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Tattoo Regret? Principles and Pearls to Optimize Laser Tattoo Removal

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Introduction

Tattooing of the skin is an age-old practice that involves delivering pigments to the dermis.[1] Tattoos can be a mark of honour or status in specific cultures, a long-lasting reminder of a moment in time, or more simply a decorative feature of self-expression. Occasionally, tattoos can become painful reminders of moments past, such as a radiation tattoo years after remission from cancer, a lover's name from a failed relationship or a tattoo from a gang affiliation/imprisonment/human trafficking. On a more mundane note, a tattoo can become out of fashion or individual taste may change over the years. "Tattoo regret" is very common and many patients seek out options to remove tattoos. Though historically, surgical techniques were required to remove tattoos, pigment-targeting lasers have become the first-line treatment. Successful and safe laser tattoo removal requires a thorough understanding of treatment principles, appropriate laser wavelength selection, relevant biological endpoints, and prognostic factors that may guide the expected number of treatment sessions needed for a satisfactory outcome.

Process of Tattooing and Tattoo Composition

Tattoos are the result of ink insertion in the dermis, where it is subsequently taken up by macrophages, mast cells, and fibroblasts. Tattoos may be professional (tattoo artists using vibrating hollow needles), amateur (most often with a solid needle using the "stick-and-poke" technique), cosmetic (such as permanent makeup for eyebrows, eyeliner, or lip liner), traumatic (pencil or gravel, often in the context of an accident) or medical (for port placement or radiotherapy fields). Though historically, specific metals were used for their colour (such as cobalt for blue or mercury sulfide for red), nowadays most tattoos are made with carbon-based dyes such as azo dyes.

Scientific Principles Behind Laser Tattoo Removal

The principle of selective photothermolysis[2] explains and guides the process of laser tattoo removal. Tattoo pigment is the chromophore that absorbs laser photons, therefore, a wavelength that has affinity for a specific pigment must be selected (**Table 1**). Longer wavelengths have deeper optical penetration within the skin, allowing them to reach deeper pigment layers. Extreme care must be exercised when using shorter wavelengths, such as a quality-switched (QS) 532 nm laser, as penetration to the dermo-epidermal junction may target endogenous melanin in patients with Fitzpatrick IV–VI skin types and cause dyspigmentation. At a given wavelength, a larger spot size can increase dermal depth of penetration if needed. Lastly, because tattoo pigment is a very small structure with a short thermal relaxation time, the pulse duration of the device must also be very short (in the nanosecond or picosecond range) to produce thermal confinement and avoid collateral damage to the surrounding dermis. Picosecond lasers, with their extremely short pulses, are believed to exert their effects through acoustic (photomechanical, shattering the particle) effects, rather than heat (photothermal, heating the particle) effects. In general, millisecond pulse duration range pigment-targeting lasers and intense pulsed light are not considered appropriate to remove tattoos.

Pigment-targeting lasers are the most commonly used for tattoo removal. In certain scenarios (see accompanying patient photos), fractional ablative resurfacing or fully ablative resurfacing may be considered. These devices target water, and so are less specific for tattoo pigment and significantly increase the risk of side-effects such as prolonged healing, hypopigmentation, and scarring.

Predicting the Number of Treatments for Laser Tattoo Removal

The factors that affect the number of treatments required to minimize the appearance of a tattoo have been studied, and a scoring scale has been published. The Kirby-Desai scale[3] (**Table 2**) is particularly useful during clinical consultations, because it provides patients with an estimated number of treatments based on their individual situation. The tattoo removal process can be lengthy and costly, thus, patients appreciate knowing the expected number of treatment sessions before starting the process. Managing patient expectation is key; the author prefers to discuss the objective of making the tattoo unrecognizable rather than fully invisible, as full removal may not always be possible.

Let us apply a patient clinical scenario to the Kirby-Desai scale. A 27-year-old female patient of Middle-Eastern origin asks about the removal of a tattoo she got in university. You score her as Fitzpatrick III, locate the tattoo on the left lateral chest, determine the amount of ink is moderate, note the absence of layering or scarring, and confirm it is all black ink with magnification. After tallying her points, you discuss that she can expect 8 treatments to be satisfied with the appearance of the tattoo. The outcome of her treatments is shown in **Figure 1**.

Counselling Regarding Expected Recovery and Risks with Laser Tattoo Removal

After treatment, crusting/blistering is expected. A bland ointment, such as petrolatum jelly, can be applied to the area. A non-stick dressing will usually be applied. Depending on the site of the tattoo, recovery may take 1–3 weeks. Sun avoidance at the treatment site is recommended to minimize the risk of dyspigmentation. Both postinflammatory hyperpigmentation and hypopigmentation are possible complications of the procedure. Scarring, though uncommon, is possible. Patients can return for treatment as frequently as every 4–6 weeks, however longer intervals between treatments do not sacrifice their long-term outcomes if treatment pauses are needed. Some experts advocate even longer intervals between treatments, as ongoing improvement may be observed in some instances.

A thorough medical history is recommended prior to starting laser tattoo removal. Though less common nowadays, patients who have been treated with systemic gold at any point during

Tattoo Colour	1064 nm	755 nm	694 nm	532 nm	Other
Black	X	X	X		
Blue	X	X	X		
Green		X	X		
Purple		X	X		
Red, orange, yellow				X	
Brown, white					Risk of immediate pigment darkening: consider spot test, ablative laser or observing

Table 1. Laser wavelength selection for tattoo colours; *courtesy of Vincent Richer, MD*.

Points	FST	Location	Ink	Layering	Scarring	Colour
0				None	No scar	
1	I	Head/neck/face	Amateur		Minimal	Black only
2	II	Upper trunk/shoulder	Minimal	Layering		Mostly black, some red
3	III	Lower trunk/upper leg	Moderate		Moderate	Mostly black/red, other colours
4	IV	Proximal extremity	Significant			Multiple colours
5	V	Distal extremity			Significant	
6	VI					

Table 2. Kirby-Desai scale.[3]

Abbreviations: FST: Fitzpatrick Skin Type

Figure 1. Black ink tattoo on the left chest of a Fitzpatrick III patient before treatment (**left**). Significant lightening was observed after 6 sessions of treatment with a Q-switched neodymium-doped yttrium aluminum garnet (NdYAG) laser and picosecond alexandrite laser (**centre**). The tattoo was rendered nearly invisible after 9 treatment sessions (**right**). Reaching this outcome required one extra treatment session beyond the Kirby-Desai scale estimation; *courtesy of Vincent Richer, MD*.

Figure 2. Biopsy-proven allergic contact dermatitis to red tattoo ink. This was associated with extreme pruritus. Intralesional triamcinolone acetonide/5-fluorouracil treated the itch and flattened the lesion, however recurrence occurred within weeks despite several treatments. Eventually ablative laser surgery was performed, as this patient preferred a scar over enduring the severe pruritus; *courtesy of Vincent Richer, MD.*

Figure 3. Blue-black eyeliner tattoo treated with 4 sessions of picosecond alexandrite laser. Metal corneal shields were placed prior to each treatment; *courtesy of Vincent Richer, MD.*

their lives are at risk of laser-induced chrysiasis[4] when using nanosecond or picosecond lasers. The blue-gray pigmentation that develops at sites of laser exposure in patients who have been treated with gold is very difficult to treat. This complication is best avoided by a thorough history and avoiding treatment with a pigment-targeting laser for these patients.

A thorough physical examination of the tattoo is also needed. Nanosecond and picosecond lasers are thought to “reduce” (the opposite of oxidize) ferrous oxide and zinc oxide particles, turning them black, in a process called immediate pigment darkening. This is of particular concern in scenarios of cosmetic tattooing, such as brown eyebrow liner or lip liner. The author unfortunately caused this complication in a patient who had cosmetic tattooing for solar lentigines years ago.[5] The skin-coloured tattoo was not noticed, and the patient did not recall getting a tattoo there until after the complication developed. This was later corrected using an ablative laser. It is prudent to perform a focal test spot prior to treating a brown or white tattoo with a laser.[6]

Photoallergic reactions (most commonly with yellow ink) or allergic contact dermatitis (most frequently seen with red ink) to tattoo ink are possible. These may be unmasked by the process of laser tattoo removal. In general, treating these reactions with nanosecond or picosecond lasers is not recommended, as it may lead to more systemic exposure and an associated systemic allergic contact dermatitis. Intralesional triamcinolone acetonide/5-fluorouracil or laser-assisted drug delivery of triamcinolone acetonide +/- 5-fluorouracil can be considered for this difficult-to-treat reaction.

Lastly, ensuring appropriate eye protection for the patient and laser operator is paramount when performing laser tattoo removal. This is a particularly sensitive matter when removing cosmetic tattoos, such as tattooed eyeliner (**Figure 3**). A metal corneal shield must be placed prior to using a device within the orbit to prevent injury to the iris or retina.[7]

Treatment Delivery and Techniques to Optimize the Laser Tattoo Removal Process

The skin should be cleansed with chlorhexidine prior to treatment. Laser exposure of tattoos is painful, therefore, anesthesia is recommended. In the author's practice, local anesthesia is injected prior to tattoo removal which far outperforms topical anesthesia or the use of cold air/ice.

Upon laser exposure, an immediate whitening reaction of the tattoo ink should be observed, and it should spare nearby healthy skin if it is partially within the beam's surface. This indicates selective lysosome cavitation under the skin, which dissipates within minutes. This biological endpoint allows for titration to a therapeutic fluence, without overtreating. Epidermolysis or immediate pinpoint bleeding may be signs that the fluence is too high.

Though picosecond lasers were developed with the exciting promise of speeding up the process of laser tattoo removal, they have not fully obviated the use of nanosecond-range lasers. Some studies have favoured picosecond lasers, others nanosecond lasers, and some have found no difference in clearance. It is likely that other factors, such as determining an appropriate biological endpoint and fluences used, affect the outcome significantly.

Combination treatments with multiple devices are common when treating tattoos, especially those with multiple colours requiring different laser wavelengths. Fractional ablative resurfacing at low density can also be performed at the same visit, which has the added benefit of reducing post-procedure blistering by ablating tiny perforations in the skin.[1]

Multi-pass treatment is another approach to accelerate the process of laser tattoo removal. Performing a second pass immediately after laser exposure is not usually effective, because the immediate whitening reaction forms an optical barrier to further treatment. The R20 method suggests waiting 20 minutes before retreating and repeating this process several times.[8] However, the practical implementation of this is difficult, due to the very long clinic visits required. In the author's practice, a truncated version

Figure 4. Immediate whitening reaction immediately after laser exposure. A nanosecond alexandrite laser was used to treat the blue and black ink, while a nanosecond 532 nm laser was used to treat yellow ink; *courtesy of Vincent Richer, MD.*

Figure 5. Traumatic tattoo on the right palm years after falling on an outstretched hand on gravel. One session of nanosecond NdYAG laser combined with a picosecond alexandrite laser yielded this improvement. In general, traumatic tattoos can be removed much more readily than professional tattoos; *courtesy of Vincent Richer, MD.*

where 5 minutes is lapsed before a second pass is performed has been helpful. A perfluorodecalin patch can also be applied to the skin prior to laser exposure.[9] This transparent patch reduces the whitening reaction and allows for faster retreatment. An adjunctive rapid acoustic pulse device has also been reported to accelerate clearance of tattoo ink.[10]

Conclusion

Laser tattoo removal can be a very rewarding process for patients and physicians alike (**Figure 5**), but expectations must be well managed. Conducting a thorough history and physical examination, understanding the laser physics, choosing the appropriate laser parameters, appropriately estimating the number of sessions to make the tattoo unrecognizable, and proactively avoiding complications can all lead to improved patient outcomes.

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