Clearance of Yellow Tattoo Ink With a Novel 532-nm Picosecond Laser

Hamad Alabdulrazzaq, MBChB,[1]* Jeremy A. Brauer, MD,[1,2] Yoon-Soo Bae, MD,[1] and Roy G. Geronemus, MD,[1,2]
[1]*Laser & Skin Surgery Center of New York, New York, New York 10016*
[2]*Ronald O. Perelman Department of Dermatology, NYU Langone Medical Center, New York, New York 10016*

Background and Objectives: Although technology and tattoo removal methods continue to evolve, yellow pigment clearance continues to be challenging and usually unsuccessful. We describe a case series of six tattoos containing yellow ink, successfully treated with a frequency-doubled Nd:YAG 532-nm picosecond laser.
Study Design/Materials and Methods: Case series with six subjects participating for the treatment of multicolored tattoos that contain yellow pigment. Treatments performed with a frequency-doubled Nd:YAG 532-nm picosecond laser at 6–8 week intervals.
Results: One subject achieved complete clearance of the treated site after one session, and five subjects required 2–4 treatments to achieve over 75% clearance. Minimal downtime was experienced, and no scarring or textural skin changes were observed in any of the treated sites.
Conclusions: This is the first case series that demonstrates effective and consistent reduction of yellow tattoo ink using a frequency doubled Nd:YAG 532-nm laser with a picosecond pulse duration. Treatments were well tolerated and subjects had positive outcomes. This is a small observational case series from an ongoing clinical trial, and studies with a larger sample size and comparative group are needed in the future. Lasers Surg. Med. 47:285–288, 2015. © 2015 Wiley Periodicals, Inc.

Key words: frequency doubled; Nd:YAG; pigment; skin

INTRODUCTION

Tattoo removal procedures continue to improve, with the introduction of both newer technologies and innovative treatment methods. For example, in just one treatment session, the 755-nm alexandrite picosecond laser, with its shorter pulse duration, has been shown to achieve greater than 75% clearance of blue and green tattoo pigment [1,2]. Treatment methods which achieve effective tattoo removal in fewer sessions continue to be developed, including the R20 method, and the R0 method with perfluorodecalin [3,4].

Despite these advances, tattoo removal still remains challenging. Treatment efficacy is strongly influenced by both ink characteristics (e.g., tattoo age and size, ink type and density, body site) and patient characteristics (e.g., smoking status) [5]. Kirby and Desai described a scale which estimates the number of sessions required to clear any given tattoo [6]. However, complete removal can never be guaranteed and residual pigment often remains after multiple sessions.

Tattoo color is one of the main predictors of clearance, and with the introduction of the alexandrite picosecond laser [1,2], blue and green pigments can now be effectively cleared with few treatments. On the other hand, there is no established and definitive treatment for yellow pigments, as the dye is not well absorbed by the current available wavelengths. Yellow dyes are typically made of cadmium sulfide, ochre, Pigment Yellow 74, chrome yellow, or curcuma yellow, and are currently treated with the Q-switched frequency doubled Nd:YAG laser with a nanosecond pulse duration, but clearance remains difficult and inconsistent. A study by Ferguson on treating multicolored tattoos with an Nd:YAG Q-switched device with a nanosecond pulse width, demonstrated an improvement of 2out 8 tattoos that contained yellow pigment, emphasizing the difficulty in clearing yellow ink. Respectively, 6 and 9 treatments were required to obtain pigment reduction, though no clearance percentages were documented [7].

We present a small case series with a unique finding from an ongoing clinical trial for the removal of tattoos using a novel picosecond frequency doubled 532-nm Nd:YAG laser (Cynosure, Westford, MA).

Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest and none were reported
Author Contributions: Dr(s) Alabdulrazzaq, Bae, Brauer and Geronemus had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design*: Dr(s) Brauer and Geronemus. *Acquisition of data*: Dr(s) Alabdulrazzaq, Bae, Brauer and Geronemus. Drafting of the manuscript: Dr(s) Alabdulrazzaq. Critical revision of the manuscript for important intellectual content: Dr(s) Bae, Brauer, and Geronemus. Study supervision: Dr(s) Geronemus.
Contract grant sponsor: Cynosure.
*Correspondence to: Hamad AlAbdulrazzaq, MBChB, Laser & Skin Surgery Center of New York, 317 East 34th Street, New York, NY 10016. E-mail: hamad.razzaq@gmail.com
Accepted 24 February 2015
Published online 15 April 2015 in Wiley Online Library (wileyonlinelibrary.com).
DOI 10.1002/lsm.22354

MATERIALS AND METHODS

Subjects with multicolored, professional, previously untreated tattoos were enrolled and treated with a frequency doubled Nd:YAG 532-nm picosecond laser (Cynosure). Subjects were recruited from patients presenting to the Laser & Skin Surgery Center of New York seeking tattoo removal. The study received approval from the New England Institutional Review Board, and written informed consent was obtained from all enrolled subjects.

Included were male and female subjects, ages 18–65 years, with an unwanted, previously untreated tattoos. Excluded were subjects with a history of keloids, poor wound healing, immunosuppression, and use of isotretinoin in the past 6 months. Pregnant or breastfeeding women were also excluded from the study.

We used a frequency doubled Nd:YAG 532-nm laser with a pulse duration ranging from 450 to 500 picoseconds, repetition rate of 5 Hz, spot size range of 2.5–3.3 mm, and fluence range of 1.1–1.4 J/cm^2. All tattoos were treated with a single pass, with subsequent sessions scheduled at 6–8 week intervals. Subjects would receive up to 10 treatments, with a final follow up to be done 2 months after the final session.

Anesthesia was achieved with either injectable 1% lidocaine with 1:100,000 epinephrine or topical lidocaine/prilocaine (EMLA® AstraZeneca). Appropriate protective eyewear was used by all subjects and medical staff during treatment sessions. Subjects were provided with wound care instructions, and tattoos were covered with Aquaphor®, non-adhesive dressing and tape after treatment completion.

Photography was obtained under standardized conditions using a Canon Rebel EOS T2i camera and image overlay software, at baseline and prior to each treatment. Photographs were taken in the same room with consistent lighting and with similar distance and angle. Anticipated and any adverse events were recorded with each visit, and pain assessments were obtained using a verbal numerical grading scale (0 = no pain, 10 = extreme pain). Clearance rates were recorded by the treating physician, using a quartile point system (<25%, 25–49%, 50–74%, >75%). In addition, three dermatologists involved in the study, individually reviewed non-randomized baseline and subsequent pre treatment pictures, and recorded their clearance scores.

RESULTS

We describe the findings of six subjects with multicolored tattoos that contain yellow pigment. The average age was 36 years (range: 25–44 years), three males and three females participated, three with Fitzpatrick skin type II and three with skin type III. The average subject tattoo size was 197 cm^2 (range 27–324 cm^2), and the median tattoo age was 13 years (range 7 weeks to 20 years).

One subject achieved complete clearance of the yellow pigment after the first treatment, and five of the subjects required between 2 and 4 treatments to achieve over 75% clearance of the yellow ink (Table 1). Anticipated events were mild to moderate in severity and included edema, erythema, pain, and crust formation. Blister formation was reported by three of the subjects, and transient hypopigmentation was noted in one subject. Of significance, no scarring or skin textural changes were seen on follow up. All of the subjects required anesthesia with an average pain score of 1.3/10 (range 0–6/10). One subject elected to use topical anesthesia, reporting a maximum pain score of 6/10 during treatment.

DISCUSSION

To our knowledge, this is the first case series to demonstrate effective and consistent reduction of yellow tattoo pigment. This is also the first report that demonstrates the efficacy of the frequency doubled picosecond laser in tattoo removal. Significant pigment reduction was

TABLE 1. Summary of Subject Demographics and Findings

Subject	Tattoo size (cm^2)	Sex	Age	# Treatments	Fitzpatrick skin type	Spot size (mm)	Energy density range (J/cm^2)	Yellow ink clearance	Observed events	Tattoo age
1	122	F	32	5	2	2.5–3.3	1.1–1.4	Near Clearance	Edema, erythema, crust, pain	17 yrs
2	120	M	34	5	3	2.5–3.3	1.1–1.4	Near Clearance	Erythema, edema, crust, pain, blistering	17 yrs
3	200	F	42	2	3	2.8–3	1.1–1.4	>75%	Edema, erythema, crust, pain, blistering	20 yrs
4	248	M	44	4	3	2.8–3	1.2–1.4	Near Clearance	Edema, erythema, crust, blistering, pain, hypopigmentation	7 weeks
5	324	M	25	3	2	2.8–3.3	1.1–1.4	>75%	Edema, erythema, crust, blistering, pain, itching	10 yrs
6	168	F	37	1	2	2.6	1.3	Cleared	Erythema, edema	15 yrs

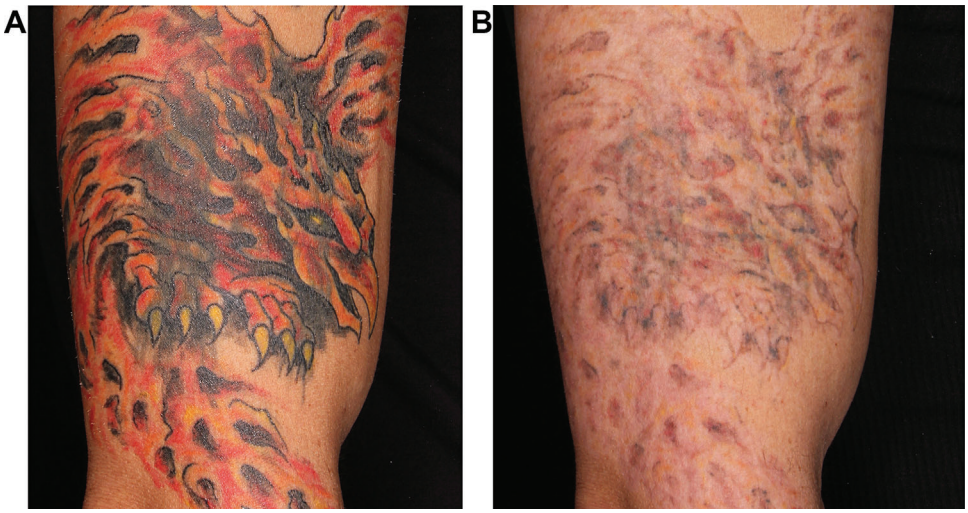

Fig. 1. (**A**) Tattoo from subject four at baseline. (**B**) Significance reduction noted after the 3rd treatment.

seen with few treatments, with complete clearance seen in one subject after a single treatment. The device was shown to have a good safety profile with minimal downtime, with the treatments being well tolerated by all subjects.

Tattoo ink particles are disrupted and broken up by the photomechanical and photothermal effects of laser energy, and it has been theorized that the optimal pulse width is within the picosecond range, allowing for a safer and more efficient procedure [8]. The recent addition of the alexandrite picosecond laser has shown great promise in rapid effective removal of blue and green inks [1,2]. The exact mechanism of yellow pigment destruction remains unclear as no laser wavelength is available that directly targets the yellow chromophore, suggesting yellow pigment maybe more susceptible to the photomechanical effect. In vitro studies have demonstrated that the peak absorption wavelengths of yellow tattoo inks are below those of the currently available Q-switched devices, measuring at 440 nm and 470–485 nm [9,10].

Red pigments have successfully been treated with the Q-switched frequency doubled Nd:YAG laser, and black inks have been cleared with multiple wavelengths including the Q-switched 1064-nm Nd:YAG, 755-nm Alexandrite, and 694-nm Ruby laser. However numerous treatments are required and there is great variation in clearance rates depending on various device, patient, and tattoo characteristics, as previously described. Clearance of yellow tattoo inks in particular has been extremely difficult, and our case series has shown the frequency doubled Nd:YAG 532-nm picosecond laser to be consistently effective in the reduction of yellow pigment in all subjects treated, regardless of the tattoo size or age, with the tattoo age in our series ranging from 7 weeks to 20 years. The tattoo in subject four (Fig. 1) consisted of two

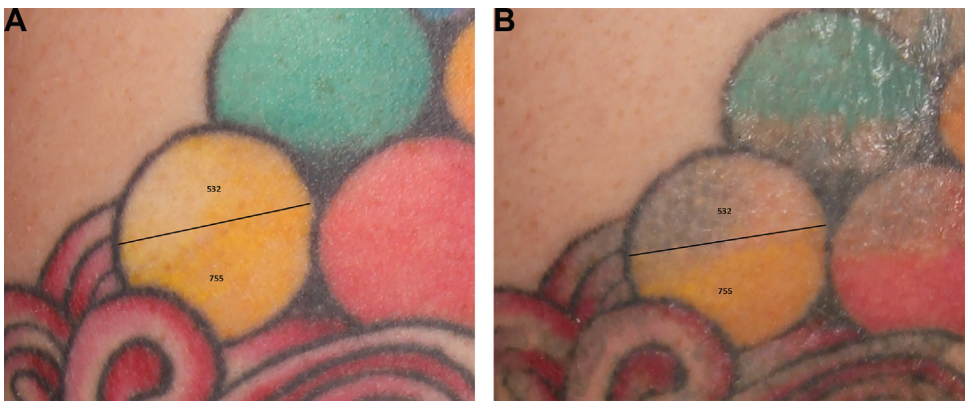

Fig. 2. (**A**) Tattoo from subject six at baseline. The top half of the yellow circle was treated with the 532-nm wavelength, while the lower half was treated with the 755-nm picosecond laser. (**B**) Clearance of yellow pigment after one treatment. The upper left quadrant containing white pigment developed paradoxical darkening.

components. An older central part with black ink done over 20 years ago, and a second cover up multicolored tattoo that contained yellow was done 7 weeks prior to initiating treatment in this study. Significant improvement was noted after three treatment sessions, with up to 75% clearance of the yellow pigment achieved.

The tattoo in subject six (Fig. 2) was subdivided and treated with both the frequency doubled Nd:YAG and Alexandrite picosecond lasers. The segment treated with the 532-nm wavelength achieved complete clearance after one treatment. While no immediate whitening reaction or pigment clearance was seen in the segment treated with the 755-nm wavelength.

To conclude, we recognize this is a case series with a small sample size, and with the ongoing advancement of the current technology and introduction of different treatment techniques, active controlled studies are warranted. However, we have demonstrated favorable outcomes with effective and consistent reduction of yellow tattoo pigment using the frequency doubled picosecond laser, with complete clearance seen after one treatment. The treatments with the developing picosecond technology at 532-nm appears to be safe and well tolerated, and appears to extend the benefits of picosecond technology to the removal of yellow ink color.

ACKNOWLEDGMENT

We are indebted to the Research Department at the Laser & Skin Surgery Center of New York.

REFERENCES

1. Brauer JA, Reddy KK, Anolik R, Weiss ET, Karen JK, Hale EK, Brightman LA, Bernstein L, Geronemus RG. Successful and rapid treatment of blue and green tattoo pigment with a novel picosecond laser. Arch Dermatol 2012;148(7):820–823.
2. Saedi N, Metelitsa A, Petrell K, Arndt KA, Dover JS. Treatment of tattoos with a picosecond alexandrite laser: A prospective trial. Arch Dermatol 2012;148(12):1360–1363.
3. Kossida T, Rigopoulos D, Katsambas A, Anderson RR. Optimal tattoo removal in a single laser session based on the method of repeated exposures. J Am Acad Dermatol 2012;66(2):271–277.
4. Reddy KK, Brauer JA, Anolik R, Bernstein L, Brightman L, Hale E, Karen J, Weiss E, Geronemus RG. Topical perfluorodecalin resolves immediate whitening reactions and allows rapid effective multiple pass treatment of tattoos. Lasers Surg Med 2013;45(2):76–80.
5. Bencini PL, Cazzaniga S, Tourlaki A, Galimberti MG, Naldi L. Removal of tattoos by q-switched laser: variables influencing outcome and sequelae in a large cohort of treated patients. Arch Dermatol 2012;148(12):1364–1369.
6. Kirby W, Chen CL, Desai A, Desai T. Causes and recommendations for unanticipated ink retention following tattoo removal treatment. J Clin Aesthet Dermatol 2013;6(7):27–31.
7. Ferguson JE, August PJ. Evaluation of the Nd/YAG laser for the treatment of amateur and professional tattoos. Br J Dermatol 1996;135(4):586–591.
8. Ho DD, London R, Zimmerman GB, Young DA. Laser-tattoo removal-a study of the mechanism and the optimal treatment strategy via computer simulations. Lasers Surg Med 2002;30-(5):389–397.
9. Gómez C, Martin V, Sastre R, Costela Á, Garća-Moreno I. In vitro and in vivo laser treatments of tattoos: High efficiency and low fluences. Arch Dermatol 2010;146(1):39–45.
10. Beute TC, Miller CH, Timko AL, Ross EV. In vitro spectral analysis of tattoo pigments. Dermatol Surg 2008;34(4):508–515. discussion 515–6.