

# Optimizing Outcomes of Laser Tattoo Removal

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## Abstract and Introduction

### Abstract

Since the elucidation of the concept of selective photothermolysis, quality-switched lasers have been the gold standard for tattoo removal. Proper patient education prior to commencing treatment is crucial to ensure realistic expectations and compliance. This article reviews appropriate device selection and technique. Clinical pearls and pitfalls are presented, as well as cutting-edge techniques and technologies are discussed in order to enable the laser practitioner to optimize outcomes.

### Introduction

The first evidence of efforts to remove body art exists in the writings of Scribonius Largus (54 A.D.), physician for the Roman Emperor Claudius. He described the use of a preparation of cantharides to induce blistering and eschar formation.<sup>[1]</sup> In the early 20th century chemical methods of tattoo removal continued to predominate. A 1928 Journal of the American Medical Association (JAMA) review of tattoos highlighted removal methods including surgical excision and electrolysis, but concluded that 50% tannic acid yielded the best results.<sup>[2]</sup> Quality-switched (QS) lasers for tattoo removal (694 nm ruby) was first reported in 1965 by Goldman.<sup>[3]</sup> However, it was not until the theory of selective photothermolysis was introduced in 1983 that QS lasers became the gold standard for modern day tattoo removal.<sup>[4]</sup>

In order to optimize the outcomes of laser tattoo removal, it is imperative at the initial consultation to thoroughly educate patients regarding the treatment process. It is costly, often far exceeding the expense of obtaining the body art. Amateur tattoos generally require four to six treatments and professional tattoos may need eight or more sessions. Tattoos in acral locations prove more challenging to remove than those placed on truncal sites and older tattoos respond more readily than newer ones.<sup>[5]</sup> The procedures can be painful and may not result in complete removal. A recent retrospective review of 238 paying patients who underwent an average of 3.57 treatments (ranging between 1–18 sessions) found that 1.26% achieved total clearance of the tattoo, defined as complete absence of pigment.<sup>[6]</sup> The authors attributed the suboptimal results to their patients being inadequately informed of the process and subsequently underwent fewer treatments. To set reasonable expectations for our prospective patients presenting with professional tattoos, the authors suggest that 75% of pigment can be diminished, however, complete removal is difficult to achieve. Prior to initiating treatment, it is important to examine the skin and query the patient regarding whether they have a history of hypertrophic scars/keloids or infectious diseases. Q-switched laser treatments are absolutely contraindicated in patients who have received gold therapy as they induce chrysiasis. Baseline photographs are highly recommended.

### Appropriate Device Selection

When approaching a patient for tattoo removal, the laser practitioner must choose an appropriate device. A QS laser is necessary to achieve selective photothermolysis, as the exposure time in the nanosecond ( $10^{-9}$ ) domain is less than half the thermal relaxation time of the target pigment. This ensures that the thermal damage is spatially confined to the target chromophore, resulting in photoacoustic destruction and minimizing damage to the surrounding tissue from thermal diffusion. The four available QS laser wavelengths are in the visible and infrared domain and include the 694 nm ruby, 755 nm alexandrite, the 1064 nm neodymium:yttrium-aluminum garnet (Nd:YAG), which when passed through a potassium titanyl phosphate (KTP) crystal will double the frequency (halve the wavelength) to 532 nm. It is essential to utilize a wavelength that will be selectively absorbed by the tattoo particle (see Table 1). Additionally, dye laser handpieces can convert 532 nm to 585 nm (sky blue) and 650 nm (green). Despite these guidelines, it is important to remember that tattoo composition can be highly variable and the pigment may not respond predictably to QS laser treatment.<sup>[7]</sup> The QS Nd:YAG is the device of choice when treating tattoos on Fitzpatrick type IV to VI patients, as the 1064 nm wavelength penetrates deepest and is minimally absorbed by epidermal melanin.

**Table 1. Efficacy of Q-switched lasers for specific tattoo colors**

| Q-switched Laser | Wavelength | Pulse Duration | Tattoo Colors              |
|------------------|------------|----------------|----------------------------|
| Ruby             | 694 nm     | < 40 ns        | black, blue, green         |
| Alexandrite      | 755 nm     | 50 ns - 100 ns | black, blue, green         |
| Nd:YAG           | 1064 nm    | < 10 ns        | black, blue                |
| KTP              | 532 nm     | < 10 ns        | red, orange, yellow, brown |

## Treatment and Technical Considerations

Adequate pain control is necessary to deliver a pleasant treatment experience. Depending on the size of the tattoo, its location, and the pain tolerance of the patient, the authors utilize topical anesthesia with a forced air-cooling device or intralesional anesthesia. When QS laser energy is directed at the tattoo, the desired endpoint is usually immediate tissue whitening, though this may not occur once the tattoo has faded significantly. The whitening, which lasts approximately 20 to 30 minutes, is a result of rapid heating of the chromophore leading to gas formation.<sup>[8]</sup> The optimal fluence is the lowest possible setting that elicits this endpoint in order to minimize the risk of thermal injury, such as blister formation and scarring. Failure to choose the proper wavelength will result in no visible laser-tissue interaction. It is beneficial for practitioners to have multiple wavelengths of light in their laser armamentarium to treat the spectrum of colors in modern-day professional tattoos.

An additional consideration is to utilize the largest spot size possible when treating tattoos. Because the smaller the spot size the greater the beam scatter, an increased amount of laser energy scattering at the edge of the field results in decreased depth of penetration.<sup>[9]</sup> There is a tendency among practitioners to reduce the spot size in order to increase the fluence in non-responding tattoos, however, this results in a more superficial delivery of energy and potentially increases epidermal damage. Treatment spots are applied with approximately 10–20% overlap and fluence is chosen to minimize pinpoint bleeding. Laser treatments are ideally spaced 4 to 6 weeks apart, however, it takes approximately 3 months for the full effect of the treatment to be realized. The authors apply a cooled hydrogel dressing (2nd Skin® Moist Burn Pads) immediately following treatment. It is important to apply emollients and an occlusive dressing to the treated area until reepithelialization is complete.

## Potential Adverse Effects

The most common side-effects of QS laser tattoo removal include scarring and dyspigmentation. When therapy is done properly, the estimated incidence of these effects is approximately 5%.<sup>[10]</sup> Hypopigmentation is more common with the 694 nm ruby laser as it is well absorbed by melanin, but can also occur with other wavelengths.<sup>[11,12]</sup> As well, all QS wavelengths can produce hyperpigmentation in darker skin types.<sup>[11,12]</sup> Moreover, because epidermal melanin serves as a competing chromophore, increasing the chance of hypopigmentation or hyperpigmentation, it is imperative that patients avoid all sun exposure at the tattoo site prior to laser treatment.

The aforementioned 1928 JAMA review cautioned, "Bad results follow attempts at removal by professional tattooers and advertising charlatans."<sup>[2]</sup> In fact, there are recent European reports of the increasing frequency of laser tattoo removal performed by laypeople.<sup>[13,14]</sup> Furthermore, the literature is replete with cases of scarring and disfigurement associated with the use of intense pulsed light, long-pulsed lasers, and even radiofrequency devices to remove body art.<sup>[2,15–17]</sup> The light devices violate the principle of selective photothermolysis by delivering energy over a longer duration than necessary, exceeding the thermal relaxation time of the pigment, thereby causing excess heat conduction to the surrounding dermis and subsequent scarring.

Caution must also be undertaken when attempting to remove pink, tan, white, yellow or other light-colored tattoos with QS lasers. These colors are often utilized in cosmetic tattoos for permanent makeup. Paradoxical darkening can occur as the titanium dioxide or iron oxide pigment is reduced by the QS laser treatment.<sup>[18,19]</sup> It is therefore prudent to perform a test spot prior to treating the entire tattoo. When paradoxical darkening occurs, clearing can at times be achieved with additional QS laser treatment.<sup>[20]</sup> Another option for cosmetic tattoos is to avoid QS lasers and treat primarily with fractional carbon dioxide (CO<sub>2</sub>) or erbium:YAG (Er:YAG) devices. Arndt and colleagues remind

practitioners to question patients whether the tattoo is a "double tattoo," with one covering the original.<sup>[21]</sup> In such cases, failure to reduce the fluence accordingly could result in hypertrophic scarring.

There are reports in the literature of successful treatment of tattoo pigment-induced local allergic reaction with QS lasers, and the authors have performed treatments after pre-medication with oral antihistamines. However, extreme prudence is recommended as there are reports of laser tattoo removal resulting in systemization of the allergic response and anaphylaxis.<sup>[15,22]</sup> In two recently reported cases, fractional Er:YAG with or without adjunctive QS laser therapy proved successful in treating tattoo pigment-induced allergy.<sup>[23]</sup>

## Advances and Future Perspectives

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Research is underway to improve both the techniques and devices used for laser tattoo removal. The recently presented "R20" method suggests repeating QS laser treatment four times in a single session spaced 20 minutes apart to allow whitening to fade.<sup>[24]</sup> The investigators found more rapid clearing with the R20 technique versus areas of the same tattoo that received a single treatment per session. Weiss et al. found that adding nonablative fractional 1550 nm laser treatment after QS laser reduced the amount of treatment-induced hypopigmentation.<sup>[25]</sup> The investigators also found that fractional CO<sub>2</sub> laser therapy immediately after QS laser treatment enhanced the rate of pigment clearance versus QS laser alone. The theoretical mechanisms described include the fractional CO<sub>2</sub> laser ablation of superficial tattoo pigment and the induction of an immune response that potentiates removal of the treated pigment.

Lasers in the picosecond ( $10^{-12}$ ) domain are currently under development.<sup>[26]</sup> Theoretically, delivering a sub-nanosecond pulse could more effectively confine the energy to the tattoo particle, resulting in increased photoacoustic breakup of the target. This would allow for effective treatment utilizing lower fluences, thereby decreasing thermal energy transfer to surrounding tissues and minimizing the risk of scarring.

## Conclusion

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Quality-switched lasers remain the gold standard for tattoo removal, but employing the appropriate device and technique does not guarantee a successful outcome. Practitioners must educate their patients in detail regarding the process of laser tattoo removal and reasonable post-treatment expectations in order to create a therapeutic alliance. Exciting new technologies and techniques promise to augment our ability to effectively rid patients of their unwanted body art.

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