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SICHERE UND EFFEKTIVE LASER-TATTOO-ENTFERNUNG
DURCH EINEN NEUARTIGEN PIKOSEKUNDENLASER MIT ZWEI WELLENLÄNGEN

Safe and effective laser tattoo removal using a new type of picosecond laser with two wavelengths

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KEYWORDS: 300 Picoseconds, Tattoo Removal, TRT, Clearance, Safety, PicoStar, Picosecond Laser

SUMMARY:

This article shows the effective clearance and safe treatment for a novel Picosecond Laser with shortest pulse width in treatment sessions with 5 patients.

Conclusion: Picosecond lasers with very short pulse length can enable a more effective and painless treatment than nanosecond Lasers for black and colored tattoos and in some cases, it is possible to clear tattoos with fluences of a lesser scale than with nanosecond domain pulses. Our cases show better clearance in less treatment sessions compared to other lasers with which we have gained experience in our practice. The MOA (Mechanism of action) allows a safe and effective treatment with lower fluences, as a result decreasing the thermal energy transfer to surrounding tissues and minimizing the risk of scarring and reducing the patient's pain.

SCHLÜSSELWÖRTER: 300 Pikosekunden, Tattooentfernung, TRT, Freigabe, Sicherheit, PicoStar, Pikosekundenlaser

ZUSAMMENFASSUNG:

Dieser Artikel zeigt die effektive Clearance und sichere Behandlung für einen neuartigen Pikosekundenlaser mit kürzester Pulsbreite in Behandlungssitzungen mit 5 Patienten.

Schlussfolgerung: Pikosekundenlaser mit sehr kurzer Pulslänge können eine effektivere und schmerzlosere Behandlung als Nanosekundenlaser für schwarze und farbige Tätowierungen ermöglichen, und in einigen Fällen ist es möglich, Tätowierungen mit Fluenzen geringeren Ausmaßes als mit Pulsen im Nanosekundenbereich zu entfernen. Unsere Fälle zeigen eine bessere Entfernung in weniger Behandlungssitzungen im Vergleich zu anderen Lasern, mit denen wir in unserer Praxis Erfahrungen gesammelt haben. Der MOA (Wirkmechanismus) ermöglicht eine sichere und wirksame Behandlung mit niedrigeren Fluenzen, wodurch die thermische Energieübertragung auf das umliegende Gewebe verringert und das Risiko der Narbenbildung sowie die Schmerzen des Patienten reduziert werden.

1. INTRODUCTION/PURPOSE

When we look back on the history of laser assisted Tattoo removal, we will mainly find Q-Switched Lasers, though in the very beginning and the first tests, HCP's (Health Care Providers) used CO_2 (carbon dioxide) lasers. The MOA (Mechanism of action) of an ablative Laser System is based on the principle of thermal coagulation and superficial ablation of skin and removal of the ink pigments [1]. As this was an invasive method related to dermatosurgical removal and the trials with ablative Lasers led to scarring a safer method was warranted. Tattoo removal with a non-ablative Q-switched ND:Yag laser was first described by Rox Anderson [4] as precise microsurgery by selective absorption of pulsed radiation .

Q-Switched (frequency doubled quality-switched) lasers of different wavelengths (532 nm and 1064 nm) were soon established as a new standard to maintain and remove tattoos by selective photothermolysis. The mechanism of selective photothermolysis is based on nanosecond pulse impulses, which are selectively absorbed by the ink particles, thereby heating them up and leading to their Thermolysis [4].

Another important factor for an optimal, selective photothermolysis of a pigmented particle, is a pulse duration equal to or less than the particle's thermal relaxation time (t½). Since tattoo particles in skin range in diameters from 40 to 300 nm, picosecond pulses would approximate TRT t½ more closely and, therefore, might be more effective at tattoo particle fragmentation [5].

Furthermore, Choi et al showed in 2018, that the TRTs for carbon particles of 40, 100, 200, and 300 nm diameters are 19.12, 119.5, 478 and 1.060 ps, respectively, according to the TRT formula [9,10].

Therefore, shorter pulses, in the picosecond range should be favorable when it comes to tattoo removal. In 1998 Anderson et al published first data, which underlined this theory (PMID: 9487208). In 2010 the first commercially

Fig. 1a–d: During the first treatment (a). A few days after treatment (b). After 6 sessions (c) and 12 months after 6 sessions (d). Treatment intervals of 8–10 weeks [13].

available Picosecond Lasers were built. This first generation of Picosecond Lasers often labeled as "Subnano" Lasers were working with pulse durations, closer to nano than picoseconds. Tattoo-pigment particle fragmentation occurs from a buildup of pressure, also known as stress, caused by rapid heating of the particle by short laser pulses. For rapid heating of tattoo particles when picosecond Lasers are applied, there are three major sources of photomechanical stress: thermal stress, acoustic stress, and explosive vaporization. Mainly photoacoustic stress, leading to smaller particle fracture resulting in increased photoacoustic breakup of the target. This "photoacoustic effect" differs Picosecond Lasers from Q-Switched systems.

It is yet controversial, whether the mechanical disruption of the tattoo pigment is followed by site clearance due to macrophages, or if the chemical cleavage of organic pigments with simultaneous loss of the chromophore leads to the fading of the tattoo [7].

Laser dermatologist often report the persistence of modern tattoos, probably containing smaller pigment agglomerates, which make the use of pico-second lasers with a picosecond pulse duration and at least dual wavelengths more appropriate and a new state of the art, also in the clearance of yellow tattoos [8].

TAB. 1: ILLUSTRATION OF TRT [6]

Target	Thermal Relaxation Time
Erythrozyte	2 µs
200 µm hair follicle	40 ms
0.5 µm melanosome	0,25 µs
10 µm naevus cell	0,1 ms
0.1 mm diameter vessel	10 ms
0.4 mm diameter vessel	80 ms
0.8 mm diameter vessel	300 ms

2. METHODS/MATERIALS

In this paper, 4 patients with 4 tattoos looking for tattoo removal have been treated. Two black tattoos were located on the neck. One colored tattoo, in the only male patient was located around the umbilicus. A multicolored, large tattoo was located on the lateral area of the lower, right leg. This example is shown in the article with 4 cases.

The treatment has been performed with a novel Picosecond Laser working at 300 ps, wavelength 1064 nm for the black tattoos and 532 nm for the colored tattoo. Initial Settings were with a 4 mm diameter, ranging from 1.2 J/cm^2 up to 5 mm diameter and 2.8 J/cm^2. Pulse duration was set at 10 Hertz. (PicoStar®, Asclepion Laser Technologies) with an interval of 6–8 weeks between treatments. For patient comfort a topical anesthetic (Anessderm®) was applied 30 minutes before treatment and a Cooling Device (Zimmer Cryo 7®) has supported a comfortable treatment. Furthermore, it is preventing side effects like blister formation and excessive erythema and post treatment edema.

After the treatment all tattoos were covered with a topical, antibacterial ointment (Fucidine®) and a specialized wound dressing (Suprasorb F®). We also gave advise to avoid sun exposure and use SPF 50 or cover the tattoo. A photographic documentation was enhanced during treatment as well, as before the following treatment.

3. RESULTS

3.1 B&A

1. Case: Female patient, 22 yrs, black tattoo (taurus sign/ neck): black. 6 Sessions: Treatment parameters: 1064 nm: 4 mm, 1–2 J, from Tx 3 : 5 mm 1.4–2.6 J.

2. Case: Male patient, 35 yrs, multicolored tattoo (sun/umbilicus): Black, red, yellow, orange. 5 Sessions with 2 wavelengths: Treatment parameters: 1064 nm: 5 mm, 0.8–2.4 J, 532 nm: 5 mm 0.5–1.4 J.

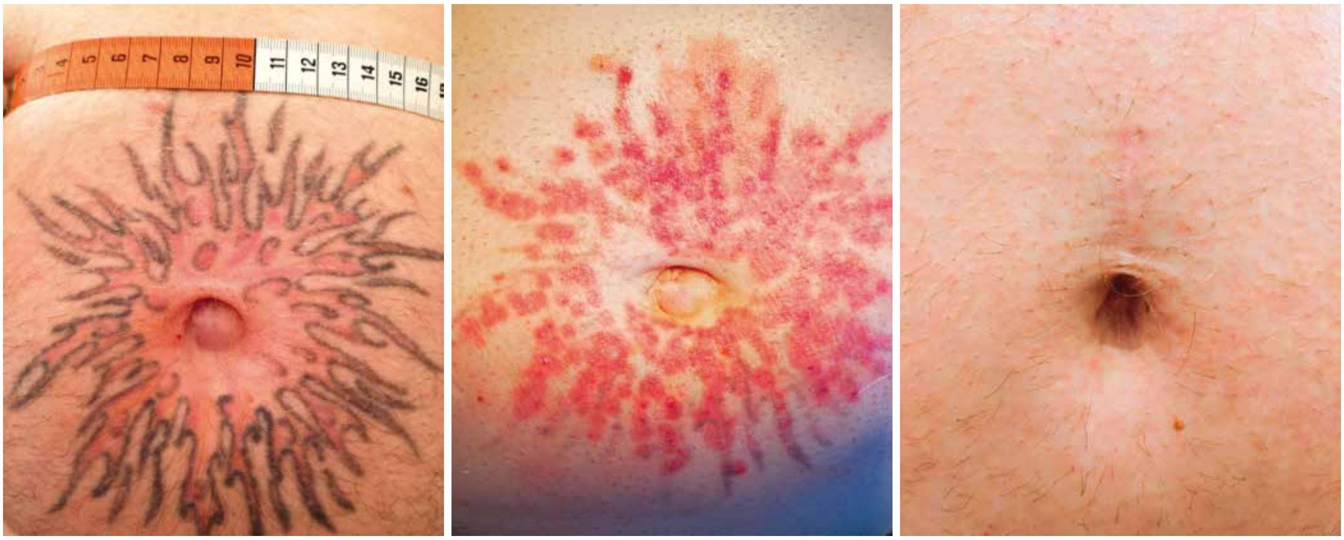

Fig. 2 a–c: Before treatment (a). Immediately after the first treatment (b). After 5 sessions (c). Treatment intervals of 8–10 weeks.

3. Case: Female patient, 27 yrs, black tattoo (lettering- Siempre en el meu cor plus 3 stars / Upper Back). 6 Sessions: Treatment Parameters: 1064 nm: 5 mm. 0.8–2.8 J.

4. Case: Female Patient, 35 yrs, black and blue tattoo (sharks, multiple symbols / right lower leg). The patient's goal was to brighten the tattoo for a so called "Cover Up". 2 Sessions: Treatment Parameters: 1064 nm: 5 mm: 1.8 J and 2.2 J.

3.2 Patient Satisfaction

The treatment was well tolerated in all patients and due to application of topical numbing agents and cold air (Zimmer, Cryo 7®), a short and efficient treatment with minimal to moderate discomfort (2–5/10 VAS pain scale), could be achieved.

3.3 Side effects

Side effects were transient and well tolerable. No severe side effects were reported. The wound healing took 5–7 days in total. Blister formation was observed in 2 black tattoos due to the density of ink but healed quickly without scarring. Subcutaneous pinpoint bleeding (Fig. 7) was almost obligatory but lasted only a few days. Interestingly almost no hypopigmentation showed after the Lhämaser treatment. In one patient with a black tattoo, we saw a small scar formation (Fig. 2c) at the tip of the tattoo. This occurred due to a patient inflicted injury of the tattoo caused by a too aggressive removal of the wound dressing and therefore ablation of skin.

3.3 Outcome

The outcome in all patients was very sufficient. The complete Tattoo removal in 3 Patients could be reached withing

Fig. 3 a–c: Before treatment (a). During treatment (b). After 6 sessions (c). Treatment intervals of 8–10 weeks.

Fig. 4 a–d: Before the treatment (a). During the 1st session (b). After 2 sessions (c). In detail (d).

TABELLE 2

Pulse duration	Wavelength (nm)	Efficacy	Surrounding tissue damage
Nanosecond	532	Red, Orange, Yellow, Green Black	Thermal damage Vacuolation on dermis
	1.064	Black	Extensive RBC extravasation Subcorneal separation
Picosecond	532	Red, Orange, Yellow, Green Black	Least epidermal effect
	735	Green, Blue	Modest epidermal effect, but rapid healing
	1.064	Black, some effect on other colors	Modest epidermal effect more prominent than following Pico-532 or Pico-755 treatment

6 Treatment Sessions for the Black Tattoos and 8 Sessions for the multicolored Tattoo. One Patient with a multicolored tattoo was looking for a so called “Cover Up” i.e., she was looking to get a new tattoo over her previous one. This target could be reached in only 3 sessions.

4. CONCLUSIONS

4.1 Comparison
See Table 2 [6].

4.2 Side Effects
The very short pulse duration compared to other devices on the market has shown reduced edema and erythema formation in these cases and has led to an abstinence of dyspigmentations and other wound healing disorders. In one patient with a black tattoo, we saw a small scar formation at the tip of the tattoo. This was due to patient inflicted injury of the tattoo because of a too aggressive removal of the wound dressing. Interestingly also the multi-colored Tattoo on the male patient, consisting of red, orange, yellow and black colors showed a complete clearing after 8 sessions. This phenomenon could be reproduced in an animal study by Choi et al [11]. In our case study we were able to determine, that this phenomenon also appears to occur in human skin.

As Kono et al. discussed, the color of iron oxide contained in some tattoos changes from brown to black through an oxidation-reduction reaction when heated to its melting point (1.400 °C). Red (iron oxide) turns to black (iron oxide) and white (Ti^{4+}) turns to black (Ti^{3+}) [10, 11]. This pigment change can be resistant to additional Q-switched laser therapy. Other color changes can occur after the treatment of cosmetic tattoos with a frequency-doubled Nd:YAG laser. There is a risk of paradoxical darkening, not only with nanosecond lasers but also with picosecond lasers. None of this occurred in the cases shown [12].

4.3 Final conclusion
Picosecond lasers with very short pulses can enable a safe and more effective treatment than nanosecond pulses for black tattoos and in some cases, it is possible to clear

Fig. 5: Side effect: Punctiform haematomas and slight blistering, mainly in the red-coloured area.

tattoos with fluences of a lesser scale, than with nanosecond domain pulses. Our trial showed better clearance in less treatments compared to other lasers with which we have gained experience in our practice. The MOA (Mechanism of action) allows an effective treatment with lower fluences, as a result decreasing the thermal energy transfer to surrounding tissues and minimizing the risk of scarring.

Compliance with ethical guidelines:

Conflicts of interest for the study: The author declares that he has no competing interests. Hans Bayer recurringly holds lectures for Asclepion Laser Technologies, the company distributing the PicoStar device. This device has been regularly purchased by the clinic. His research did not involve animals. Informed consent was obtained. The PI commits himself to comply with the local regulations applicable to clinical studies.

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