures and continents.[2] Decorative tattooing gained popularity in many western countries throughout the 1990s and is increasingly observed in both sexes especially among young adults with current estimates of over 20 million to 30 million people in the western world having at least one tattoo.[1-5]

A study in 2004 reported a prevalence of 24 % among college students in the United States.[6,7] Some estimates show that approximately 10 % of men in the US already have at least one tattoo and that up to 100,000 women actively pursue tattooing as body art each year.[2,3,8]

However, tattoos often become a personal regret. Tattoo removal attempts probably began as early as tattooing itself and the demand for tattoo removal is nowadays indisputably growing. As recent surveys suggest, 17 % of people that have obtained a tattoo and more than 50 % of adults over the age of 40 in the US consider having them removed.[1-4,9]

Similar trend can be observed in our country as well. As the number of individuals that pursue tattooing as body art has been rapidly growing for the past few years, so has the need for the removal of unwanted tattoos.

The various motivating reasons behind tattoo regret include social stigmatization, familial pressure, a desire to improve career opportunities, and maturity-related factors.[6] On average, tattoo removal is initiated after 14 years of remorse, however in some cases it occurs within months.[6,7]

Over the centuries, different methods for tattoo removal have been explored including different mechanical, chemical and thermal techniques, such as salabrasion, dermabrasion, surgical excision of skin containing tattoo pigment, the use of caustic chemicals (tannic acid and silver nitrate) and the use of infrared coagulator or liquid nitrogen.[2] Unfortunately most of these techniques not only destroyed the tattoo but also the skin which contained it and resulted in considerable scarring.[1,2,4]

Since then many things have changed and laser therapy is considered as the gold standard for tattoo removal.[1] Developments in medical laser technology and the discovery of selective photothermolysis based on the ability to selectively remove target structures without disrupting neighbouring structures, made it possible to remove tattoos without causing collateral damage to the surrounding skin.[4]

Lasers have been used to remove tattoos since the late 1970s and have in recent years become the mainstay for removal due to their high efficacy and low incidence of deleterious side effects.

In Slovenia, laser tattoo removal therapy is available and widely accessible. There is a wide range of facilities offering laser tattoo removal, ranging from different private clinics to beauty salons. Different facilities use different lasers, however not all lasers are adequate for tattoo removal.

Our recent survey showed that private clinics and beauty salons in our country use the so-called 'intense pulsed light source' or 'IPL', alexandrite, and Nd:YAG lasers for tattoo removal. None of these lasers, however, are optimal for successful and complete tattoo removal, as they can cause many side effects.

The only laser system that provides satisfactory results is the so called quality-switched or Q-switched laser system.

Q-switched Nd:YAG laser which we used in our treatments is a high-energy single nanosecond pulse generating laser system

Figure 1: A tattoo 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. Third image shows the same tattoo after five treatments.

which offers four different wavelengths in a single system, enabling us to treat a wide range of different ink colors and minimizing unwanted side effects and the number of treatments required for satisfactory results.

Materials and methods

From March 2008 through January 2011 twenty (20) patients requesting a tattoo removal had been treated in our department. Eleven patients (2 men, 9 women) that had fully completed the treatment program had been included in our retrospective study. One of the patients had three tattoos, therefore we treated thirteen tattoos altogether.

Exclusion criteria for initiation of laser treatment included history of keloidal scarring, pregnancy, lactating mothers and administration of photosensitive drugs.

All of our 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.

Treatments were administered by manually scanning the rapidly pulsed laser in an even motion throughout the entire treatment zone. The laser handpiece was oriented perpendicular to the skin at all times, at a distance of 1–2 cm. A 2–6 mm spot size handpiece was used, depending on the size and the type of the tattoo. But in most cases a 5 mm spot size was used.

Treatments were performed using different frequencies, ranging from 1–10 Hz, and fluences, ranging from 2 J/cm² up to 9 J/cm² (average 6 J/cm²) and a nanosecond pulse duration. Initially, lower fluences were used and were usually progressively increased on each subsequent laser treatment.

When treating a tattoo with a Q-switched laser, immediate whitening appears, caused by rapid, micro-localized heating with steam or gas formation, forming a so-called optical shield (Figure 1). This is a normal reaction of

Table 1: We evaluated general satisfaction, satisfaction with the number of treatments, unwanted side effects and pain of tattoo removal by the following criteria

	1	2	3	4	5	6
Satisfaction with tattoo removal	Completely unsatisfied	Unsatisfied	Slightly unsatisfied	Satisfied	Very satisfied	Completely satisfied
Satisfaction with the no. of treatments	Completely unsatisfied	Unsatisfied	Slightly unsatisfied	Satisfied	Very satisfied	Completely satisfied
Unwanted side effects	None	Very mild	Mild	Moderate	Severe	Extreme
Pain	None	Very mild	Mild	Moderate	Severe	Extreme

Figure 2: Amateur tattoo on the chest. Pictures taken before treatment, after the first treatment and a final result after third treatment.

the tissue treated with Q-switch laser, which disappears in 10 to 30 minutes.

Treatments were conducted with appropriate glasses at all times. High-resolution digital photographs of each patient were taken prior to the first treatment, after several subsequent treatments and again after the final treatment. Cold compresses, cooling ointments and analgesics such as paracetamol and non-steroidal anti-inflammatory drugs were used to relieve pain during and after the treatment.

After completed treatments, patients were given a questionnaire to assess their satisfaction with the results of laser tattoo removal with grades from 1 to 6 (Table 1 and Table 2), 1 – being the minimum and 6 – the maximum satisfaction.

Results

Satisfactory tattoo removal was achieved in all the treated patients. Furthermore, 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. (Table 2).

The average number of treatments required for complete tattoo removal was less than 7, ranging from 3 to 21 treatments. (Table 3).

Table 2: Average scores for 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

Cases

Case 1

The patient requiring the least treatments for a good end-result, was a patient with an amateur tattoo placed on the chest (volim te–sign). A complete tattoo removal was achieved after only three treatments. (Figure 2)

Case 2

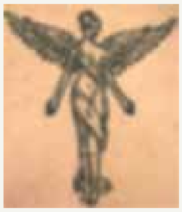
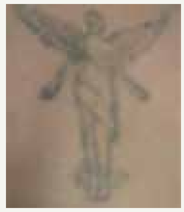
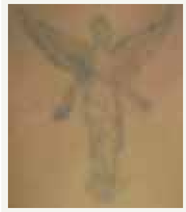
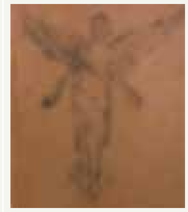
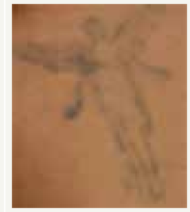
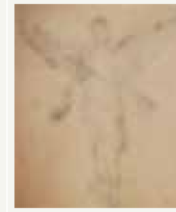
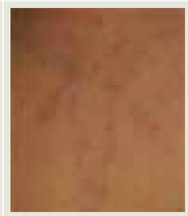
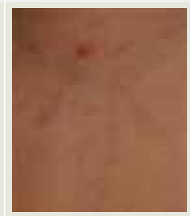
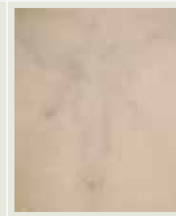
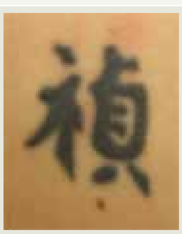
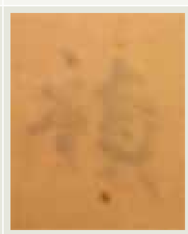
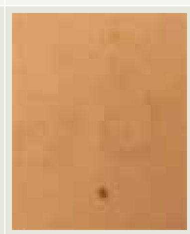
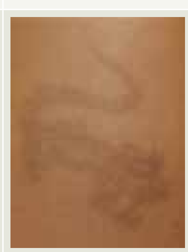
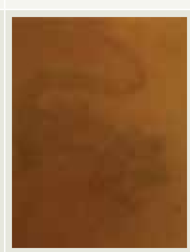
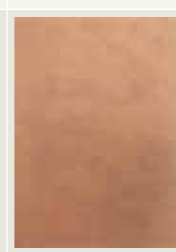
Our patient who required most treatments, was a patient with a professional tattoo of an angel, placed on the upper back in the interscapular area. (Figure 3) After 21 treatments with the Fotona's QX-MAX laser, we were able to achieve a satisfactory result with very little visible tattoo remaining.

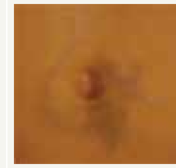
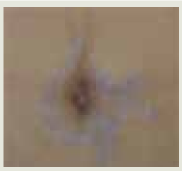
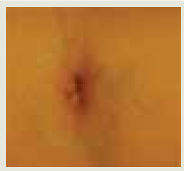
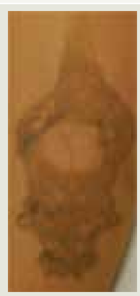
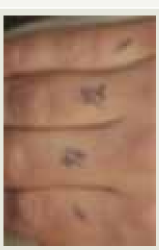
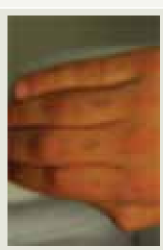
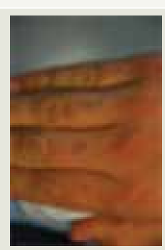
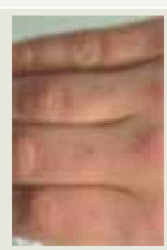
Table 3 shows the esthetic results and intermediate stages of tattoo removal of all of our cases, including Case 1 and Case 2 mentioned above (in Table 3 indicated below the sequence numbers 11 and 1).

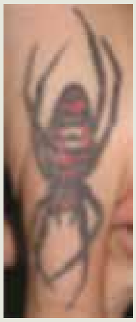
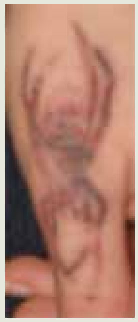
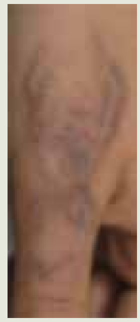
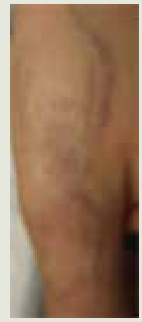
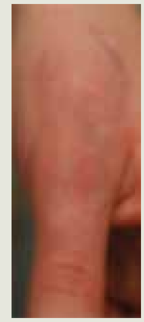
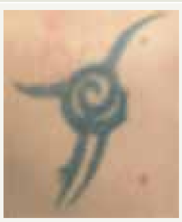
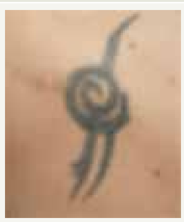
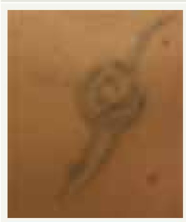
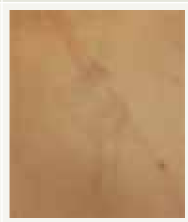
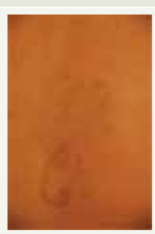
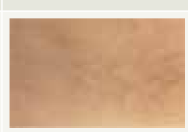
Side effects

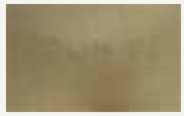
Most of our patients had common side effects such as localized acute inflammatory reactions, mild edema and erythema, which usually subsided without consequences within 2–3 days. Swollen lymph nodes can appear as well. One of our patients had severe edema which appeared within 24 hours after treatment, but it also subsided without any consequence within 48 hours. There was also one case of tattoo-darkening after laser treatment, while treating a female patient with a skin-colored cosmetic tattoo. After applying laser treatment on a small test area we noticed the expected tattoo-darkening and the treatment session was instantly stopped. However no subsequent treatments

Table 3: 11 cases of tattoo removal with Q-switched Nd:YAG laser (QX-max, Fotona, Slovenia) and the parameters used.

	before	Tx 11	Tx 12	Tx 13	Tx 14	Tx 15
Case 1						
Parameters Fluence Wavelength Spot size Frequency		1064 nm 4 J/cm^2 5 mm 2,5 Hz	1064 nm 7 J/cm^2 4 mm 1,5 Hz	1064 nm 6,5 J/cm^2 4 mm 2 Hz	1064 nm 7 J/cm^2 4 mm 2 Hz	1064 nm 7,2 J/cm^2 4 mm 3 Hz
	Tx 16	**Tx 17**	**Tx 18**	**Tx 19**	**Tx 20**	**Tx 21**
						
Parameters Wavelength Fluence Spot size Frequency	1064 nm 7 J/cm^2 5 mm 2,5 Hz	1064 nm 7,5 J/cm^2 4 mm 1,5 Hz	1064 nm 7,5 J/cm^2 4 mm 2,5 Hz	1064 nm 7,5 J/cm^2 4 mm 2 Hz	1064 nm 7,5 J/cm^2 4 mm 2 Hz	1064 nm 8 J/cm^2 4 mm 2 Hz
Case 2						
Parameters Wavelength Fluence Spot size Frequency		1064 nm 4,2 J/cm^2 5 mm 2 Hz	1064 nm 4,6 J/cm^2 5 mm 2 Hz	1064 nm 6,1 J/cm^2 5 mm 2 Hz	1064 nm 6,3 J/cm^2 5 mm 2 Hz	1064 nm 6,5 J/cm^2 5 mm 2 Hz
Case 3						
Parameters Wavelength Fluence Spot size Frequency		1064 nm 3,1 J/cm^2 6 mm 5 Hz	1064 nm 3,8 J/cm^2 6 mm 3 Hz	1064 nm 4,5 J/cm^2 6 mm 4 Hz	1064 nm 5,5 J/cm^2 6 mm 4 Hz	1064 nm 6 J/cm^2 6 mm 5 Hz

	before	**Tx 1**	**Tx 2**	**Tx 3**	**Tx 4**	**Tx 5**
Case 4						
Parameters Wavelength Fluence Spot size Frequency		1064 nm 4 J/cm^2 5 mm 2,5 Hz	1064 nm 4,3 J/cm^2 5 mm 2,5 Hz	1064 nm 5 J/cm^2 5 mm 2,5 Hz	1064 nm 5,5 J/cm^2 5 mm 2,5 Hz	1064 nm 5,8 J/cm^2 5 mm 2 Hz
	Tx 6	**Tx 7**	**Tx 8**	**Tx 9**		
						
Parameters Wavelength Fluence Spot size Frequency	1064 nm 6 J/cm^2 5 mm 2 Hz	1064 nm 6,2 J/cm^2 5 mm 2 Hz	1064 nm 6,2 J/cm^2 5 mm 2 Hz	1064 nm 6,5 J/cm^2 5 mm 2 Hz		
Case 5						
Parameters Wavelength Spot size Frequency		1064 nm 5 J/cm^2 4 mm 2 Hz	1064 nm 6,5 J/cm^2 4 mm 6 Hz	1064 nm 7,5 J/cm^2 4 mm 2 Hz	1064 nm 8 J/cm^2 4 mm 2 Hz	1064 nm 8 J/cm^2 4 mm 2 Hz
Case 6						
Parameters Wavelength Spot size Frequency		1064 nm 5 J/cm^2 2 mm 2,5 Hz	1064 nm 6 J/cm^2 2 mm 3 Hz	1064 nm 7 J/cm^2 2 mm 1,5 Hz	1064 nm 8 J/cm^2 2 mm 1,5 Hz	

Case 7						
Parameters Wavelength Fluence Spot size Frequency		1064 nm 4,6 J/cm^2 5 mm 2,5 Hz	1064 nm 5 J/cm^2 5 mm 2,5 Hz	1064 nm 5,2 J/cm^2 4 mm 2,5 Hz	1064 nm 5,2 J/cm^2 4 mm 2,5 Hz	1064 nm 6 J/cm^2 4 mm 2,5 Hz
Parameters Wavelength Fluence Spot size Frequency		532 nm 2 J/cm^2 3 mm 1,5 Hz	532 nm 2 J/cm^2 3 mm 1,5 Hz			
Case 8						
Parameters Wavelength Fluence Spot size Frequency		1064 nm 6,2 J/cm^2 4 mm 2 Hz	1064 nm 5 J/cm^2 4 mm 2 Hz	1064 nm 6,3 J/cm^2 4 mm 2 Hz		
Case 9						
Parameters Wavelength Fluence Spot size Frequency		1064 nm 4 J/cm^2 4 mm 2 Hz	1064 nm 6 J/cm^2 4 mm 3 Hz			
Case 10						
Parameters Wavelength Fluence Spot size Frequency		1064 nm 5 J/cm^2 4 mm 1,5 Hz	1064 nm 6 J/cm^2 4 mm 1,5 Hz	1064 nm 6,5 J/cm^2 4 mm 2 Hz		

Case 11						
Parameters Wavelength Fluence Spot size Frequency		 1064 nm 6,6 J/cm^2 4 mm 2,5 Hz	 1064 nm 7 J/cm^2 4 mm 2,5 Hz	 1064 nm 7,5 J/cm^2 4 mm 2,5 Hz		

were done as the patient never returned for additional therapy.

Figure 3: Professional tattoo on the upper back – before treatment and after the last treatment.

Discussion

Tattoo pigment particles can be selectively destroyed without harming the surrounding tissue by means of selective photothermolysis.[6,10] The term selective photothermolysis refers to the precise targeting of a structure or tissue using a specific wavelength of light with the intention of absorbing light into that target area alone. Pulsed laser wavelength must be well absorbed by the targeted tattoo pigment. Absorbtion of a particular wavelength is highest in its complement color.[4] The energy directed into the target area produces sufficient heat to damage the target while allowing the surrounding area to remain relatively intact. This requires the correct choice of laser parameters, including wavelength, radiant exposure, and pulse duration of the laser applied.

Our study clearly shows that Q-switched laser is a good choice of treatment for tattoo removal. As we have already stated, our observation showed that private clinics and beauty salons in our country use different lasers, such as alexandrite and Nd:YAG for tattoo removal or even IPL, which are not appropriate for removing a tattoo and can even cause permanent side effects such as scarring. Figure 4 and Figure 5 show two of our patients with extensive scarring who seeked our help after having their tattoos treated with a non-Q-switched lasers in private clinics. Scar tissue caused by the non-Q-switched laser might also be responsible for the remaining tattoo pigment and a poor end-result, as the phagocitosed color particles cannot be succesfully removed through it, because of decreased lymphatic drainage.

While with the use of QX MAX Nd:YAG laser, scarring has become a rare side effect, it still remains a common feature of tattoo treatment with other laser systems. Hypertrophic scars usually occur on sites of increased skin movement. Areas of predilection for keloids include sternal area, shoulders (Figure 4), and upper back. Sometimes scarring is so extensive and esthetically unacceptable that surgical excision of the scar tissue is the only solution, as was the case in one of our patients that had his tattoo unsuccesfully removed with a non-Q-switch laser in a private practice. (Figure 5 and 6)

In general, amateur tattoos require fewer treatment sessions than professional tattoos, although amateur tattoos are less predictable. When treating amateur tattoo placed on the chest (Case 1), we managed to remove the tattoo pigment completely in just three treatments and achieved a perfect end-result. However, tattoos on distal extremities, being either amateur or professional, are more difficult to treat, presumably due to decreased lymphatic drainage of phagocyto-

Figure 4: Scar tissue after improper choice of laser.

sed pigment. Older tattoos in most cases responded more favorably, due to decreased density of pigment from its natural migration.[9]

One of our patients (Case 2) required a particularly high number of treatments (21 treatments). The reason for so many laser treatments for a good end-result was a combination of many parameters such as a large amount of tattoo pigment used, patient's skin type, the location of tattoo and the fact that it was a professional tattoo.

More treatments were also required when treating multi-colored tattoos. In particular, purple, yellow, and green tones turned out to be therapeutically more challenging. However, most of our patients had tattoos where only one or two colors were used, which is one of the reasons why less than 7 treatments were required on average .

Tattoo inks are exogenous chromophores in the skin. Light energy from lasers is rapidly absorbed into the chromophores with an abrupt deposition of energy, creating photoacoustic fragmentation of the tattoo particles. The fragmented tattoo particles are phagocytosed and removed by lymphatic drainage.[1] This process takes approximately two months to complete. Therefore, the current recommendation is to treat at 6- to 8-week intervals unless a longer period is needed for tissue recovery.[2]

High intensity ultra-short nanosecond pulse durations are necessary for successful tattoo removal. They are provided only by a special laser technique known as 'Q-switching'. Only Q-switched lasers can effectively remove tattoo ink. At present, there are 4 different types of Q-switched lasers that are successful in tattoo removal: 532 nm and 1064 nm Nd:YAG, alexandrite, and ruby laser.[1,2,6,9,11]

Having a range of single wavelength laser systems to remove each color separately is time-consuming and presents a great expense. No single-wavelength laser can remove all the tattoo color effectively, especially when treating multicolored tattoos.[12,13] Therefore we use a QX MAX's quality-switched 1064nm Nd:YAG laser which can be reliably converted to other wavelenghts for tattoo removal, specifically to 532nm, using a frequency doubling KTP crystal. There is also a possibility of converting to 585nm and 650nm by using polymer dye handpieces.[4] This selection of wavelengths provides the ability to treat a wide range of different tattoo inks, and a possibility of removing even the most complex, multicolored tattoos.

These days, tattoo artists use a wide range of tattoo pigments resulting in multicolored tattoos including the shades of pink, purple, brown and even fluorescent colors. Black ink is the most common color seen in tattoos, followed by blue, green, red, yellow and orange.

Many tattoo inks are even a mixture of colors with a wide range of tint (blue, green, viollet, orange) and are therefore impossible to classify as a single pigment, thus presenting a problem in choosing the right wavelength for treatment.[2]

We used Q-switched laser in all of our tattoo removal treatments and achieved satisfactory tattoo removal in all the treated patients. QX MAX is the highest single pulse energy generating Q-switched laser available today. This high energy allows larger spot sizes to remain effective by avoiding the scattering effect of laser light in the tissue. In turn, laser light can penetrate deeper into the skin to treat deeper-lying pigment.

Figure 5 (left): Scar tissue after a tattoo removal with a Non-Q-switch laser.
Figure 6 (right): Post-operative state, after surgical excision of the scar tissue.

Its single nanosecond pulses are more efficient at removing pigment than those lasers that use multiple pulse technologies that generate equivalent high powers. In contrast to other laser systems, QX MAX's nanosecond pulses are not affected by the optical shielding phenomenon, therefore the deeper lying structures can also be reached and successfully removed. The pulse duration of lasers that do not use the Q-switch technology are considerably longer than those required with the principles of selective photothermolysis. Therefore, non-Q-switched lasers and intense pulsed light (IPL) sources with millisecond pulses and low light intensities are not suitable to be applied for tattoo removal as they can cause significant scarring and pigmentation changes.[6,8]

The QX MAX Q-switched laser also has an almost perfectly homogeneous beam profile in comparison to non-linear beam profile of standard Q-switched lasers. Homogeneity of the laser beam ensures more safety during treatment as it minimizes epidermal damage, the risk of bleeding and transient textural changes of the skin.[9] This feature enabled us to treat our patients more efficiently with less unwanted side effects such as superinfection of the wounded skin and less treatments required for complete tattoo removal.

It is now a well known fact that treating tattoos with laser can also result in unwanted side effects such as 'paradoxical darkening' of the tattoo. Pigments including red, brown and white, usually used for cosmetic (permanent make-up) tattoos, are at highest risk for complications such as laser-induced photochemical changes of the tattoo ink, resulting in immediate darkening of the tattoo.[5,6,14] This effect is caused by the reduction of iron-containing pigments (used in certain cosmetic applications) to iron-oxide. Titanium dioxide, a white pigment that is widely used to lighten or brighten two-thirds of all tattoo colors,[6,15] can also darken following irradiation with Q-switched laser energy. Therefore, before attempting to treat a tattoo, it is highly important to asses its complexity and the risk of occurrence of unwanted side effects. Patients should be counseled on the risk of potential darkening of the tattoo. Test sites are recommended with patient consent and if darkening occurs, the area should be re-treated.[2]

Besides trying to avoid unwanted side effects, evaluation of tattoo complexity prior to treatment is important in terms of being able to estimate the number of treatment sessions required to fully remove it. For this purpose, the Kirby-Desai scale can be used. It is a scale that takes all the important parameters into consideration, such as the patient's skin type, location of tattoo, the colors used, amount of ink, tattoo layering and the presence of scarring or tissue change. A retrospective study revealed a good correlation between the Kirby-Desai scores and the number of tattoo-removal treatments required. The higher the score on Kirby-Desai scale, the more treatments were required for complete tattoo removal.[3,4] It is advisable to counsel patients on the expected treatment outcomes, and that sometimes a complete clearance of the tattoo color pigments cannot be achieved by laser therapy.[6] Given the available technology and knowledge, the establishing of realistic goals is of utmost importance.[1]

As tattoos continue to gain in popularity, research is being focused on the development of new and even more effective laser systems.[1] Currently, lasers with picosecond pulse durations are being developed.[16,17] The optimal pulse duration for fragmenting tattoo particles is belived to be 10 picoseconds to 100 picoseconds. Picosecond lasers such as the titanium:sapphire (795nm) laser are being compared to current Q-switched technology. It is theorized that by confining thermal and photomechanical damage to the target particle more effectively, these lasers may optimize tattoo removal either by increased phagocytosis or through transepidermal elimination.[17] Initial animal studies[18] have been promising, as was a study in human subjects that showed a higher success rate of tattoo clearing with fewer laser treatments.[19] To date, however, only prototypes of this laser are available.[17] Given equal energy, shorter pulse duration can offer a more efficient treatment, minimizing fluence and collateral damage, therefore scarless tattoo removal is finally becoming a reality.[1,2,20] Developments leading to new tattoo inks, feedback systems to detect the absorbance characteristics of tattoo inks and dermal clearing agents might also improve the results in the future.[16,20]

Nevertheless, multiple treatment sessions are still needed and unwanted side effects such as 'paradoxical' darkening of the tattoo can still occur, but are in most cases treatable.

Conclusion

Our study showed that Q-switched laser successfully removes tattoo ink. Q-switched laser is the only laser system that should be used for tattoo removal, as other laser systems have a high degree of side effects, complications and therefore unsatisfied patients. However, several treatments are still required for satisfactory tattoo removal.

Tattoo removal may seem a simple aesthetic problem, but for the satisfaction of patients, a thorough knowledge of the anatomy and pathophysiology of the skin, as well as a detailed understanding of the functioning of technologically advanced laser devices is needed. Therefore, it would make sense that the general practitioners have a basic understanding of the laser operation so that patients can be properly advised.

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