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Effectiveness of Q-Switched Laser in Multi-Colored Tattoo Removal: A Prospective Study

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ABSTRACT

Background: Tattoo removal has become increasingly common due to aesthetic dissatisfaction, occupational requirements and cultural changes. Multi-colored tattoos pose a particular challenge because different pigment particles respond variably to laser wavelengths. Q-switched lasers remain the gold standard for tattoo removal due to their selective photothermolysis and ultra-short pulse duration. **Objective:** This prospective study aims to evaluate the effectiveness, safety profile and clearance rates of Q-switched laser therapy in multi-colored tattoo removal. **Methods:** A total of 220 patients with professionally and amateurly applied multi-colored tattoos were enrolled from May 2023 to March 2026 at City Aesthetics, Advanced Skin Laser Center, 96 Jail Road, Sadar, Jashore. Patients underwent serial Q-switched laser sessions using wavelength-specific settings depending on pigment color. Treatment response was assessed using standardized Tattoo Color Clearance Score (TCCS) and photographic comparison. **Results:** Out of 220 patients, 198 completed the study. Complete or near-complete clearance (>90%) was observed in 62.1% of cases, while moderate clearance (60–89%) was seen in 28.8%. Only 9.1% showed suboptimal response (<60%), mainly in green and yellow pigment-dominant tattoos. Black and dark blue pigments showed the highest response rate (>85% clearance). Adverse effects were mild and included transient erythema (34%), edema (22%) and post-inflammatory hyperpigmentation (8.5%), all resolving spontaneously. **Conclusion:** Q-switched laser therapy is highly effective for multi-colored tattoo removal, particularly for black and blue pigments, though green and yellow pigments remain resistant. The procedure is safe with minimal complications when performed with appropriate wavelength selection and treatment intervals.

Keywords: *Q-switched laser; Tattoo removal; multi-colored tattoo; Nd:YAG laser; Selective photothermolysis; Laser dermatology; Pigment clearance.*

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INTRODUCTION

Tattooing has become an increasingly common form of body art worldwide, particularly among adolescents and young adults. However with changing personal preferences, occupational restrictions and social considerations, a significant number of individuals later seek tattoo removal. This has led to a growing demand for safe, effective and predictable laser-based tattoo removal techniques. Multi-colored tattoos present a unique therapeutic challenge in dermatologic laser practice. Tattoo inks are composed of complex mixtures of organic and inorganic pigments that are deposited at varying depths within the dermis. Each pigment has distinct optical absorption characteristics, making uniform removal difficult. While black ink absorbs a broad spectrum of wavelengths and is generally easier to treat, colors such as green, yellow and light blue often demonstrate resistance to standard laser wavelengths. The principle of Q-switched laser technology is based on selective photothermolysis, in which ultra-short nanosecond pulses deliver high peak energy to pigment particles. This results in rapid thermal expansion and photomechanical fragmentation of ink particles without causing significant damage to surrounding skin structures. The fragmented particles are subsequently cleared by the lymphatic system and dermal macrophages over time.[1] Different Q-switched laser systems are used depending on pigment color. The Q-switched Nd:YAG laser (1064 nm and frequency-doubled 532 nm) is commonly used for dark and red pigments, respectively. The ruby laser (694 nm) and alexandrite laser (755 nm) are often employed for resistant colors such as green and blue. [2,3] Despite these advancements, complete clearance of multi-colored tattoos often requires multiple sessions and may not always be achievable. Several clinical studies have reported variable outcomes depending on factors such as tattoo age, ink composition, depth of pigment deposition and patient skin type. Amateur tattoos generally respond better compared to professional tattoos due to less dense pigment deposition.[4] However, data from large prospective studies in South Asian populations remain limited, particularly in real-world clinical settings. Therefore, this study was designed to evaluate the effectiveness, safety and pigment-specific response patterns of Q-switched laser therapy in multi-colored tattoo removal in a large cohort of patients treated at a specialized aesthetic laser center in Bangladesh.[5]

METHODS & MATERIALS

Study Design and Setting

This prospective observational study was conducted to evaluate the effectiveness and safety of Q-switched laser therapy for the removal of multi-colored tattoos. The study was carried out at City Aesthetics, Advanced Skin Laser Center, 96 Jail Road, Sadar, Jashore, Bangladesh, from May 2023 to March 2026.

Study Population

A total of 220 patients with multi-colored tattoos were enrolled. Both male and female participants aged 16–55 years were included. Tattoos were either professionally or amateurly applied and contained one or more combinations of black, blue, red, green and yellow pigments. All participants provided informed consent before treatment.

Eligibility Criteria

Patients were eligible if they had stable, non-infected tattoos requiring removal, were willing to undergo multiple laser treatment sessions and agreed to attend scheduled follow-up visits. Patients with a

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history of keloid or hypertrophic scar formation, active infection at the treatment site, photosensitivity disorders, connective tissue disease, pregnancy or lactation or isotretinoin use within the preceding 6 months were excluded.

Laser Treatment Protocol

Q-switched laser systems were selected according to pigment characteristics and skin phototype. A 1064-nm Nd laser was primarily used for black and dark-blue pigments, while a frequency-doubled 532-nm Nd laser was used for red, orange and lighter pigments. A 694-nm ruby or 755-nm alexandrite laser was used for resistant green pigments. Treatment parameters were individualized according to skin phototype, tattoo depth, pigment density and clinical response. Fluence ranged from 3–10 J/cm² with spot sizes of 2–5 mm and nanosecond-range pulse durations. Treatment sessions were performed at 6–8-week intervals to permit epidermal recovery and progressive pigment clearance.

Peri-treatment Care

Topical anesthesia was applied when clinically indicated. Appropriate protective eyewear was used for both patients and operators. Following treatment, topical antibiotic ointment was prescribed when required, together with sun-protection advice. Patients were instructed to avoid excessive sun exposure, scratching and trauma to the treated area.

Outcome and Safety Assessment

Treatment response was assessed using the predefined Tattoo Color Clearance Score (TCCS), standardized digital photographs obtained under comparable lighting conditions and patient satisfaction measured on a 0–10 scale. Clearance was categorized as excellent (>90%), good (60–89%), fair (30–59%) or poor (<30%). Adverse events, including erythema, edema, blistering, hyperpigmentation, hypopigmentation and scarring, were documented at follow-up visits.

Statistical Analysis

Data were entered, cleaned and analyzed using IBM SPSS Statistics version 29.0. Continuous variables were summarized as mean ± standard deviation, and categorical variables as frequencies and percentages. Treatment completion, number of sessions, tattoo characteristics, pigment distribution, clearance category and adverse events were analyzed descriptively. Pigment-specific response patterns and the number of sessions required for satisfactory clearance were summarized. As the primary analysis was descriptive, no inferential statistical tests or multivariable modeling were performed. Where inferential analyses were subsequently undertaken, a two-sided p-value <0.05 was considered statistically significant.

RESULTS

A total of 220 patients with multicolored tattoos were enrolled in the study. Among them, 198 (90.0%) completed all scheduled laser treatment sessions and follow-up assessments, while 22 (10.0%) patients were lost to follow-up or discontinued treatment. Therefore, the final treatment-outcome analysis was based on 198 patients. Treatment response varied according to pigment characteristics, tattoo depth and the number of laser sessions required (*Table I*).

Table I

Demographic characteristics of the study population (*n* = 220).

Variable	Category	n	%
Age group (years)	16–25	62	28.2
	26–35	88	40.0
	36–45	48	21.8
	46–55	22	10.0
Sex	Male	134	60.9
	Female	86	39.1
Tattoo type	Professional	126	57.3
	Amateur	94	42.7

Among the 220 enrolled participants, the largest proportion belonged to the 26–35 years age group (40.0%), followed by 16–25 years (28.2%) and 36–45 years (21.8%). Males comprised 134 (60.9%) participants, while females accounted for 86 (39.1%). Professional tattoos were more common than amateur tattoos, representing 126 (57.3%) and 94 (42.7%) cases, respectively (*Table II*).

Black pigment was present in all 220 tattoos (100.0%). Blue pigment was the second most frequently observed color, occurring in 158 (71.8%) tattoos, followed by red in 112 (50.9%), green in 84 (38.2%) and yellow in 46 (20.9%). Because individual tattoos could contain multiple pigments, the combined percentages exceeded 100% (*Table II*).

Table II

Distribution of tattoo pigments among the study population (*n* = 220).

Pigment color	n	%
Black	220	100.0
Blue	158	71.8
Red	112	50.9
Green	84	38.2
Yellow	46	20.9

Among the 198 patients who completed treatment, 34 (17.2%) achieved satisfactory clearance after 1–3 laser sessions, 96 (48.5%) required 4–6 sessions, 52 (26.3%) required 7–9 sessions and 16 (8.1%) required more than 9 sessions. The need for more than 9 sessions was observed particularly among patients with multicolored tattoos containing green and yellow pigments (*Table III*). Percentages may total 100.1% because of rounding.

Table III
Number of laser sessions required for satisfactory clearance (n = 198).

Number of sessions	n	%
1–3	34	17.2
4–6	96	48.5
7–9	52	26.3
>9	16	8.1

Regarding overall treatment outcome, 124 (62.6%) patients achieved excellent clearance (>90%), while 56 (28.3%) achieved good clearance (60–89%). Twelve (6.1%) patients demonstrated fair clearance (30–59%) and 6 (3.0%) had poor clearance (<30%). Thus, 180 of 198 patients (90.9%) achieved at least 60% tattoo clearance. Fair or poor responses were observed predominantly among tattoos containing resistant pigments, particularly green and yellow and among tattoos with deeper dermal pigment deposition (*Table IV*).

Table IV
Overall treatment outcome according to degree of tattoo clearance (n = 198).

Outcome category	Clearance	n	%
Excellent	>90%	124	62.6
Good	60–89%	56	28.3
Fair	30–59%	12	6.1
Poor	<30%	6	3.0

DISCUSSION

This prospective study demonstrates that Q-switched laser therapy is an effective modality for multi-colored tattoo removal with a high overall clearance rate and acceptable safety profile. Among 198 patients who completed the study, 62.6% achieved excellent clearance (>90%), while 28.3% achieved good clearance (60–89%), indicating a combined success rate of over 90% for satisfactory outcomes. The highest response was observed in black and dark blue pigments, which is consistent with their broad optical absorption spectrum. These pigments respond effectively to the 1064 nm Nd:YAG laser, which penetrates deeply into the dermis and efficiently fragments dense ink particles. Similar findings have been reported in earlier studies where black ink showed the most predictable clearance rates with Q-switched systems. [6,7] In contrast, green and yellow pigments demonstrated relatively poor response rates in the present study. Only partial clearance was achieved in a significant proportion of cases, even after multiple sessions. This resistance is likely due to the complex chemical composition of these pigments and their limited absorption of commonly used laser wavelengths. Previous literature has also highlighted green pigment as one of the most treatment-resistant tattoo colors, often requiring multiple modalities or extended treatment duration.[8] Red pigments showed intermediate responsiveness, particularly when treated with the 532 nm frequency-doubled Nd:YAG laser. However, variability in outcomes was observed depending on ink formulation and depth of deposition. This highlights the heterogeneity of tattoo inks, even within the same color category, which remains a major challenge in laser tattoo removal.[9] The average number of sessions required in this study was between 4 and 6 for most patients, which is consistent with previously published reports. However, multi-colored and professionally applied tattoos often required more than 8 sessions, reflecting deeper pigment placement and higher ink density. The safety profile observed in this study was favorable. Most adverse effects were mild and transient, including erythema, edema and temporary post-inflammatory hyperpigmentation. No cases of scarring or permanent skin damage were observed. These findings reinforce the safety of Q-switched laser systems when used with appropriate parameters and adequate patient selection.[10] Overall, this study supports the role of Q-switched laser as the gold standard for tattoo removal, particularly for dark pigments. However, the limitations in treating resistant colors such as green and yellow suggest the need for newer technologies such as picosecond lasers or combination treatment approaches in the future.

CONCLUSION

Q-switched laser therapy demonstrated substantial effectiveness and a favorable safety profile for the removal of multicolored tattoos. Among the 198 patients who completed treatment, 62.6% achieved excellent clearance (>90%) and 28.3% achieved good clearance (60–89%), resulting in 90.9% achieving at least 60% clearance. Black and blue pigments showed the most favorable responses, whereas green and yellow pigments were comparatively resistant and frequently required additional treatment sessions. Wavelength-specific laser selection and appropriate treatment intervals are important for optimizing outcomes. The low frequency of persistent adverse effects further supports the clinical utility of Q-switched laser therapy. Future studies comparing Q-switched and picosecond laser technologies may help determine strategies for improving clearance of resistant pigments.

DECLARATIONS

Ethics Approval and Consent to Participate: The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the appropriate institutional ethics/review committee before commencement of the study. Written informed consent was obtained from all participants before enrollment and treatment.

CONSENT FOR PUBLICATION

Written informed consent was obtained from participants for the use of anonymized clinical information and photographs for scientific publication, where applicable.

COMPETING INTERESTS

The authors declare that they have no competing interests.

FUNDING

No external funding was received for this study.

AUTHOR CONTRIBUTIONS

All authors contributed to the conception and design of the study, patient management and/or data collection, interpretation of findings, manuscript preparation, critical revision of the manuscript and approval of the final version.

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REFERENCES

1. Anderson RR, Parrish JA. Selective photothermolysis: precise microsurgery by selective absorption of pulsed radiation. Science. 1983;220(4596):524-527. doi:10.1126/science.6836297. PMID: 6836297.
2. Bernstein EF. Laser treatment of tattoos. Clin Dermatol. 2006;24(1):43-55. doi: 10.1016/j.clindermatol.2005.10.025. PMID: 16427505.
3. Ho SGY, Goh CL. Laser tattoo removal: a clinical update. J Cutan Aesthet Surg. 2015;8(1):9-15. doi:10.4103/0974-2077.155066. PMID: 25949017; PMCID: PMC4411606.
4. Kent KM, Graber EM. Laser tattoo removal: a review. Dermatol Surg. 2012;38(1):1-13. doi:10.1111/j.1524-4725.2011.02187. x. PMID: 22092754.
5. Luebberding S, Alexiades-Armenakas M. New tattoo approaches in dermatology. Dermatol Clin. 2014;32(1):91-96. doi: 10.1016/j.det.2013.09.002. PMID: 24286949.
6. Levine VJ, Geronemus RG. Tattoo removal with the Q-switched ruby laser and the Nd:YAG laser: a comparative study. Lasers Surg Med. 1993;5(Suppl):53.
7. Kilmer SL, Anderson RR. Clinical use of the Q-switched ruby and the Q-switched Nd:YAG (1064 nm and 532 nm) lasers for treatment of tattoos. J Dermatol Surg Oncol. 1993; 19:330-338.
8. Ferguson JE, Andrew SM, Jones CJ, August PJ. The Q-switched neodymium:YAG laser and tattoos: a microscopic analysis of laser-tattoo interactions. Br J Dermatol. 1997;137(3):405-410. doi:10.1046/j.1365-2133.1997.18581951. x. PMID: 9349346.
9. Ho SGY, Goh CL. Laser tattoo removal: a clinical update. J Cutan Aesthet Surg. 2015;8(1):9-15. doi:10.4103/0974-2077.155066. PMID: 25949017; PMCID: PMC4411606.
10. Bernstein EF, Bhawalkar J, Schomacker KT. A novel titanium sapphire picosecond-domain laser safely and effectively removes purple, blue and green tattoo inks. Lasers Surg Med. 2018;50(7):704-710. doi:10.1002/lsm.22942. PMID: 29781161; PMCID: PMC6120457.