

Removal of Tattoo By 1064 and 532nm Q-switched Nd: YAG laser

Fatima A. Mohammad Ali MBChB; DDV , Ali S. Mahmood MBChB; CABS;
HDipLM/surgery.

Abstract

Background: A tattoo is made of particles of pigment injected into the skin. Although the body attempts to remove them, the particles of tattoo are too large to be removed and the body responds by encapsulating the whole tattoo in a wall of collagen that traps it within the skin permanently.

Objective: to evaluate Nd-YAG laser effects for removing tattoo.

Materials & Methods: The study was done on 99 tattoo lesions (in both genders) on different parts of the body (hand, foot, face and chest), ages were between 21- 60 years, and most common age group was between 20-30 years. In this work, tattoo were divided according to its colors, into black, blue, green, and red (The red color always shares with other colors), and each subdivided to amateur and professional tattoos. Quality-switched (Q-switched) 1064 nm, Nd: YAG laser, pulse width of 10 nanosecond and repetition rate (R.R) 5 Hz with different fluencies (energy/area) was used. These parameters were

used for black, green, and blue tattoos. To red color tattoo 532nm Nd: YAG Q-switched laser, 7 ns pulse duration, R.R 10Hz, fluencies from 7.3 - 10.3 Joule/cm² was used. The exposure time needed for treatment was from 2-5 min. according to the size of tattoo. Time interval between two sessions was from 3-4 weeks.

Results: Black and blue color tattoo removed rather completely with faint shadow. Red color tattoo removed completely. For green color tattoo there was no responses. In this study the treatment with Q-switched Nd: YAG laser offers bloodless, low-risk, no permanent complication, no scarring, and no disfigurements in skin.

Conclusion: Laser use is considered standard treatment for patient seeking tattoo removal.

Keyword: Tattoo/ Q-switched Nd: YAG laser/ Fluencies.

IRAQI J MED SCI, 2009; VOL.7 (3):66-81

Introduction

The origin of tattooing among humans is as old as humanity itself ⁽¹⁾. A tattoo is a permanent make or design made on the body when pigment is inserted into the dermal layer of the skin through ruptures in the skin's top layer ⁽⁹⁾. The National Institute of Health recognizes five types of tattoo; amateur, professional, cosmetic, medical, and traumatic (natural).

Dept. Biomedical applications / Institute of Laser for Postgraduate Studies, Baghdad University.

Address Correspondence to: Dr. Fatima A. Mohammad Ali

E-mail: fabidry@yahoo.com

Received: 15th June 2008 , Accepted: 7th October 2009.

Amateur tattoo are usually done with commonly available inks or pigments introduced into the skin manually. Professional tattoo uses commercial grade inks applied with a "gun" or specially designed apparatus. The main reasons for removing tattoos are enhancement of self-esteem and social, work or family reasons ⁽³⁰⁾. There are medical complications may be seen in patients with tattoo like bacterial endocarditis, dermatofibrosarcoma protuberans, hepatitis, lichenoid, metal toxicity and unusual cutaneous lesions like Boeck's sarcoid, secondary syphilis, discoid lupus erythematosus and eruption due to mercury sensitivity. Many different kinds of removal methods have been used throughout the

centuries, such as chemical (trichloacetic acid) ^(21, 29), mechanical (dermabrasion) ⁽⁵⁾, surgical (excision) ⁽²⁰⁾ and thermal (electrocautery) ⁽⁵⁾. All these techniques left some kind of hypo or hyper-pigmentation as well as scarring ⁽¹⁹⁾. With the advent of lasers in the late 1960's the outcome of tattoo removal completely changed, due to its specific absorption by the pigment itself. One study resumes the final cosmetic outcome in removing tattoos with the (continuous wave) CW CO₂ laser ⁽⁴⁾. Even though the CO₂ laser gave more acceptable results than chemical or mechanical methods, there was still unacceptable scarring. All patients treated by argon and carbon dioxide laser have some form of secondary scar formation making both of them are not the ideal treatment modalities ^(3,6). Leon Goldman published his first report of the use of a Q-switched ruby laser on a tattoo removal ⁽¹²⁾. The technique was abandoned for almost 20 years. The reasons were mainly technical and commercial. The Q-switched ruby laser at this time was more a laboratory system than a laser which could be used in daily dermatological clinics. The first no scarring tattoo removal was demonstrated in Scotland by Reid et al ⁽²³⁾. later on other teams refined the technique and used other Q-switched laser ⁽¹⁷⁾. Within the last 13 years, Q-switched laser systems have been available, which leave minimal damage.

They are able to remove some tattoos, depending on pigments that used ⁽¹⁹⁾, without scarring, hypo or hyper-pigmentation. Caution must be taken with the use of these lasers to avoid complications such as darkening. Some tattoo colors including flesh tones, light red, white, peach, and light brown containing pigments as well as some green and blue tattoo pigments, changed to black when irradiated with Q-switched laser pulses ⁽²⁾. Therefore in case of a multicolor tattoo treatment it is best to perform first a spot test on suspicious areas ⁽²²⁾.

Materials and methods

After clinical assessments of tattoo, (99) lesions were divided according to their tattoo's colors, then subdivided into amateur and professional (see table 1). Complete medical history was taken about blood diseases, viral hepatitis, history of medications that were used by patient (aspirin, steroid, and anticoagulant), type of ink and instrument which were employed to make tattoo and the age of tattoo. Then prepare the person, shaving the hair, clean the area, apply a topical anesthetic (Emla cream) to skin, covered with an occlusive dressing and left for 30 minutes. This study was done at the dermatology department in al-zahura hospital, Damascus / Syria from 1st of august to 20th of December 2007.

Table 1: Number of lesions, color of tattoo, and type of tattoo.

No. of lesions	Color of tattoo	Type of tattoo
20	blue	professional
38	blue	amateur
10	black	professional
6	black	amateur
8	green	professional
3	green	amateur
14	red(usually with other color)	professional

The laser employed in this present work was a Q-Switched Nd: YAG laser which is characterized by: Maximum output energy is 1Joule. Peak power is [1J/10ns] =100 Megawatts. Pulse duration is 7-10ns. Wavelength is 1064 and 532nm. Repetition frequency is (1, 3, 5, and 10Hz). Diameter of light spot is 2-8mm (for 1064nm). Diameter of light spot is 2-6mm (for 532nm). Energy of pulse is 1000mJ (for 1064nm). Energy of pulse is 500mJ (for 532nm). Different fluencies were used according to treatment session (see table 2). Aiming beam is 3.0 mW of 635nm diode laser.

Results

The study revealed the following results (table 2 and figures 1-7):Blue color tattoo, amateur type responded faster than professional, needed 3-4 sessions, while the professional needed 5-6 sessions with faint shadow (figure 1-2). Black color amateur tattoo was responded faster than professional, needed 2-4 sessions (figure 3 and 5). While the professional black color tattoo needed 3-5 treatment sessions (see figure 4). Complete removal of red tattoo after 2-3 treatment sessions was obtained (figure 2, 4 and 6). For green color tattoo there was no response after 10 sessions (figure 7).

Table 2: Parameters and Results

Wavelength(nm)	Parameters	Color of tattoo	Type of tattoo	Results
1064	Pulse width 10ns Spot size (3mm) R.R 5Hz Fluence 6.3-10.1j/cm ²	Blue	Professional	(20) Persons required (5-6) treatment sessions but all patients still have shadow.
			amateur	(38) Persons required (3-4) treatment sessions but all patients still have slight shadow.
1064	Pulse width 10ns Spot size (3mm) R.R 5Hz Fluence 6.3-10.1j/cm ²	Black	Professional	(10) persons required (3-5) treatment sessions for removing completely except (6) Patients still have cosmetically acceptable slight shadow.
			amateur	(6) Persons required (2-4) treatment sessions for removing completely tattoos except (2) patients still have cosmetically acceptable slight shadow.
1064	Pulse width 10ns Spot size (3mm) R.R 5Hz Fluence 6.3-10.1j/cm ²	Green	Professional	(8) Persons not response to treatment after (9-10).secessions.
			amateur	(3) Persons not response to treatment after (9-10).secessions except (1) patient slight faint in color after (9) sessions.
532	Pulse width 7ns Spot size (2mm) R.R 10Hz Fluence 7.3-10.3j/cm ²	Red	Professional And amateur	Always the red color tattoo in companion with other color (Blue, black, green). (14) Red color tattoos all of them professional required (2-3) treatment sessions to be removed completely.

Blue color tattoo



**Figure 1: Professional blue tattoo A=2nd session.B= 3rd session.
C= 4th session. D= 5th session and E= 6th session.**

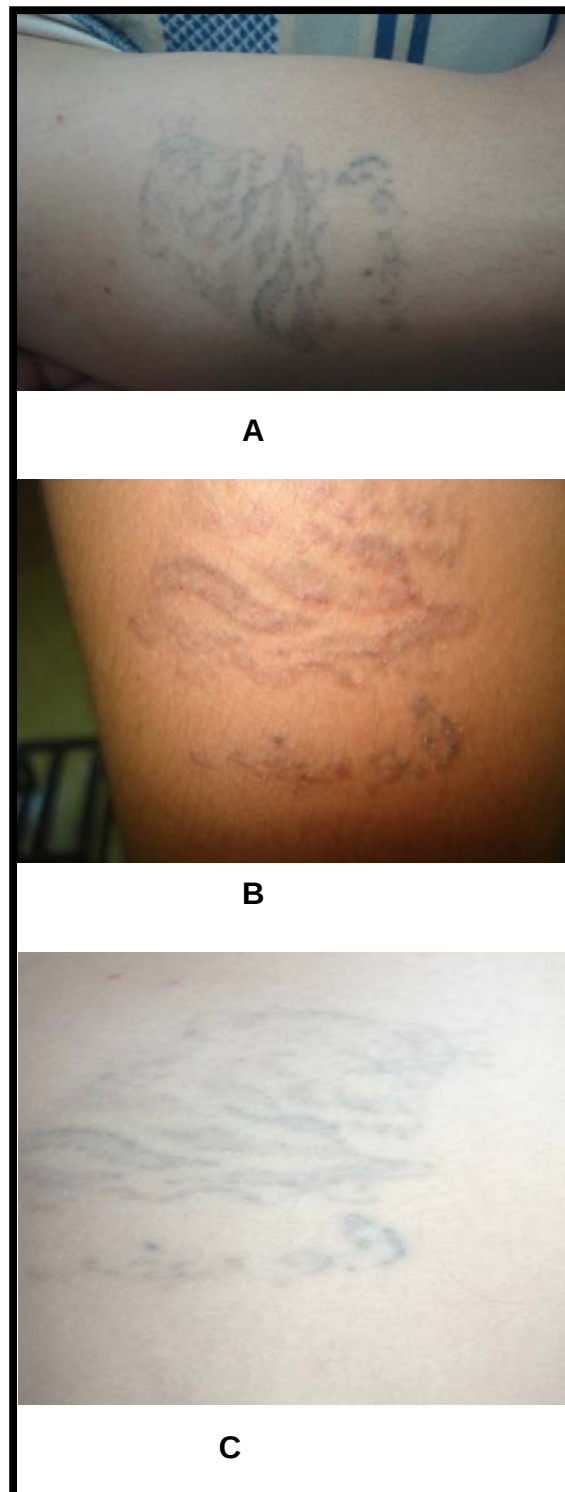


Figure 2: Professional blue and red tattoo. A=4th session for blue and 1st session for red. B=5th session for blue and 2nd session for red. C= 6th session for blue and 3rd for red.

Black color tattoo

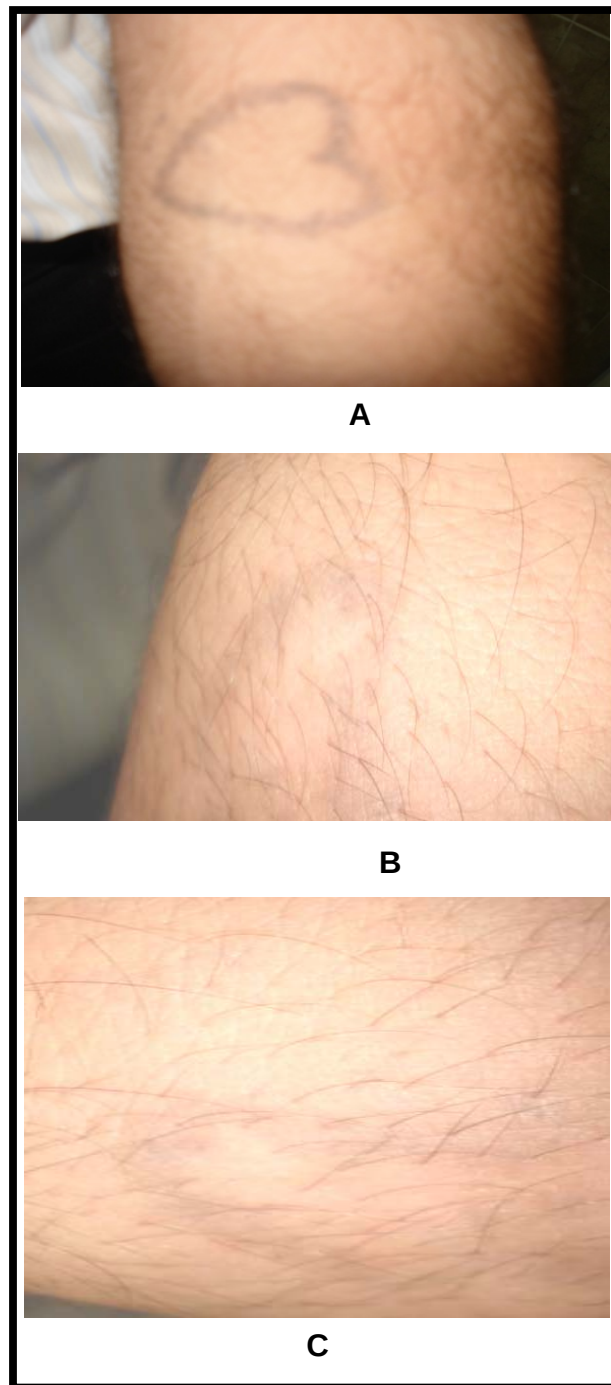


Figure 3: Amateur black tattoo. A= 2nd session. B= 3rd session .C= 4th session

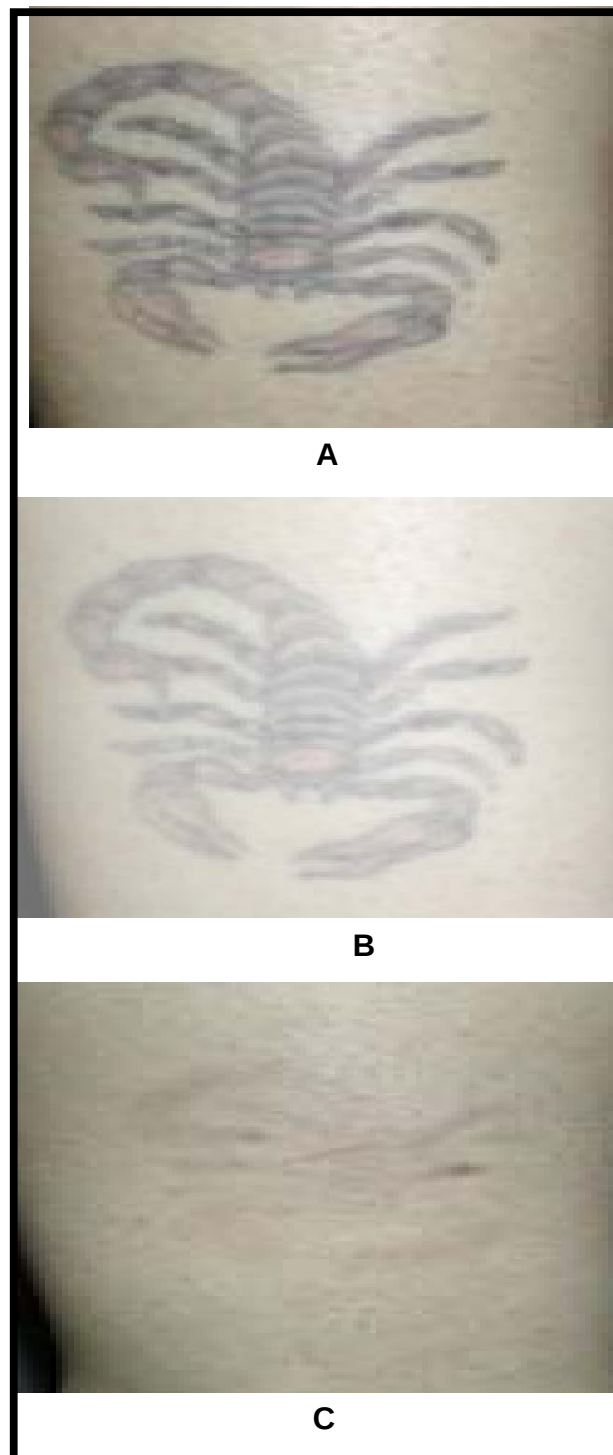


Figure 4: Professional black and red tattoo. A= 2nd session for black and 1st session for red. B= 3rd for black and 2nd for red. C= 4th for black and 3rd for red.



Figure 5: Amateur black tattoo. A= 2nd session .B= 3rd and C=4th session.

Red color tattoo

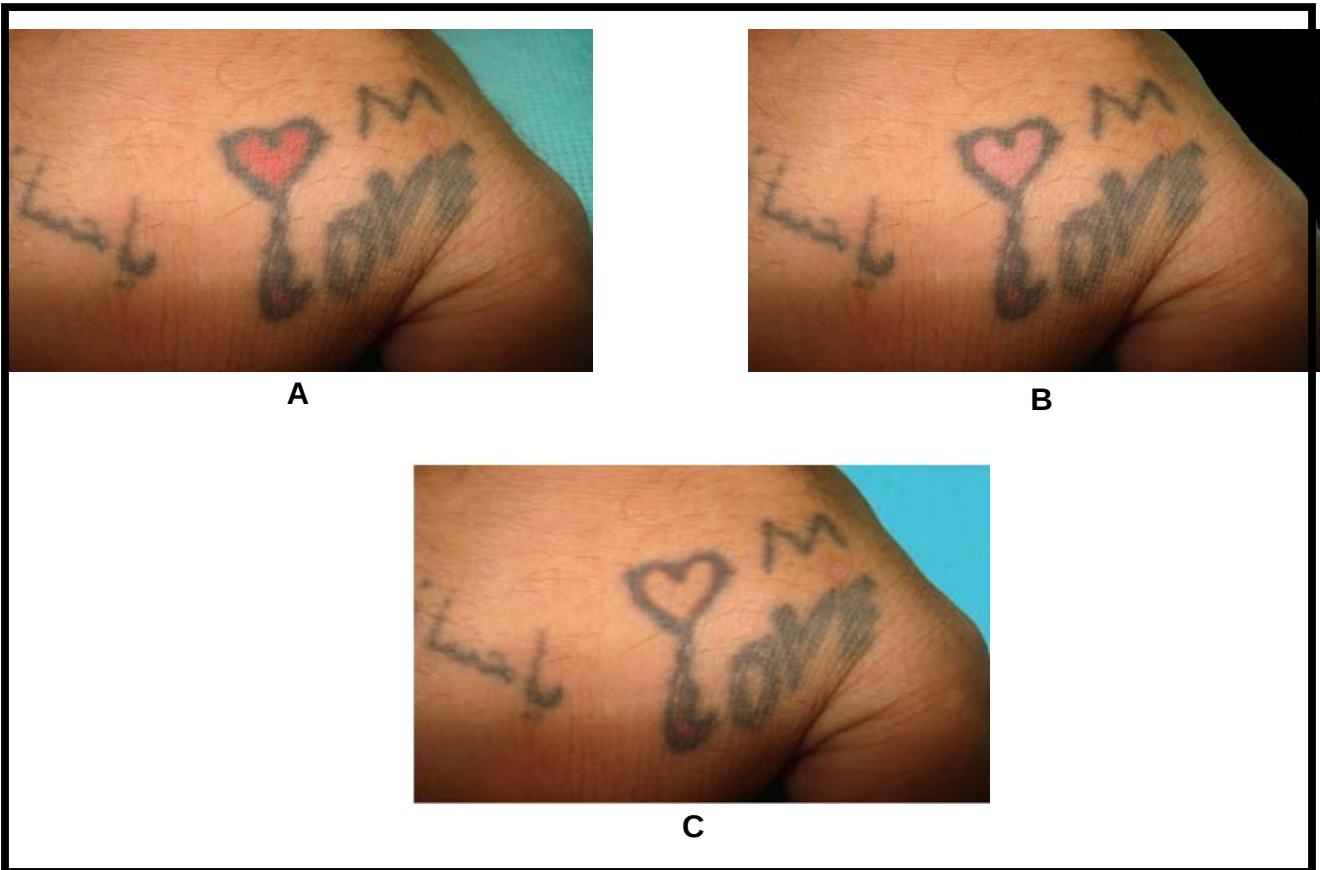


Figure 6: Red tattoo. A=1st session. B= 2nd session. C= 3rd session

Green color tattoo

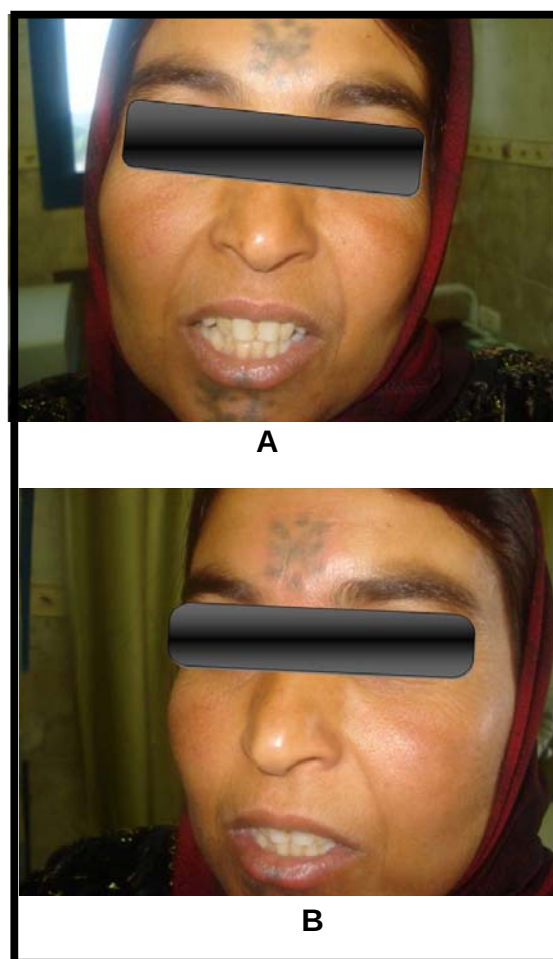


Figure 7: Green tattoo. A= 9th session. B= 10th session.

Complications

No complications have been seen like: scar, disfigurement or changing in the skin pigment, except the following transient complications have been noticed during this study (table 3 and figure 8).

1. Transient textural change was seen in (15) cases; occurred after multiple treatment sessions (figure 8, E and F). The textural change was resolved completely after 4 weeks without scarring; bepanthen ointment was used for treatment.

2. Pin-point bleeding: - occurred in (20) cases (figure 8, E and F) this due to in

direct vascular injury from photo acoustic waves generated by the laser's interaction with tattoo pigment⁽⁴⁰⁾. The pin-point bleeding was resolved within 5-7 days; it was treated by cleaning the area and topically applying antibiotic ointment and protective dressing to prevent secondary infection.

3. Systemic allergy occurred in one case only; the patient gave previous history of allergic rhinitis, the patient suffered, from joint pain, chills rhinitis, myalgia and itching after each laser treatment. Oral antihistamines and oral steroids before laser treatment are useful in this

case. The Q-switched laser is mobilizing the ink which may generate systemic allergic response

4. Local allergic response (figure 8, D) happened in two cases, probably due to photo allergic reaction Erythema, pruritus was happened in two cases after Q- switched laser treatment for red ink

tattoo, this probably because the red ink contain cinnabar (mercuric sulphide) . This complication was treated by locally applied (steroid + antibiotic) ointment, oral antihistamines and sunscreen after laser treatment.

Table 3: Complications after laser treatment.

Type of Complication	Number of lesions	%	notes
Hypopigmentation	Nil	-	-
Depigmentation	Nil	-	-
Hyperpigmentation	Nil	-	-
Transient textural change	15	17.64	Often resolved within one month
Permanent textural change	Nil	-	-
Scar	Nil	-	-
blister	Nil	-	-
Local allergic response	2	2.35	-
Erythema, pruritus	2	2.35	In red color tattoo (red ink contain cinnabar)
Inflamed nodules, varicose papules.	Nil	-	-
granulomas	Nil	-	-
Systemic allergic	1	1.17	Responded to antihistamines and steroids due to Q-switched mobilizing the ink which may generate systemic allergic response
Rupture blood vessels and aerosolize tissue	Nil	-	-
Pin-point bleeding	20	23.52	-



**Figure 8: A, B and C = Pin-point bleeding. D= local allergic response.
E and F= transient textural changes.**

Discussion

The absorption of light pulses by the tattoo pigments is the first and most important step. If there is no absorption, there is no reaction⁽¹⁹⁾. When the laser light is absorbed by the pigment molecule, the light energy is converted to heat or break chemical bonds in the pigment molecules⁽³⁰⁾. As the pigment heats up, the pigment molecule becomes extremely hot and causes rapid expansion of the water surrounding the molecule within the cell⁽³⁰⁾. This in turn creates negative pressure and a shock wave is created near the surface of the pigment molecule which helps to destroy it⁽³⁰⁾. The newly created smaller fragments are released into the lymphatic system and removed from the body⁽³⁰⁾.

The only part of the pigment which is really eliminated from the body is a very superficial one as it is eliminated by desquamation of epidermis during its repair; this phenomenon is called transepidermal elimination⁽³⁵⁾. Removal of tattoo pigments probably depend on variables factor such as color of ink and on the chemical composition of ink, amount of ink injected in the skin, the immune ability to remove the disrupted ink particles, natural skin colors and how the depth of injected ink⁽¹⁶⁾.

The reason that amateur tattoo ink is eliminated faster than professional ink is most likely due to a less uniform, most shallow distribution in the dermis as well as larger size of the individual ink particles found in amateur tattoo. For that reason amateur tattoo in blue and black colors needs less treatment session than professional. The study which done by Reid R⁽²²⁾⁽²⁴⁾ stated that, professional tattoos required 1 - 3 additional treatment sessions for complete pigment removal. Another study done by Stratigos AJ⁽²⁶⁾ stated that Amateur

tattoos require less number of treatments than professional tattoos. In this study red color tattoo required from 2-3 treatment sessions to be removed completely by 532nm Nd: YAG Q-switched laser. This explained in one study stated that, the red color well absorbed by 532nm⁽¹¹⁾⁽¹⁶⁾. Other study stated that the red and black response well in most instances⁽²⁵⁾. Study done by Kilmer et al, stated that all tattoos containing red ink were removed completely in 1-3 treatment sessions⁽¹⁵⁾. Green color tattoo not response to Nd:YAG laser 1064nm, only one case slight faint in color after 9 sessions this may be due to the green color ink contain titanium dioxide (TiO₂) as explain in study stated that {white ink, composed of about 95% (TiO₂), is commonly used to brighten green, yellow, and purple tattoos. the resulting mixtures are made such that green inks, for example, are typically composed of 30% to 40% (TiO₂)⁽²⁵⁾⁽²⁸⁾. Therefore, it is possible that tattoos with a large titanium fraction turn deeply black with Q-switched laser treatment, whereas other tattoos with smaller titanium "burdens" darken so little with laser irradiation that they appear grossly not to lighten. With repeated treatments of green tattoos, one possible scenario is that the green "organic" portion, at least superficially, is being eliminated, where as the titanium portion is darkening⁽²⁵⁾. It is unknown, however, whether TiO₂ is playing a role in resistance or, alternately, whether there is simply a higher damage threshold for the organic azo-dyes commonly used as green tattoo inks⁽²⁵⁾. Other study stated that green ink is best treated by a red wavelength (694nm or 755nm) because the absorption of green ink is greatest at this

wavelength. ⁽¹¹⁾⁽¹⁷⁾⁽¹⁸⁾. The Q-switched Nd: YAG presented better initial as well as long-term results ^{(13) (14)}. Other study done by Jone A, and Grevelink JM, showed that the benefit of Q-switched Nd: YAG laser, it is safe used in darker-skinned patient in whom melanin absorption is concerned ^{(10) (12)}.

In the present study the treatment with Q-switched Nd: YAG laser offers bloodless, low risk, no permanent complication no scarring and no disfigurement in skin was seen, The complication in this study is mainly transient textural change (no scarring) often resolved within one month, and pinpoint bleeding resolved within 5-7 days. There is no change in pigmentation of skin (no hypopigmentation or hyperpigmentation) this probably due to good preparation to patients; sun block is used by patients before and after laser treatment. So it is considered standard treatment for patient seeking tattoo removal.

References

1. Adatto Ma. : In Living Skin – Decorative Tattooing and Dermatology, Editions Roche Basel, (1993).
2. Anderson RR, Geronemus R, Kilmer SL, et al.: Cosmetic tattoo ink darkening. A complication of Q-switched and pulsed- laser treatment. Arch Dermatol. (1993). Aug; 129(8): 1010-4.
3. Apfelberg DB, Maser MR, and Lash H: Comparison of argon and carbon dioxide laser treatment of decorative tattoos: a preliminary report. Ann Plast Surg. (1985); Jan; 14(1): 6-15.
4. Arellano CR, Leopold DA, Shafiroff BB: Tattoo removal comparative study of six methods in the pig. Plast Reconstr Surg (1982). 70(6): 609–703
5. Boo-Chai K: The decorative tattoo: its removal by superficial dermabrasion. Plast Reconstr Surg(1963). 32: 559–563
6. Brady SC, Blokmanis A, and Jewett L: Tattoo removal with the carbon dioxide laser. Ann Plast Surg. (1979): Jun; 2(6): 482-90.
7. Colver GB, Cherry GW, Dawber RP, and Ryan TJ: Tattoo removal using infra-red

coagulation. Br J Dermatol (1985). 112(4):481–485

8. Goldman L, Wilson RG, Hornby P, Meyer RG: Radiation from a Q-switched ruby laser. Effect of repeated impacts of power output of 10 megawatt on a tattoo of man. J Invest Dermatol (1965). 44: 69–71
9. Goldstein AP: VII Histologic reactions in tattoos. J Dermatol Surg Oncol(1979). Nov; 5(11): 896-900.
10. Grevelink JM, Duke D, van Leeuwen RL: Laser treatment of tattoos in darkly pigmented patients: efficacy and side effects. J Am Acad Dermatol. (1996): Apr; 34(4): 653-6.
11. Haedersdal M, Bech-Thomsen N, Wulf HC, Hodersdal M: Skin reflectance-guided laser selections for treatment of decorative tattoos. Arch Dermatol (1996): Apr; 132(4): 403-7.
12. Jones A, Roddey P, Orengo I, Rosen T: The Q-switched ND: YAG laser effectively treats tattoos in darkly pigmented skin. Dermatol Surg. Dec; (1996): 22(12): 999-1001.
13. Kaufman, R, Boehncke, WH, Konig, K, Hibst, R: Comparative study of Q-switched Nd: YAG and alexandrite laser treatment of tattoos. Lasers Surg. Med.; (1993). S5: 54.
14. Kaufman R, Hibst R: Pulsed Erbium:YAG laser ablation in cutaneous surgery. Lasers Surg Med; (1996): 19(3): 324-30.
15. Kilmer SL, Lee MS, and Anderson RR: Treatment of multi-colored tattoos with the Q-switched Nd: YAG laser (532 nm): a dose response study with comparison to the Q-switched ruby laser. Lasers Surg Med Suppl. (1993). 5: 54.
16. 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(4): 330-338.
17. Kilmer SL, Lee MS, Grevelink JM, Flotte TJ, and Anderson RR: The Q-switched Nd: YAG laser effectively treats tattoos. A controlled, dose-response study. Arch Dermatol. (1993). 129:971–978.
18. Kuperman-Beade M, Levine VJ, Ashinoff R: Laser removal of tattoos. Am J Clin Dermatol. (2001). 2: 21–25.
19. Maurice A. Adatto: Laser: Tattoo Removal: Benefits and Caveat, Med. Laser Appl., (2004). 19: 175–185.
20. Miller TH, Hay-Roe V: Conventional surgery in techniques of removal tattoos. Plast Reconstr Surg 20: 910–914.
21. Piggot TA, Norris RW (1988). : The treatment of tattoos with trichloroacetic acid:

experience with 670 patients. *Br J Plast Surg*(1979). 41: 112–117.

22. Reid R, Muller S: Tattoo removal by CO laser dermabrasion. *Plast Reconstr Surg.* (1980). Jun; 65(6): 717-28.

23. Reid WH, Mcleod PJ, Ritchie A, Ferguson-Pell M: Q-switched Ruby laser treatment of black tattoos. *Br J Plast Surg:* (1983). 36: 455–459.

24. Reid, WH, Miller, ID, Murphy, MJ, Paul, JP, Evans, JH: Q-switched ruby laser treatment of tattoos, a 9-year experience. *Br. J. Plast. Surg.* (1990). 43:663-669.

25. Ross, E.V., Yashar, S., Michaud, N., Fitzpatrick, R., Geronemus, R., Tope, W.D., Anderson, R.R.: Tattoo Darkening and Non response after Laser Treatment. *Arch Dermatol* (2001). 137, 33-37.

26. Stratigos AJ, Alora MB, Urioste S: Cutaneous laser surgery. *Curr Probl Dermatol* (1998). 10:127-74.

27. Taylor CR, Anderson RR, Gange RW, Michaud NA, Flotte TJ: Light and electron microscopic analysis of tattoos treated by Q-switched ruby laser. *J Invest Dermatol* (1991). 97:131–136.

28. Timko AL, Miller CH, Johnson FB, Ross EV: In vitro quantitative chemical analysis of tattoo pigments. *Arch Dermatol.* (2001). 137: 143–147.

29. Van Der Velden EM, Van Der Walle HB, and Groote AD: Tattoo removal: tannic acid method of Variot. *Int J Dermatol* (1993). 32(5): 376–380.

30. Varma, S. Swanson, N.A., Lee, K.K.: Tattoo Ink Darkening Of A Yellow Tattoo After Q-switched Laser Treatment. *Clin. Exp. Dermatol.* (2002). 27, 461-463