



OPEN ACCESS

Key Words

Tattoo removal, ultra pulse CO2 laser, Q-switched Nd:YAG, combination therapy, pigment clearance, laser safety

Corresponding Author

Metta Arun Kumar,
Department of Dermatology,
Venerology and Leprosy, Gayatri
Vidya Parishad Institute of Health
Care and Medical Technology,
Visakhapatnam, Andhra Pradesh,
India
drmettaarun@yahoo.co.in

Author Designation

¹Assistant Professor

²Professor

³Honorary Professor

Received: 05 October 2024

Accepted: 20 November 2024

Published: 22 November 2024

Citation: Lasya Priya Gollamudi, Metta Arun Kumar and Turpati Narayana Rao, 2024. Comparative Efficacy and Safety of Combined Ultra Pulse CO2 Laser and Q-Switched Nd:YAG Versus Q-Switched Nd:YAG Alone in Tattoo Removal: A Prospective Study. Res. J. Med. Sci., 18: 196-200, doi: 10.36478/makrjms.2024.12.196.200

Copy Right: MAK HILL Publications

Comparative Efficacy and Safety of Combined Ultra Pulse CO2 Laser and Q-Switched Nd:YAG Laser Versus Q-Switched Nd:YAG Alone in Tattoo Removal: A Prospective Study

¹Lasya Priya Gollamudi, ²Metta Arun Kumar and ³Turpati Narayana Rao

¹Department of Dermatology, Venerology and Leprosy, Konaseema Institute of Medical Sciences, Chaitanya City, Amalapuram, Andhra Pradesh, India

^{2,3}Department of Dermatology, Venerology and Leprosy, Gayatri Vidya Parishad Institute of Health Care and Medical Technology, Visakhapatnam, Andhra Pradesh, India

ABSTRACT

Tattoo removal is a growing clinical demand with various laser modalities being employed. While Q-Switched Nd:YAG is considered the gold standard, it often requires multiple sessions and may result in incomplete pigment clearance. This study compares the efficacy and safety of combined Ultra Pulse CO2 laser followed by Q-Switched Nd:YAG with Q-Switched Nd:YAG alone in tattoo removal. This prospective study included 50 participants aged 18-37 years with amateur or professional tattoos. Each tattoo was divided into two halves: one treated with a combination of Ultra Pulse CO2 laser and Q-Switched Nd:YAG and the other with Q-Switched Nd:YAG alone. Treatment was performed at six-week intervals for a maximum of six sessions. Efficacy was evaluated using physician assessment scores, patient satisfaction scores and the number of sessions required for >95% pigment clearance. Side effects were documented and optimal fluence was determined for both modalities. Combination therapy achieved >95% pigment clearance in fewer sessions (3.58 ± 0.73) compared to Nd:YAG (5.86 ± 0.35 , $p=0.001$). Mean physician and patient satisfaction scores were significantly higher for combination therapy (4.00 ± 0.46 and 8.42 ± 0.77 , respectively, $p=0.001$). Side effects, including pigmentation changes and scarring, were comparable between the two groups. The combination therapy required lower optimal fluence (2.92 ± 0.77 J/cm² vs. 6.20 ± 1.19 J/cm², $p=0.001$). Combination therapy demonstrated superior efficacy and patient satisfaction with fewer sessions and lower fluence, making it a promising approach for tattoo removal.

INTRODUCTION

Tattooing has been an integral part of human culture for centuries, serving as a form of self-expression, religious symbolism, or social identification^[1]. However, with the rise in tattoo prevalence globally, there is a growing demand for effective tattoo removal due to personal regret, professional obligations, or medical indications^[2]. Traditional methods like salabrasion, dermabrasion and surgical excision often led to significant scarring and incomplete pigment removal, highlighting the need for advanced techniques^[3]. The advent of laser technology revolutionized tattoo removal, with Q-Switched (QS) lasers becoming the gold standard due to their ability to selectively target tattoo pigments while sparing surrounding tissues. Among QS lasers, Nd:YAG (1064 nm) is particularly effective for darker pigments and deeper dermal penetration, making it suitable for Indian skin types^[4,5]. However, limitations such as incomplete pigment clearance, higher fluence requirements and the need for multiple sessions persist, especially for professional and multi-colored tattoos. Recent advancements have explored combination therapies to enhance outcomes. Ultra Pulse CO2 laser, known for its precise epidermal ablation, can enhance the penetration of QS Nd:YAG by removing superficial barriers. This combination has the potential to improve efficacy, reduce treatment sessions and minimize adverse effects. This study aims to compare the efficacy, safety and patient satisfaction of combined Ultra Pulse CO2 laser and QS Nd:YAG versus QS Nd:YAG alone in tattoo removal, providing evidence for optimized clinical management of tattoos in diverse populations.

MATERIALS AND METHODS

Study Design and Setting: This prospective, open-label, comparative therapeutic study was conducted at the Department of Dermatology, Venereology and Leprosy, Maharajah's Institute of Medical Sciences, Vizianagaram, Andhra Pradesh, over 22 months (January 2020 to October 2021). Institutional ethics committee approval was obtained before study initiation.

Participants: The study included 50 participants aged 18 years and above with amateur or professional tattoos who had not undergone previous tattoo removal. Written informed consent was obtained.

Exclusion Criteria: Pregnancy or lactation, active skin disease at the tattoo site, history of recurrent herpes simplex virus infection, bleeding disorders, poor wound healing, keloidal tendency, use of photosensitizing drugs within the past 3 months and unwillingness to participate.

Study Procedure: Each tattoo was divided into two halves (upper/lower or left/right). The combination therapy group (Ultra Pulse CO2 + QS Nd:YAG) received a single-pass Ultra Pulse CO2 laser (750mJ/pulse) followed by QS Nd:YAG (1064nm, ≥ 150 mJ). The other half was treated with QS Nd:YAG alone. Treatments were administered at six-week intervals for up to six sessions. Subsequent sessions for the combination group used QS Nd:YAG alone to prevent scarring.

Outcome Measures:

Efficacy: Physician assessment score for tattoo ink lightening (>95% clearance).

Satisfaction: Patient-reported satisfaction on a numeric scale (0-10).

Safety: Documentation of side effects (pigmentary changes, scarring).

Fluence: Determination of optimal fluence for both groups.

Data Analysis: Statistical analysis was conducted using SPSS version 26. Descriptive statistics were used to summarize demographic and clinical data. Paired t-tests were employed to compare outcomes between groups. A p-value <0.05 was considered statistically significant.

RESULTS AND DISCUSSIONS

Demographic Distribution: The study included 50 participants aged between 18-37 years, with a mean age of 23.94±4.37 years. The majority of participants (46%) were in the 18–22 age group. Male participants constituted 78% (n=39), while females made up 22% (n=11), yielding a male-to-female ratio of 3.54:1 (Table 1).

Table 1: Demographic Distribution

Category	Details
Age Range (years)	18-37
Mean Age	23.94±4.37
Male Participants	39 (78%)
Female Participants	11 (22%)
Male-to-Female Ratio	3.54:1

Tattoo Characteristics: The duration of tattoos ranged from 1-25 years, with a mean duration of 7.84±5.78 years. Most tattoos (42%) were present for <5 years. Amateur tattoos were more prevalent (68%) compared to professional tattoos (32%). The most common tattoo location was the flexor aspect of the forearm (48%), followed by the dorsal hand and lateral forearm, each accounting for 10% (Table 2).

Table 2: Tattoo Characteristics

Characteristic	Details
Tattoo Duration (years)	1-25
Mean Duration (years)	7.84±5.78
Amateur Tattoos	34 (68%)
Professional Tattoos	16 (32%)
Most Common Site	Flexor Forearm (48%)

Treatment Outcomes: The combination therapy group (Ultra Pulse CO₂ + Q-Switched Nd:YAG) achieved >95% pigment clearance in significantly fewer sessions (3.58±0.73) compared to the Nd:YAG alone group (5.86±0.35, p=0.001). Additionally, the mean physician scores post-treatment were higher for the combination therapy group (4.00±0.46) compared to the Nd:YAG alone group (2.67±0.51, p=0.001) (Table 3).

Table 3: Treatment Outcomes

Measure	Combination Measure	Nd: YAG Laser Alone
Mean Sessions for >95% Clearance	3.58±0.73	5.86±0.35
Mean Physician Scores	4.00±0.46	2.67±0.51

Patient Satisfaction: Patients reported significantly greater satisfaction with combination therapy. Satisfaction scores of 7-10 were observed in 100% of cases for combination therapy compared to 27.8% for the Nd:YAG alone group. The mean satisfaction score was 8.42±0.77 for combination therapy versus 5.58±1.42 for Nd:YAG alone (p=0.001) (Table 4).

Table 4: Patient Satisfaction

Satisfaction Score	Combination Therapy (n=36)	Nd:YAG Laser Alone (n=36)
7-10	100%	27.8%
5-6	-	47.2%
3-4	-	25%

Side Effects: Adverse events were comparable between the two groups. On the combination therapy side, depigmentation and hyperpigmentation were noted in 8.33% of cases each, while scarring was seen in 13.8%. In the Nd:YAG alone group, depigmentation, hyperpigmentation and pinpoint bleeding occurred in 8.33% of cases each. The mean side-effect scores were not significantly different between the groups (p=0.35) (Table 5).

Table 5: Side Effects

Side Effect	Combination Therapy	Nd:YAG Laser Alone
Depigmentation	8.33%	8.33%
Hyperpigmentation	8.33%	8.33%
Scarring	13.8%	-
Pinpoint Bleeding	-	8.33%

Optimal Fluence: The combination therapy group required significantly lower optimal fluence (2.92±0.77J/cm²) compared to the Nd laser alone group (6.20±1.19J/cm², p=0.001) (Table 6).

Table 6: Optimal Fluence

Measure	Optimal Fluence (J/cm ²)
Combination Therapy	2.92±0.77
Nd:YAG Laser Alone	6.20±1.19

Follow-Up Distribution: Of the initial 50 participants, 36 (72%) completed the study, while 14 (28%) were lost to follow-up (Table 7).

Table 7: Follow-Up Distribution

Category	Details
Completed Study	36 (72%)
Lost to Follow-Up	14 (28%)



Fig. 1: Nd:YAG Laser



Fig. 2: CO₂ Laser



Fig. 3: Professional Tatoo Before First Session

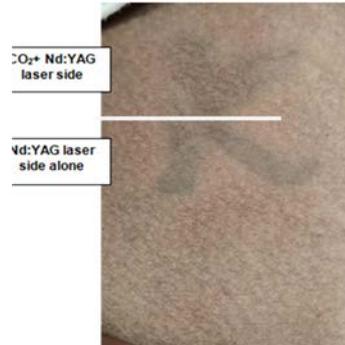


Fig.4: Professional Tatoo After Six Sessions



Fig. 5: Professional Tatoo Before First Session



Fig. 6: Professional Tatoo After Six Sessions



Fig.7: Pinpoint Bleeding



Fig. 8: Post Inflammatory Depigmentation



Fig. 9: Hypopigmented Scar

The present study evaluated the efficacy, safety and patient satisfaction of combining Ultra Pulse CO2 laser with Q-Switched Nd:YAG therapy compared to Q-Switched Nd:YAG alone for tattoo removal. The results demonstrate that the combination therapy provides superior outcomes, requiring fewer sessions, achieving higher pigment clearance rates and improving patient satisfaction.

Efficacy of Combination Therapy: The combination of Ultra Pulse CO2 and Q-Switched Nd:YAG demonstrated significantly faster clearance of tattoo pigments, with a mean of 3.58 ± 0.73 sessions compared to 5.86 ± 0.35 sessions with Nd:YAG alone ($p=0.001$). These findings align with those of Vanarase *et al.*, who reported enhanced pigment clearance using combination therapy due to better exposure of deeper pigments following CO2 laser ablation^[7]. Similarly, Sardana *et al.* demonstrated that sequential use of CO2 Nd:YAG followed by Nd:YAG accelerates tattoo pigment clearance by enhancing penetration efficiency^[8]. Radmanesh *et al.* also confirmed that combination therapies outperform Nd:YAG alone, particularly for challenging tattoos^[9].

Patient Satisfaction and Physician Scores: The combination therapy resulted in significantly higher physician assessment scores (4.00 ± 0.46 vs. 2.67 ± 0.51 , $p=0.001$) and patient satisfaction scores (8.42 ± 0.77 vs. 5.58 ± 1.42 , $p=0.001$). These results are consistent with Shah and Aurangabadkar's findings, highlighting patient preference for combination therapies due to improved cosmetic outcomes and reduced treatment burden^[10]. The enhanced clearance rate and reduced number of sessions contribute to a lower psychological impact and better overall experience for patients.

Safety Profile: Adverse events, including scarring and pigmentation changes, were comparable between groups, with no significant difference in side-effect scores ($p=0.35$). Limiting CO2 laser use to the initial session minimized scarring risks, similar to the approach recommended by Sardana^[8] Wang *et al.* reported that CO2 fractional lasers used judiciously have a safe profile and can enhance the effectiveness of subsequent treatments^[12].

Optimal Fluence: The combination therapy required significantly lower fluence ($2.92 \pm 0.77 \text{ J/cm}^2$) than Nd:YAG alone ($6.20 \pm 1.19 \text{ J/cm}^2$, $p=0.001$). Kilmer *et al.* emphasized that lower fluence minimizes thermal damage, particularly in darker skin types, making the combination therapy more suitable for diverse patient populations^[11]. The reduced fluence also highlights the efficiency of combination therapy in achieving pigment clearance while maintaining safety.

Clinical Implications: The combination of Ultra Pulse CO₂ and Q-Switched Nd:YAG offers a promising alternative for tattoo removal, particularly for professional and multicolored tattoos, where standalone therapies often fall short. This approach not only enhances treatment efficacy but also reduces the burden of repeated sessions, making it cost-effective and patient-friendly.

Limitations and Future Directions: This study had a small sample size and a short follow-up period. Future research with larger cohorts and longer follow-ups is necessary to confirm long-term efficacy and safety. Additionally, evaluating outcomes in various skin types and tattoo colors can provide broader clinical applicability.

CONCLUSION

This study demonstrates that combining Ultra Pulse CO₂ laser with Q-Switched Nd:YAG significantly improves the efficacy and efficiency of tattoo removal compared to Q-Switched Nd:YAG alone. The combination therapy achieved >95% pigment clearance in fewer sessions, with higher physician and patient satisfaction scores. Despite minor adverse effects, the safety profile of the combination therapy was comparable to standalone Nd:YAG. Additionally, the reduced optimal fluence in the combination group highlights its suitability for diverse skin types. This approach offers a promising, efficient and patient-friendly alternative for managing challenging tattoos, including professional and multicolored designs.

REFERENCES

1. Angsuwarangsee, S. and N. Polnikorn, 2003. Combined Ultrapulse CO₂Laser and Q-Switched Alexandrite Laser Compared with Q-Switched Alexandrite Laser Alone for Refractory Melasma: Split-Face Design. *Dermatologic Surg.*, 29: 59-64.
2. Beyzaee, A.M., A. Patil, M. Goldust, M. Moslemi, A. Kazeminejad and G.R. Rokni, 2021. Comparative Efficacy of Fractional CO₂ Laser and Q-Switched Nd:YAG Laser in Combination Therapy with Tranexamic Acid in Refractory Melasma: Results of a Prospective Clinical Trial. *Cosmetics*, Vol. 8 .10.3390/cosmetics8020037.
3. Geisler, A.N., A. Eber, K. Kim and K.A. Arndt, 2023. Lasers for the treatment of eyebrow microblading and cosmetic tattoo pigment: A review of the literature. *Lasers Med. Sci.*, Vol. 38 .10.1007/s10103-023-03921-z.
4. Kupermanbeade, M., V.J. Levine and R. Ashinoff, 2001. Laser Removal of Tattoos. *Am. J. Clin. Dermatol.*, 2: 21-25.
5. Leuenberger, M.L., M.W. Mulas, T.R. Hata, M.P. Goldman, R.E. Fitzpatrick and J.M. Grevelink, 1999. Comparison of the Q-Switched Alexandrite, ND:YAG, and Ruby Lasers in Treating Blue-Black Tattoos. *Dermatologic Surg.*, 25: 10-14.
6. Vachiramon, V., W. Panmanee, T. Techapichetvanich and K. Chanprapaph, 2016. Comparison of Q-switched Nd: YAG laser and fractional carbon dioxide laser for the treatment of solar lentigines in asians. *Lasers Surg. Med.*, 48: 354-359.
7. Vanarase, M., R.K. Gautam, P. Arora, S. Bajaj, N. Meena and A. Khurana, 2017. Comparison of Q-switched Nd:YAG laser alone versus its combination with ultrapulse CO₂ laser for the treatment of black tattoo. *J. Cosmet. Laser Ther.*, 19: 259-265.
8. Sardana, K., V.K. Garg, S. Bansal and K. Goel, 2013. A promising split-lesion technique for rapid tattoo removal using a novel sequential approach of a single sitting of pulsed CO₂ followed by Q-switched Nd: YAG laser (1064 nm). *J. Cosmet. Dermatol.*, 12: 296-305.
9. Radmanesh, M. and Z. Rafiei, 2014. Combination of CO₂And Q-switched Nd:YAG lasers is more effective than Q-switched Nd:YAG laser alone for eyebrow tattoo removal. *J. Cosmet. Laser Ther.*, 17: 65-68.
10. Shah, S. and S. Aurangabadkar, 2015. Newer trends in laser tattoo removal. *J. Cutaneous Aesthetic Surg.*, 8: 25-29.
11. Kilmer, S.L., M.S. Lee, J.M. Grevelink, T.J. Flotte and R.R. Anderson., 1993. The Q-Switched Nd:YAG Laser Effectively Treats Tattoos. *Arch. Dermatol.*, 129: 971-981.
12. Wang, C.C., C.L. Huang, Y.M. Sue, S.C. Lee and F.J. Leu, 2013. Treatment of Cosmetic Tattoos Using Carbon Dioxide Ablative Fractional Resurfacing in an Animal Model: A Novel Method Confirmed Histopathologically. *Dermatologic Surg.*, 39: 571-577.