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Commentary: Laser Tattoo Removal: Laser Principles and an Updated Guide for Clinicians

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In their recent review article in the Lasers in Medical Science Journal, Hernandez et al. (2022) present a comprehensive summary of laser fundamentals, the cutaneous response to tattoos, and recent developments in the field of laser tattoo removal[1]. The authors recognize the great need for quality reviews of laser therapy to provide evidence-based recommendations to Dermatologists. It is crucial that Dermatologists are well informed about which lasers to use to optimize the removal of tattoos and to be aware of situations in which the application of laser therapy should be avoided. The review article exquisitely outlines how Dermatologists should approach a patient who desires tattoo removal, acknowledging the plethora of reasons an individual may seek such treatment. The authors of this commentary agree that as long as tattoos exist, there will be a demand for their removal. The motivation for tattoo removal is varied but deserves increasing attention as tattoos are becoming more popular. At present, laser therapy is the mainstay of treatments for the removal of tattoos. In their review article, the authors correctly addressed the efficacy and safety of laser therapy in the removal of tattoos compared to other non-laser techniques, including salabrasion, dermabrasion and electrocauterization.

The review article provides Dermatologists with an in-depth understanding of the process of tattooing and the cutaneous response to tattoos. By understanding the intricacies of a patient's tattoo, such as the origin and color and whether their tattoo is layered, a Dermatologist may optimize the removal of the patient's tattoo and minimize adverse effects. Accordingly, the review article thoroughly describes laser physics and the principle of selective photothermolysis to elucidate to the reader the significance of laser selection in the removal of tattoos.

Picosecond Laser – The New Gold Standard for Laser Tattoo Removal

In their review article, Hernandez et al. (2022) highlight the increasing use of picosecond lasers but should further explain that picosecond lasers were designed to overcome the limitations of nanosecond lasers, including hyper or hypopigmentation, textural changes, and scarring[2]. Something that would strengthen the authors' argument that picosecond lasers might be more efficacious than nanosecond lasers in terms of tattoo removal would be to mention that picosecond lasers have now become the mainstay of tattoo removal due to their superior efficacy and decreased treatment durations[3]. The findings of a single-blind randomized trial by Lorgeou et al. (2017) supports this argument[4]. The study found that in 49 patients with primarily professional, black or blue tattoos, the picosecond 1064/532 nm laser was more effective in reducing 75 percent of the color intensity of the tattoos compared to the QS 1064/532 nm nanosecond laser. Another study by Brauer et al. (2012) showed that picosecond lasers highly expedited clearance and necessitated less treatment sessions. At least 75% clearance of blue and green pigment was achieved with a 755-nm alexandrite laser in just 1-2 treatments[5]. At present, picosecond pulse lasers have been developed at wavelengths of 532, 730, 755, 785 and 1064 nm. At these wavelengths, they appear to be effective at clearing most colors of tattoo ink, as well as paradoxical darkening of tattoos[6-12]. Paradoxical darkening is the hyperpigmentation of the tattoo after treatment, which is thought to occur from titanium dioxide and mercury components in the ink, although the process is poorly understood[13, 14]. Furthermore, when directly comparing the effect on tattoo particles of a 750 picosecond 1064 nm Nd:YAG laser versus a 5 nanosecond 1064 nm Nd:YAG laser, Ahn et al. found compelling data to suggest that not only is the picosecond laser likely superior, but the nanosecond laser may not be necessary in order to achieve optimal tattoo removal[15]. The study found that the picosecond laser achieved the greatest degree of particle fragmentation at all fluence levels, and this efficacy persisted at low fluence levels. In contrast, the nanosecond laser lost its efficacy at low fluence levels. While sustained exposure with the picosecond laser resulted in continued particle fragmentation, the nanosecond laser became ineffective at targeting smaller fragmentations. Finally, a recent systematic review of picosecond lasers by Wu et al. (2020) communicates the safety and efficacy of picosecond lasers for a broad range of dermatologic indications, including the removal of tattoos[16]. Just as discussed in the review article itself, this systematic review acknowledged the conflicting findings in the literature regarding picosecond laser efficacy compared to nanosecond lasers. The systematic review goes further to explain that these contradictions may be a result of variations in study design and study device optimization.

Picosecond lasers - Future Directions

According to mathematical calculations and the principles of selective photothermolysis, a pulse duration between 10 and 100 picoseconds would be optimal in the targeting of tattoo ink particles[16, 17]. However, the shortest pulse duration of the picosecond lasers that are currently available is 250 picoseconds. It will be interesting to see whether picosecond lasers with shorter pulse durations will optimize the removal of tattoos or even introduce new adverse effects. These future directions will surely drive the growth of picosecond laser technology and thus the future of tattoo removal.

Interprofessional Objectives

Besides Dermatologists, various healthcare workers perform the removal of tattoos, including plastic surgeons, primary care providers and nurse practitioners. Effective interprofessional communication and education about proper techniques and potential complications are essential to ensure the safety of the patients seeking laser procedures, such as the removal of tattoos[18].

Kirby-Desai Scale for Treatment Number Estimation

Hernandez et al. (2022) raised an interesting issue when discussing the Kirby-Desai scale and its ability to estimate the number of required treatments for the complete removal of a patient's tattoo, which was proposed in a retrospective review studying 100 patients who had successfully completed treatment for complete removal of their tattoo. They accurately recognized that the scale had been designed with the assumption a QS Nd:YAG or Alexandrite laser would be used. Accordingly, Aurangabadkar et al. evaluated the Kerby-Desai scale's ability to predict the number of required treatments when utilizing the R0 technique, thought to aid in a faster clearance of tattoos[19]. The study found that when the R0 technique was applied for tattoo removal in skin types IV to VI, the R0 method required significantly fewer sessions than predicted with the Kirby-Desai scale. A more recent study by Pedrelli et al. evaluated the number of treatment sessions needed for the picosecond laser compared to the Q-switched laser. They found that the picosecond laser resulted in a 24.8% reduction of treatments compared to the results expected from the Q-switched laser based on the Kirby-Desai Scale ($p<0.0001$). Therefore, the Kirby-Desai scale likely overestimates the number of treatments required to achieve therapeutic maxima for tattoo removal when utilizing the picosecond laser[20]. Future studies should explore whether the Kirby-Desai scale still accurately predicts the number of required treatments when utilizing other novel laser types, such as the picosecond laser, multi-wavelength laser therapy, combination therapy and multi-pass therapy.

Methods to Minimize Dyspigmentation from Laser Tattoo Removal

Hernandez et al (2022) identified hyperpigmentation and hypopigmentation as common adverse side effects from laser tattoo removal, particularly in darker-skinned patients. While they provided extensive advice on the types of lasers, laser wavelengths, and other laser settings, they did not discuss additional measures that can be taken to minimize dyspigmentation. Intraoperative cooling strategies can reduce damage to the epidermis, allow for higher fluences to be applied safely, and offset adverse pigmentary changes in laser therapy. It is particularly useful in darker skin types[21, 22]. An easy, affordable option is the application of cooled hydrogel dressing onto the tattoo immediately before laser treatment. This technique can enhance epidermal protection by directly cooling the skin and having the hydrogel dressing act as a "heat sink" during treatment[23]. Air cooling is also commonly used in laser therapy to protect the epidermal melanin from heat, preventing unwanted hyperpigmentation. It also has an analgesic effect[21, 24]. Efforts have also been made to repigment hypopigmented scars with a combination of fractional resurfacing and subsequent topical bimatoprost and tretinoin or pimecrolimus, with long-lasting effects[25]. In summary, Hernandez et al. (2022) thoroughly explored laser fundamentals in the context of tattoo removal and provided a systematic guide for Dermatologists to utilize. In their future work, the authors may wish to explore further the implications of picosecond lasers with shorter pulse durations, the reproducibility of the Kirby-Desai scale with novel laser types and review additional methodology to minimize dyspigmentation.

Conflict of interest

The authors declare no competing interests.

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