

Q-Switched Neodymium: YAG Laser in Treatment of Tattoos

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ABSTRACT

Background: Tattoos become more popular in the community nowadays, hence the demand for tattoo removal had increased especially that laser tattoo removal due to it is the least traumatic to skin than all other methods that involve tattoo removal.

Aim of Work: In this study we investigated the effectiveness of Q-switched Nd:YAG laser in treating many types of tattoos in thirty patients.

Results: Our results showed that tattoo removal for grade 1, no change or mild improvement after laser treatment; (0-≤25% of improvement) 3.3% of treated patients; grade 2, improvement (>25%, ≤50%) in 10% of patients; grade 3, moderate improvement (>50%, ≤75%) in 16.6% of patients; and grade 4, significant improvement (>75%, <100%) occurred in 70% of patients.

Conclusion: The use of Q-Nd:YAG laser is a good choice for tattoo removal with lesser complications.

Key Words: Laser – Tattoo – Q-Nd:YAG – Skin type.

INTRODUCTION

The practice of tattooing has a ritual and religious origins [1]. From being regarded as a stigmatizing sign of certain subcultures, tattoos have lately become popular and fashionable particularly in Western societies [2]. Requests for the removal of tattoos are growing more numerous as the number of persons with tattoos increases [3]. Numerous treatments such as surgical excision, dermabrasion, chemical therapy, cryosurgery and electrosurgery have been used [4]. But each technique was limited by undesirable scarring or pigmentary alterations [5].

Many laser treatments have been introduced in recent years. The earlier laser systems had less specificity and, therefore, more side effects than the latest lasers with technologic advances [6]. The Q-switched laser systems, including the ruby, Nd:YAG, and alexandrite, have shown the greatest promise in treating tattoos because of their ability

to preferentially injure structures in the dermis that contain pigment with brief, selectively absorbed laser pulses. This process is termed selective photothermolysis where thermal damage is localized by the choice of a wavelength that is selectively absorbed by the specific target chromophore and by delivering sufficient energy to damage the target within a pulse duration which is briefer than the time taken for the target to cool this brief time named thermal relaxation time [7].

The Q-switched Nd:YAG laser has been reported as being an effective type of laser especially for removing tattoos from dark-skinned individuals its wavelength is 1064 and an impulse duration of 5-20ns. This laser has a deep penetration and reaches the papillary dermis. It is well absorbed by dark blue-black colours and dermal pigment. The number of treatment sessions depends on pigment color, composition, density, depth, duration, body location, and the number of tattoo inks present. Each successive treatment removes some of the remaining pigment. Laser treatment fragments the tattoo ink particles, which are then cleared or phagocytosed into smaller aggregations to the point where the tattoo is no longer clinically apparent [8].

This study was conducted to evaluate the effectiveness of Q-switched Nd:YAG laser in treatment of tattoo.

PATIENTS AND METHODS

The study was conducted on 30 patients with black dark green and dark blue ink tattoos at NILES March 2013 – November 2014, the patients seek tattoo removal for different reasons; religious, social and fashion changes. Exclusion criteria from the study were tattoo size larger than 25cm², pregnancy, breast feeding, history of autoimmune or connective tissue disorders, recent history of sun exposure, use of coumadin, or aspirin, for the past 10 days. Patient's demographic data regarding age,

gender, skin type (Fitzpatrick classification), duration of tattoo, and history of prior treatments of tattoo was collected. An informed consent was signed before starting treatment.

Laser treatment:

The laser used was Q-switched Nd:YAG (1064nm) (Duolite QS Deka Lasers Ltd, Italy), with energy up to 2 Joules and 10ns pulse duration, spot size 2-5mm. The fluence used ranged from (2-18 J/cm²) and it is determined for each patient according to the threshold response, skin type and degree of tattoo ink. At each treatment the tattoo was covered by adjacent non overlapped laser pulses till blanching of the dark color of the tattoo is reached and considered as a therapeutic end point. Thick layer of EMLA cream (EMLA® cream; M/s. AstraZeneca, USA) was applied, to the treatment site for 60-90 minutes, just prior to laser treatment. Sessions were performed 4-6 weeks apart. Antibiotic ointment was prescribed for one week after laser session sun block with SPF over 50 was advised to be used by patients before sun exposure for tattoos located in exposed areas as the face.

Evaluation for treatment response:

Treatment response regarded as clearance of the tattoo pigment from the skin, response was categorized into four grades according to the clearance as follows: Grade 1, no change or mild improvement after laser treatment; (0-≤25% of improvement); Grade 2, improvement (>25%, ≤50%); Grade 3, moderate improvement (>50%, ≤75%); Grade 4, significant improvement (>75%, <100%). Response to treatment was assessed clinically and by evaluating the photographs taken before and after the end of treatment by the senior author.

Complications as pigmentary and textural changes were classified as none, mild, moderate, or severe and recorded.

The endpoint for treatment of each patient was determined when no further blanching was noted in the treatment area, despite increasing the fluence and pulse duration and hence the decision was made to stop treatment.

Statistical analysis:

Data were collected, tabulated, and then analyzed by using SPSS® computer software version 18.0 (Statistical Package for Social Sciences, SPSS, Inc., Chicago, IL). Mean, standard deviation (±SD), Median, Minimum and maximum values were calculated. Paired *t*-test was used to assess the

statistical significance of the difference between two means for group. A difference with “*p*” value <0.05 will be considered statistically significant otherwise it will be insignificant.

RESULTS

Thirty patients; 16 females and 14 males participated in this study their ages ranged from 21-54 years (Mean±SD; 33.78±8.1 years). The patients were of darker skin types; 19 patients (63.3%) of skin type III, 7 patients (23.3%) of skin type IV and four patients (13.3%) of skin type V. Of the 30 patients 5 patients (16.7%) were received previous remedy in a trial of treatment. The parameters of the laser used ranged from fluence 7 J/cm² for the spot size 4mm to 20 J/cm² for 2mm spot size (mean±SD 13.8 ±5.5 J/cm²).

Descriptive data of the tattoos showed that the duration of tattoos were ranged from 1-23 years (Mean±S.D 7.48±4.704 years). The sites where tattoos were located on the body were as follows: Upper arm in 8 patients (26.6%), forearm in 6 patients (20%), trunk in four patients (13.3%), legs in five patients (16.6%) and on the face in 7 patients (23.3%). Type and color of tattoos pigmentation are shown in (Table 1).

Table (1): Types and color of the tattoos within patients group.

Type of tattoo	Lesions No. (%)	Color of Tattoo	Lesions No. (%)
Professional	13 (43.3)	Dark blue	14 (46.6)
Amateur	19 (63.3)	Dark green	10 (33.3)
Traumatic	6 (20)	Black	3 (10)
Medical	2 (6.6)	Other colors	3 (10)

The pulses delivered on each tattoo, ranging from 117 to 680 pulses per session (Mean±SD 435±20.45) pulses. All patients tolerated treatment well but during the session some patients experienced mild pain whereas others needed anesthetic administration before the session. Pain was greater with darker skin and/or denser tattoo pigment. Slightly raised, white papules appeared immediately after the laser exposure corresponding each exactly to the laser spot, this immediate whitening response faded away within 30 minutes. There was a transient inflammatory changes and a crust were observed over the treated area which sloughed within 2 weeks. Treated areas required 1-3 weeks to heal, some lesions remained erythematous during this period and slight postinflammatory hyperpigmentation occurred in those patients.

The tattoos then gradually faded over 6 to 10 weeks and the most (46.6%) of the tattoo n=14 showed clearance at Grade 3 (>50%, ≤75%). Whereas as the significant improvement at Grade 4 (>75%, <100%) showed in ten tattoos (30%) (Fig. 1). Mild improvement Grade 1 response (0-≤25%) seen only in one patient (3.3%) (Fig. 2).

The other five patients (16.6%) showed Grade 2 response (>25%, ≤50%).

Generally A better response was noted with older, tattoos and dark blue inks in comparison to other colors. No scarring or, infection had developed in any case.

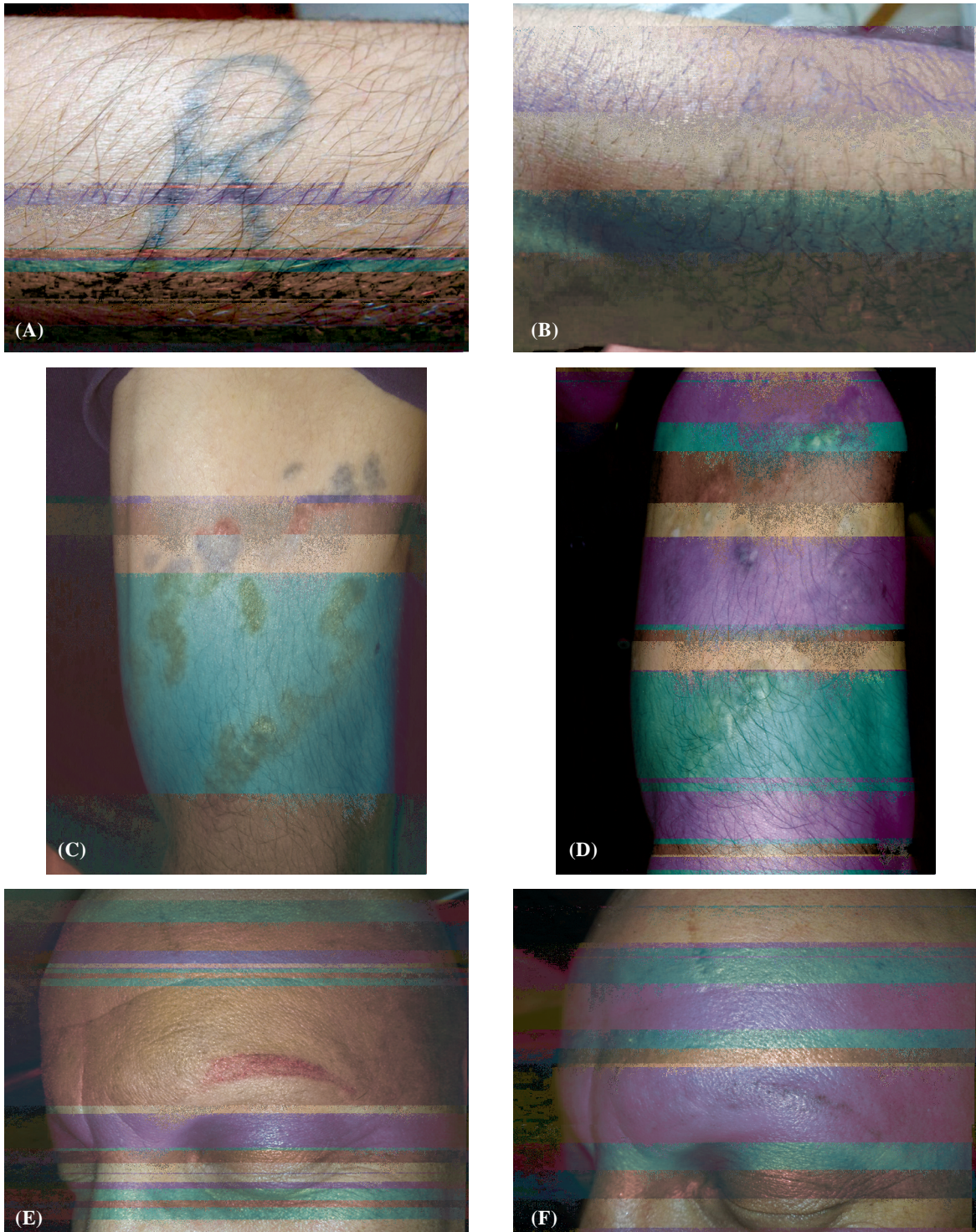


Fig. (1): Significant improvement of tattoo (A,C,E, Before) (B,D,F, After) laser therapy.

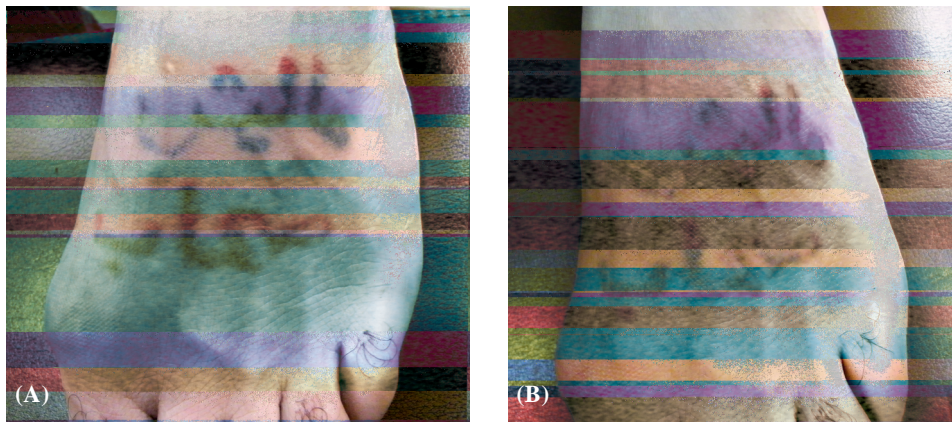


Fig. (2): Patient with mild improvement after 4 sessions (A, Before) (B, After) laser therapy.

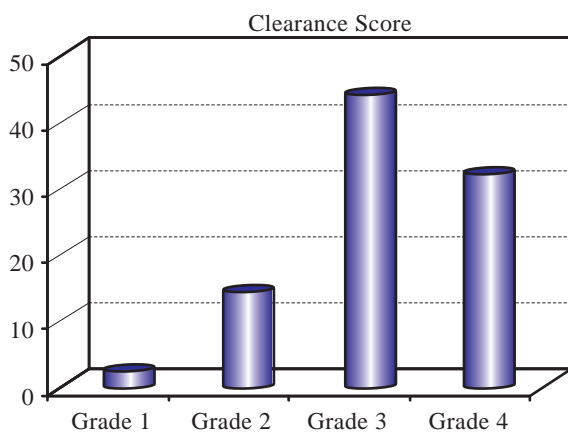


Table (1): Grades of tattoos clearance within the study group.

Correlation between tattoo clearance and variables:

Pearson’s product moment correlation coefficient test was used to measure the correlation between the degree of clearance with the site, color and type of tattoos. A positive correlation was found between the excellent grade 4 degree of clearance and the face lesions ($r=0.959, p=0.182$), the upper arm ($r=0.814, p=0.394$) and the forearm ($r=0.814, p=0.394$) however this was statistically insignificant. A significant positive correlation was found between the grade 4 degree of clearance and the black color tattoos ($r=0.832, p=0.182$), and the blue color tattoos ($r=0.959, p=0.394$) A positive correlation was found between the excellent degree of improvement and the amateur tattoo ($r=0.944, p<0.001$), the traumatic ($r=0.956, p<0.001$).

Complications:

Most of the patients treated with the Q-switched Nd:YAG laser showed no changes in skin pigment or texture after treatment. Transient mild hyperpigmentation that lasted for 2-4 months was noted in 7 (23.3%) patients, and mild textural changes in two (6.6%). There were no cases of scarring or permanent pigmentary changes.

DISCUSSION

Multiple laser modalities have been reported in the literature in the treatment of tattoo including carbon dioxide (CO₂), argon, Erbium:YAG, neodymium: YAG, Q-switched ruby, and Q-switched alexandrite laser. The type of laser selected is somewhat dependent on the desired depth of penetration, adverse effects, the surgeon’s familiarity with the laser, availability of equipment. The primary consideration, however, in the selection of the appropriate laser is the target chromophore [9].

Ablating the skin with CO₂ lasers have been used in the treatment of tattoos However it does not target the pigment particles as effectively as other laser modalities, hence the great possibility of destroying surrounding tissue when treating deep located particles [10]. Complications have been reported with the CO₂ laser for laser resurfacing of tattoo including hyper-pigmentation, hypopigmentation, hypertrophic and keloid scarring [11].

The neodymium:YAG 1064-nm laser has been effective for removal of both professional and traumatic tattoos. The Q switched Nd:YAG 1064-nm wavelength may be effective in accessing the deeper pigment due to the longer wavelength relative to the aforementioned lasers. Furthermore, the wavelength targets pigment chromophores effectively and may avoid hypertrophic scarring due to lack of alteration of the underlying collagen and elastic fibers [12,13]. For these reasons, we have found this laser to be an excellent choice for the treatment of traumatic tattoo as evidenced by this case.

The efficacy and side effects of The Q switched Nd:YAG laser for tattoo removal investigated in darker skin patients and concluded that Q-switched

laser treatment can be performed successfully in this population [14].

Comparisons between different types of tattoos showed that the Q-switched laser is more effective in removing amateur, carbon-based tattoos than professional, densely colored tattoos [15]. Probably because of the selective absorption of the 1064nm wavelength by the carbon particles, the resulting photopyrolysis and photoacoustic disruption of the phagocytized particles allows them to be transported away in lymphatic vessels, eliminated transcutaneously, or re-phagocytized in macrophages [16].

The present study included a relatively large population of patients with Fitzpatrick skin types III-IV; this darker skin types was difficult to treat with other laser types as ruby 694nm and alexandrite 755nm due to relative affinity of these lasers type to be absorbed by the melanin of the skin. The treatment success with the Q-switched Nd:YAG laser was significant as seen in our study so upon completion of 4 treatment sessions, we reached clearance rates of (>75%, <100% in 14/18 amateur tattoos, and 7/12 professional tattoos. In agreement with earlier studies, the aesthetic outcome was excellent (75% to 100%) clearance in 70% of cases, to results in light-skinned patients [17].

These findings highlight the usefulness of Q-switched Nd:YAG laser technology for tattoo removal. The positive correlation that has been found between the excellent degree of improvement and the face when compared to other sites could be due to the less skin thickness. Also the significant positive correlation between the excellent degree of improvement and the black, the dark blue and the blue confirmed the efficacy of Q-switched Nd:YAG laser in these inks.

From the present study, we conclude that the improved clearance of tattoos is probably attributable to the larger spot size and larger energy fluence in the deeper layers of the dermis, resulting in less treatment sessions and less potential for tissue reaction this is because larger spot size increases the depth of the thermal injury irrespective of laser wavelength [18]. The differences in the energy fluences as potential confounding variables should be considered in interpreting the results. Theoretically, the treatment success could be attributed to either "spot size" and/or "energy fluence". Detailed analysis of the energy data, however, did not reveal clinically relevant differences during both treatment courses. Mean energy fluence and maximum energy fluence during the treatment course were about 10-20% different from patient

to another when compared with each other. It is unlikely that this energy difference significantly influenced the clearance rates. One has also to keep in mind, that a change in spot size in some cases has necessitated a change in energy fluence in order to obtain the required clinical endpoint of whitening. In general, small spot sizes require higher fluences because scattering at the edge diffuses the beam and reduces the intensity. Thus, an increase in spot size resulted in only small increments in the laser treatment irradiance during the treatment course. A frequent cause of transient hyperpigmentation that patients incorrectly attribute to QS laser use is post-inflammatory hyperpigmentation due to irritant contact dermatitis from the use of ice packs and adhesive tape as well as allergic contact dermatitis to over-the-counter post-treatment topical antibacterial preparations. Undesired pigmentary alteration; hyper and hypopigmentation was found in 53.3% of patients. We became aware through verbal reports of our patients that one of the main obstacles to tattoo removal among is the financial considerations.

Conclusions: The use of Q-switched Nd: YAG laser is good choice in treatment of Tattoos especially in darker skin types but still part of the tattoos not cleared even with increase number of sessions so other investigations are needed to elucidate this possibility.

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