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ORIGINAL ARTICLE

Picosecond Nd:YAG laser for the removal of cosmetic tattoos of the eyebrow: a single-center retrospective review

Laser de picossegundo Nd:YAG para a remoção de tatuagens cosméticas da sobrancelha: uma revisão retrospectiva de um único centro

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Abstract

Objective: To review the efficacy and safety of PS neodymium-doped yttrium aluminum garnet (Nd:YAG) laser for the removal of cosmetic tattoos of the eyebrows. **Method:** This was a retrospective review from January 2022 to August 2023 of patients who underwent cosmetic tattoo removal of the eyebrows with PS Nd:YAG laser. **Results:** A total of 24 patients were included in the review. 70% of patients were rated as "very much improved" (75-100% of the tattoo removed) and 30% of patients were rated "much improved" (50-75% of the tattoo removed). 1064-nm was the 1st wavelength used in all the cases. The average number of sessions required to obtain satisfactory results was 3. Four patients experienced unexpected change in their primary color of the eyebrow tattoos after the 1st treatment, which was successfully treated with 532-nm wavelength. None of the patients experienced dyspigmentation, scarring, or damage/bleaching of hairs of the eyebrows. **Conclusion:** PS Nd:YAG garnet laser is an effective and safe treatment for the removal of cosmetic tattoos of the eyebrows.

Keywords: Cosmetic. Eyebrow. Picosecond NdYAG laser. Tattoo.

Resumo

Objetivo: Revisar a eficácia e segurança do laser de picossegundo de neodímio dopado com ítrio, alumínio e granada (Nd:YAG) para a remoção de tatuagens cosméticas das sobrancelhas. **Métodos:** Esta foi uma revisão retrospectiva de janeiro de 2022 a agosto de 2023 de pacientes que se submeteram à remoção de tatuagens cosméticas das sobrancelhas com o laser de picossegundo Nd:YAG. **Resultado:** Um total de 24 pacientes foram incluídos na revisão. 70% dos pacientes foram classificados como "muito melhorados" (75-100% da tatuagem removida) e 30% foram classificados como "melhorados" (50-75% da tatuagem removida). O comprimento de onda de 1064 nm foi o primeiro utilizado em todos os casos. O número médio de sessões necessárias para obter resultados satisfatórios foi 3. Quatro pacientes tiveram uma mudança inesperada na cor principal das tatuagens das sobrancelhas após o primeiro tratamento, que foi tratada com sucesso com o comprimento de onda de 532 nm. Nenhum dos pacientes apresentou despigmentação, cicatrizes ou danos/descoloração dos pelos das sobrancelhas. **Conclusão:** O laser de picossegundo Nd:YAG é um tratamento eficaz e seguro para a remoção de tatuagens cosméticas das sobrancelhas.

Palavras-chave: Cosmético. Sobrancelha. Laser de picossegundo NdYAG. Tatuagem.

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Introduction

Over the past few years, cosmetic tattoos, i.e., permanent makeup, have become increasingly popular throughout the world. It includes lip liner and lip color, eyeliner, hairline tattooing, areola tattooing, and eyebrow tattooing. With increased eyebrow tattooing, there is also rise in the number of patients seeking treatment to remove it safely[1]. Being a mixture of unknown pigments, which are not standardized and blended and layered by the tattoo artist, cosmetic tattoos become challenging task to treat. While dealing with such cases, it is very important to avoid side effects such as pigmentary alterations, scarring, paradoxical tattoo ink darkening, and hair bleaching or damage[1]. Before the discovery of nanosecond Q-switched lasers (QS), carbon dioxide (CO_2) and erbium-doped yttrium aluminum garnet lasers were used to ablate and thus remove the tattoo-containing dermis, but it used to cause scarring and dyspigmentation[2]. QS laser requires multiple treatment sessions and there is a higher risk of dyspigmentation, especially in darker skin type due to absorption of laser by melanin[3]. The picosecond (PS) lasers produce shorter pulse durations of 10^{-12} s resulting a greater photoacoustic effect which enable PS laser to reach the smallest tattoo particles resulting in more rapid and effective clearance. Furthermore, it affords to use lower fluences compared to nanosecond laser, thus protecting against inflammation and dyspigmentation. This specific feature also plays an important role, especially when treating cosmetically sensitive areas, such as eyebrows, where hairs may become damaged due to thermal injury[4]. Thus, PS lasers have emerged as an effective and safer treatment option for treating esthetically important areas. With this retrospective review, we aim to evaluate the efficacy and safety of PS neodymium-doped yttrium aluminum garnet (Nd:YAG) laser in the cosmetic tattoos of the eyebrows only.

Material and methods

We performed a retrospective review at a single cosmetic dermatology clinic from January 2022 to August 2023 of the patients, who underwent cosmetic tattoo removal of the eyebrows only. The patients who underwent at least 1 laser treatment session for eyebrow tattoos and returned for follow-up after the last treatment and with adequate photographic and medical record documentation were included in the study. Those with incomplete follow-up and photographic documentation and incomplete medical record were excluded from the study. Twenty-four patients met the inclusion criteria and thus were included in the study. The tattoo colors noted were black, gray, brown, and dark brown. All the tattoos were treated with a PS Nd:YAG laser (PicoWay; Candela, Wayland, MA) (Table 1). For the black, gray, and brown and dark brown tattoos, a 1064-nm wavelength was used with 3-5 mm spot size and 1.5-3.4 J/cm^2 fluence. In four cases, we used the 532-nm wavelength with 2-4 mm spot size and fluence of 0.75-1.8 J/cm^2 for orange tattoos. The efficacy and safety of PS laser was determined by two dermatologists by evaluating before-and-after photographs and medical record of each patient. Global Esthetic Improvement Scale was used to assess the clearance of tattoo were completed based on photography. Adverse events and complications were assessed through the review of medical record and photographs.

Results

In this study, 24 patients were included (all female, age range: 26-56 years, fitzpatrick skin types ranged from II-V). As the initial color of tattoos in all the patients were black, gray or brown, they were treated with the 1,064-nm Nd:YAG PS laser initially. In 4 patients (16.66%), the initial tattoo color, i.e., brownish black, changed to orange after the 1st session with 1064 nm; thus, on subsequent follow-up, it was treated with the 532-nm PS laser (range-from 1 to 4 sessions). The average number of sessions to achieve satisfactory results was 3 (range- from 2 to 6 sessions). Most of the patients (n = 8, 33.33%) achieved complete clearance of tattoos with 3 treatment sessions. Regarding patient satisfaction, 75% (n = 18) of patients were rated as "very much improved" on the Physician Global Esthetic Improvement Scale with 76-100% of the tattoo removed (Figs. 1 and 2). 25% (n = 6) of subjects were rated "much improved" with 51-75% of the tattoo clearance.

Regarding adverse events, all patients experienced immediate, transient erythema and edema of the treated area and 3 patients developed bruises near eyebrow, all of it resolved without any sequelae. Two patients (eyebrow color black) experienced hives with pruritus near eyebrows and at distant areas, few hours following the 1st treatment session and it resolved with oral antihistamines in 2 days. Interestingly, none of the patients experienced scarring, dyspigmentation, or hair bleaching or hair damage of the treated sites.

Discussion

Although QS nanosecond laser and ablative laser show efficacy in treating cosmetic eyebrow tattoos, multiple sessions are needed. Furthermore, there are undesirable side effects such as dyspigmentation, incomplete

Table 1. Parameters used for the eyebrow tattoo removal

Wavelength of picosecond Nd:YAG laser	Number of patients	Parameters used	No. of sessions = No. of patients	Note
1064 nm	24	Beam spot diameter: 3-5 mm Fluence: 1.5-3.4 J/cm^2	1 = 1 2 = 5 3 = 8 4 = 4 5 = 2 6 = 2	4 patients developed orange discoloration of tattoo 2 patients developed urticaria
532 nm	4	Beam spot diameter: 3-5 mm Fluence: 0.75-1.8 J/cm^2	1 = 1 2 = 2 3 = 1 4 = 1	

Figure 1. Black eyebrow tattoo before treatment (top) and after 3 treatments with the 1,064-nm PS laser neodymium-doped yttrium aluminum garnet laser (bottom).

Figure 2. Brownish-black eyebrow tattoo before the first treatment (left side), red-orange discoloration immediately after the 1st treatment with the 1,064-nm PS laser neodymium-doped yttrium aluminum garnet laser (right side).

clearance leading to residual tattoo, paradoxical darkening, hair bleaching, hair damage, and scarring[5]. PS lasers are more effective in clearing tattoos than QS lasers. This is due to its low pulse duration, which is less than the thermal relaxation time of the commonly used black ink in tattoos, as thermal relaxation time of carbon black in India ink is < 10 ns. PS laser pulses spare surrounding epidermis, as heat generated with pulses confined to the ink particles without significant thermal diffusion, thus making it a safer choice in darker skin types. Less number of sessions, optimum results, and good safety profile are the other benefits of PS lasers[6].

There are few studies on the treatment of cosmetic eyebrow and/or eyeliner tattoos using ablative and QS Nd:YAG lasers, whereas studies involving PS laser are scarce in literature (Table 2). Zhang et al.[12] retrospectively compared alexandrite PS laser and Nd:YAG nanosecond laser in Chinese population and found no statistically significant difference between the both lasers for removing eyeliner tattoos which were > 10 years. Moustafa et al.[15] found effective and safe clearance of brown and black ink eyebrow tattoos in four patients (3 of them were skin type IV) with the use of 532- and 1,064-nm wavelength of the PS Nd:YAG laser; however, the authors used the perfluorodecalin-infused patch during the treatment. In a retrospective review of 32 patients by Hartman et al.[16], the authors documented excellent to good response in the removal of the eyebrow cosmetic tattoos using PS 532- and 1,064-nm Nd:YAG laser after an average of only 3 treatment

Table 2. Studies involving cosmetic eyebrow tattoo removal by lasers

Study, year	No. of patients	Color of the eyebrow/ eyeliner tattoo	Laser/wavelength	No. of sessions	Results
Watts et al., 1992[7]	6	Black	QS Nd:YAG 1064 nm	2-10	Incomplete response
Fitzpatrick et al., 1994[8]	10		CO_2+30% TCA	1-2	Complete clearance
Jimenez et al., 2002[9]	1	Multicolor	QS Nd:YAG 1064 nm QS Nd:YAG 532 nm QS ruby 694 nm	1 6 5	Significant but incomplete resolution
Lee et al., 2009[10]	1	Red and brown	QS Nd:YAG 1064 nm	5	Complete clearance
Radmanesh et al., 2014[11]	20	Black and brown	Right eyebrow: CO_2, QS Nd:YAG 1064 nm QS Nd:YAG 532 nm Left eyebrow: QS Nd:YAG 1064 nm QS Nd:YAG 532 nm	1 treatment 1 treatment	75-100% improvement in 6 of 20 patients > 50% improvement in 3 of 20 patients 75-100% improvement in 1 of 20 patients > 50% improvement in 6 of 20 patients
Zhang et al., 2018[12]	72	Blue and black	755-nm alexandrite PS laser QS Nd:YAG 1064 nm	1-4 1-4	After 1 session: Excellent improvement: 25% Good improvement: 50% Excellent improvement: 12.5% Good improvement: 65.6%
McIlwee and Alster, 2018[13]	2	Blue, black, green	CO_2	1	Complete clearance
Cannarozzo et al., 2019[14]	10	Black, gray, dark pink	QS Nd:YAG 1064 nm, QS Nd:YAG 532 nm Resistant tattoos: CO_2 Fractional laser before QS Nd:YAG 1064 nm	2-10	Complete clearance
Moustafa et al., 2020[15]	4	Black and brown	QS Nd:YAG 1064 nm QS Nd:YAG 532 nm	1-4	75% clearance - 2 patients 90% clearance - 1 patient 100% clearance - 1 patient
Hartman et al., 2023[16]	32	Black and brown	PS Nd:YAG 1064 nm, PS Nd:YAG 532 nm Few cases: CO_2 Fractional laser after PS laser	1-11	On PGAIS scale Very much improved: 66% Much improved: 34%
Menozzi-Smarrito and Smarrito, 2023[17]	70	Black, red, orange, yellow	PS 755 nm and QS Nd:YAG 532 nm	1-8	Complete clearance

TCA: trichloroacetic acid; PGAIS: Physician Global Esthetic Improvement Scale.

sessions. In 2 cases, they used the CO_2 laser for faster pigment clearance, and in 1 case, 2 treatments with a CO_2 laser were performed for the removal of a yellow pigment from the persistent tattoo ink. Recently, Menozzi-Smarrito and Smarrito et al.[17], in a study of 70 patients, found complete clearance of complex eyebrow tattoos with an average of 3 laser sessions; however, for visible warm pigments (red, orange, and yellow), the number of sessions was significantly higher. In our study, we also noted complete clearance of the tattoos with an average of 3 sessions with the use of PS Nd:YAG laser. Although paradoxical darkening is observed with PS lasers, it is believed to be less common than with QS lasers. In our study, 4 patients experienced immediate orange-red discoloration after laser shots. However, with 532 PS Nd:YAG laser in 1-4 sessions, complete clearance was noted. The ability to remove specific colors has been reported to be mainly due to the specific wavelength. 532-nm wavelength is highly absorbed by orange and red color than the 1064-nm wavelength[5]. Cosmetic tattoo inks

may include mineral iron oxides (red, yellow, and black pigments) that induce color change. Titanium dioxide and ferric oxide, present in the ink particle, undergo a reduction reaction (Ti41 → Ti31 [dark violet] and Fe31 → Fe21 [black]) resulting paradoxical darkening due to high-energy, short-pulse duration of PS lasers[16]. Interestingly, our 2 patients experienced delayed hypersensitivity reactions manifesting urticarial hives that occurred near eyebrows and at a distant, untreated tattoo site, which is yet to be reported with removal of cosmetic tattoos of the eyebrow. This urticarial reaction may have resulted from an immunologic response to the ink particles, especially titanium dioxide[18].

After PS laser therapy immediate whitening i.e., cavitation bubbles occur due to the rapid heating of tattoo particles by the laser. These steam bubbles in the epidermis and dermis hinder laser-tattoo interaction; hence, multiple laser shots become ineffective. To overcome this phenomenon, perfluorodecalin-infused patches (PFDs), acoustic shock wave therapies, and R20 method (4 laser passes with a 20 min gap between each pass in a single session) have been used[15,16]. PFD patch acts as an optical clearing agent (due to similar index of refraction as that of human epidermal tissue), reducing scatter, allowing more photons to penetrate to a greater depth, and interacting with deeply residing ink particles enhancing clinical outcomes. PFD patches also provide thermal protection of the epidermis by reducing local fluence near the skin's surface[19].

The shortcomings of our study are small sample size, noncontrolled, and retrospective nature and short-term follow-up. The results might be skewed due to the retrospective nature of the study and due to variations in the parameters, especially fluence, chosen for each patient and variable number of treatments session.

Conclusion

This retrospective study has shown that the PS Nd:YAG laser was effective and safe in complete clearance of cosmetic tattoos of the eyebrows without causing scarring, dyspigmentation, and damaging hairs. Brownish black color eyebrow tattoos were prone to paradoxical darkening and changing to orange color; however, with 532-nm Nd:YAG PS laser, it was removed completely.

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Conflicts of interest

None.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that no patient data appear in this article. Furthermore, they have acknowledged and followed the recommendations as per the SAGER guidelines depending on the type and nature of the study.

Right to privacy and informed consent. The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author is in possession of this document.

Use of artificial intelligence for generating text. The authors declare that they have not used any type of generative artificial intelligence for the writing of this manuscript, nor for the creation of images, graphics, tables, or their corresponding captions.

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