

LASER TATTOO REMOVAL COMPARISON BETWEEN 1064 AND 532 NM OF A Q-SWITCHED Nd:YAG LASER TREATMENT

Nada Abusalah Almabrouk Imrigha^{a,b}, Lau Pik Suan^a, Shumaila Islam^a, Ganesan Krishnan^{a,b}, Noriah Bidin^{a,b*}

^aLaser Centre, IBNU-SINA Institute for Scientific and Industrial Research, Universiti Teknologi Malaysia, 81310 UTM Johor, Bahru, Johor, Malaysia

^bDepartment of Physics, Faculty of Science, Universiti Teknologi Malaysia, 81310 UTM Johor, Bahru, Johor, Malaysia

Article history

Received

15 August 2015

Received in revised form

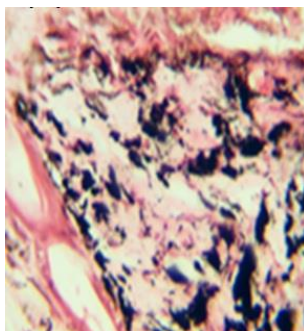
15 November 2015

Accepted

30 December 2015

*Corresponding author
noriah@utm.my

Graphical abstract



Abstract

Invention of the Q-switch advanced laser method is the most effective methods of tattoo removal compared to other methods of i.e. chemical, mechanical and surgical. In this study, we are reporting black pigment tattoo removal by comparing two wavelengths 532 nm and 1064 nm of Q-switched Nd-YAG laser. Using a single-pulse laser at 1064 nm wavelength, the maximum laser fluence for skin damage is 3.04 J/cm² with pulse energy 0.55 J. While, at 532 nm wavelength, maximum laser fluence is 0.5 J/cm² with pulse energy 0.42 J at 8-10 ns for tattooed skins. Moreover, after 1064 nm and 532 nm laser irradiations, skin biopsy of black tattooed rat's skin demonstrates the ink granules local redistribution. Microscopic study indicates that black ink particles become smaller and vanished from the skins after 1064 nm laser treatment. The findings of this study indicate that 1064 nm wavelengths of Q-switched Nd-YAG laser treatment with 0.55 J pulse energy, is one of the significant methods of black tattoo removal with remarkable differences.

Keywords: Q-switched Nd:YAG laser, Tattoo removal, Sprague Dawley rats, Interaction of laser with rats' skins

Abstrak

Penciptaan kaedah laser pensuisan-Q adalah kaedah yang paling berkesan untuk menyingkirkan tatu berbanding kaedah lain seperti kaedah kimia, mekanikal dan pembedahan. Dalam kajian ini, kami melaporkan penyingkiran pigmen tatu hitam dengan menggunakan laser Nd-YAG pensuisan-Q pada dua panjang gelombang 532 nm dan 1064 nm. Dengan menggunakan denyut tunggal laser pada panjang gelombang 1064 nm, ketumpatan tenaga maksimum bagi kerosakan kulit adalah 3.04 J/cm² dengan tenaga denyut 0.55 J. Pada masa yang sama, ketumpatan tenaga maksimum bagi panjang gelombang 532 nm ialah 0.5 J/cm² dengan tenaga denyut 0.42 J pada 8-10 ns. Selain itu, selepas kulit tikus didedahkan kepada sinaran laser 1064 nm dan 532 nm, biopsi kulit dilakukan pada kulit tikus dengan tatu hitam menunjukkan taburan semula dakwat granul setempat. Kajian mikroskopik menunjukkan bahawa zarah dakwat hitam menjadi lebih kecil dan hilang daripada kulit selepas rawatan laser 1064 nm. Hasil kajian ini menunjukkan bahawa laser Nd-YAG pensuisan-Q pada panjang gelombang 1064 nm dengan tenaga denyut 0.55 J merupakan salah satu kaedah yang penting untuk penyingkiran tatu hitam dengan perbezaan yang luar biasa.

Kata kunci: Laser Nd:YAG pensuisan-Q, penyingkiran tatu, tikus Sprague Dawley, interaksi laser dan kulit tikus

© 2016 Penerbit UTM Press. All rights reserved

1.0 INTRODUCTION

A tattoo is a form of body modification, it is using the ink needle pierce into the skin layer to change the pigment and created some permanent patterns or word¹. Tattooing was historically practiced during religious ceremonies, rites of passage, social status and worship strikethrough²⁻⁴. Furthermore, indigenous groups have been practicing the tattoo as traditional culture; it is a way of communication to spread out some information such as bravery, mature to marry, request protection from gods and social status⁵. Some of indigenous believe the tattoo will bring courage, harvest and good luck to their group⁶. Furthermore, in early 1980s, tattoo culture was linked to the underworld gang and considered as a courageous and brave behavior symbol, hence the tattoo test been given before join and recognize by gang member⁷. However, it is considered as criminal or low morale which was beginning to give impact in future. Therefore, people, due to constraint of society and psychosocial reasons, want to remove their tattoos. As a result, the removal of tattoos is one of the development researches. In history, there is variety of methods to remove the tattoo with various tools. The primary method used to remove a tattoo was barbaric technique by today's standard.

Dermabrasion and salabrasion are techniques that use a wire brush or salt to strip away layers of skin until the ink was no longer visible⁸. Thereafter, trichloroacetic acid (TCA) was used to remove the primary layers of skin to remove the tattoo ink⁹. The removal procedures are used in the early days also including excision and surgical treatments. This was time consuming, painful and very risky and also leads to other serious side effects i. e. being permanent scarring or deadly infection. Laser technology has promoted more efficient in clearing tattoo, reducing the risk of infection or scars and accelerate the healing process¹⁰⁻¹². It is advanced, safe and efficient method to remove the tattoo ink. Generally, during the treatment process, a medical-grade chiller/cooler or a topical anesthetic was mostly used to mitigate the pain. Afterword, the laser beam passes harmlessly through the skin and targets the ink only resting in a liquid state within. However, the effectiveness of treatment depends on laser parameters; wavelength, dose, power and duration of laser exposure. Inappropriate of laser parameter will cause scarring, hypopigmentation, or hyperpigmentation or limited success¹³⁻¹⁴. To overcome the stated problems, we used two wavelengths 532 nm and 1064 nm wavelength, 1064 nm with pulse energy of 0.55 J was

observed with stable, painless and fast outcomes. It is worth mentioning here that laser treatments are discussed in many studies but the "perfect tattoo laser removal" is not invented to date in our best knowledge. In this study, we are reporting a comparison between two laser wavelengths which was investigated on black pigmented tattoos applied on rats' skins.

2.0 MATERIAL AND METHOD

For this study, 4 male and female Sprague Dawley rats, weighing between the ranges of 250–300 g were employed as experimental animals. The particulars of experimental rats are summarized in Table 1. All procedures on animal handling followed the policy for care and use of experimental animals as approved by the Animal Ethics Committee, Universiti Kebangsaan Malaysia (approval project code: UTM/2015/NORIAH/29-JULY-2015-JULY-2017). The rats were anesthetized with KTX (0.1 ml/100gm).

The furs on the dorsal surface of rats were shaved off using an electric mouse clipper. The shaved surfaces were first cleaned with an alcohol pad for skin disinfection. Furthermore, all the surgical procedures were undertaken in the same conditions to limit variability in the wounding procedure. For tattoo designs, the tattoo gun, 20 turns/second with 2 needles of 0.5 cm tips was used which has the capability to inject the black pigment 1.5 mm deep into the dermis. The tattoo pigment was true black ink "C.i.77226". A total of 10 tattoos were drawing on the rat's skin in a single session. After four weeks, laser treatment of 532 nm and 1064 nm wavelengths was applied to each animal and observed the differences with microscopic and histopathological observations.

3.0 LASER PROCEDURE

Experiment start after anesthesia, because of the KTX injection action on the spot. All rats treated with a Q-switched (532 nm and 1064 nm) Nd:YAG laser using a 10 cm distance, 2 mm spot size and a pulse duration of 8-10 ns. The fluencies used were in the range of 0.50-3.04 J/cm².

Table 1 Particulars of experimental rats

Age, months	Gender	Weight, g
8	F	301
8	M	278
11	F	293
11	M	258

The laser parameters are tabulated in Table 2 which has been used for removal of black ink tattoos. In order to identify the tattoo removal with or without laser therapy, optical micrographs were taken with Amscope MU035, 5.0 megapixel camera. For histopathological assessment, microscopic slides were dyed with hematoxyline and eosine dyes and were examined under 20 × magnifications.

Table 2 Laser parameters

Wavelength (nm)	Energy (mJ)	Laser beam (mm)	Frequency (Hz)	Fluence (J/cm ²)
1064	500	10	1	3.04
532	400	10	1	0.50

4.0 RESULTS AND DISCUSSION

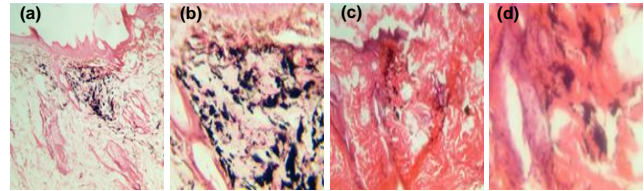
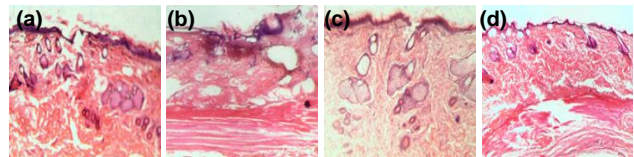
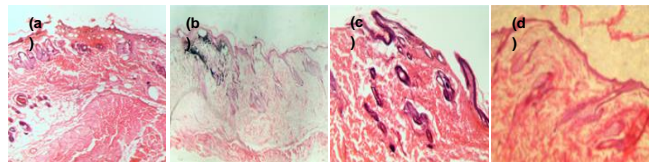
Two different wavelengths i.e. 532 nm and 1064 nm Nd:YAG laser using four moderate fluence sessions, (0.5–3.04 J/cm²) laser fluency were used to remove the black pigment tattoos from rats' skins. The fluence was determined prior and after tattoo removal treatment from area and pulse energy at two wavelengths. The values are tabulated in Table 3. The fluence 3.04 J/cm² with pulse energy 0.55 J was observed best for 1064 nm compared to fluence 0.5 J/cm² with pulse energy 0.42 J for 532 nm.

Table 3 The pulse energy variations at two wavelengths

Wavelength (nm)	Area (cm ²)	Pulse energy (J)	Fluence (J/cm ²)
532	0.659	0.14	0.21
	0.626	0.24	0.40
	0.836	0.32	0.40
	0.964	0.38	0.40
	0.807	0.42	0.50
	1.379	0.48	0.30
1064	0.134	0.17	1.30
	0.187	0.31	1.70
	0.164	0.35	2.10
	0.219	0.46	2.10
	0.328	0.55	3.04
	0.261	0.66	3.00

Furthermore, the Figure 1(a-d) shows the tattooed skin without laser treatment at different magnifications i.e. 10, 20, 40 and 100 x. The clear tattoo results can be seen at 20 x magnification as shown in Figure 1(b); the micrographs after laser

treatment were captured at this magnification. Histology laser tattoo removal at 532 nm at 20 x magnifications is shown in Figure 2 (a-d) corresponding to 0.14 J, 0.24 J, 0.38 J and 0.42 J laser pulses respectively.

**Figure 1** Histology laser tattoo removal without laser treatment at (a-d) at 10, 20, 40 and 100x magnifications respectively**Figure 2** Histology laser tattoo removal at 532 nm at 20x magnifications, (a-d) corresponding to 0.14 J, 0.24 J, 0.38 J and 0.42 J respectively**Figure 3** Histology laser tattoo removal at 1064 nm at 20x magnifications, (a-d) corresponding to 0.17J, 0.31J, 0.35J and 0.55J respectively

The micrograph indicates better tattoo clearance after 0.42 J laser pulse treatment as shown in Figure 2(d) at 20x magnification. It is probably due to the higher absorption coefficient at this mentioned wavelength¹⁵. Moreover, a frequency doubled wavelength at 532 nm has effectively treated for other colors than black ink tattoo¹⁶. Furthermore, the 1064 nm wavelength revealed a reduction of black tattoo pigments gradually with different pulse energy as shown in Figure 3(a-d). When the tattooed skin was treated with 1064 nm with low energy pulses (0.17, 0.31 and 0.35) as shown in Figure 3(a-c) respectively, tattoo ink reduction was observed but not removed completely. However, after high energy pulses i.e. 0.55 J, the tattoo was vanished after 10 laser shots as can be seen in Figure 3(d). Hassan et al. (2014) reported that pulse energy in 1064 nm is more efficient than pulse energy in 532 nm at black tattoo particle fragmentation¹⁶.

5.0 CONCLUSION

The Q-switched 532 and 1064 nm wavelength Nd:YAG laser with 2 mm spot size and a pulse duration of 8-10 ns was used for tattoo removal with efficient laser energy of (0.5-3.04 J/cm²) to remove black ink spots from the tattoo's skin. From experimental findings, it is observed that 1064 nm wavelength with maximum laser fluency 3.04 J/cm² and 0.55J energy pulse has capability to remove the tattoo ink from the rats' skins completely. Therefore, it concluded that the laser tattoo removal treatment at the mentioned wavelength is an effective method to remove the tattoos with less skin surface's damages or scars.

Acknowledgement

The authors would like to thank the Malaysian Ministry of Higher Education and Universiti Teknologi Malaysia for their financial funding through FRGS grant 4F543.

References

- [1] Goldstein, N. 2007. Tattoos Defined. *Clinics in Dermatology*. 25(4): 417-420.
- [2] Corrente, S., Moschese, V., Chianca, M., Graziani, S., Iannini, R., Rocca, M., and Chini, L. 2007. Temporary Henna Tattoo in Unsafe in Atopic Children. *Acta Paediatrica*. 96(3): 469-471.
- [3] DeSilva, D., and Seah, A. 2007. A "Tattoo" of Erythema Multiforme. *Annals of the Academy of Medicine. Singapore*. 36(3): 226.
- [4] Bazan, L. E., Harris, L. and Lorentzen, L. A. 2002. Migrant Gangs, Religion and Tattoo Removal. *Peace Review*. 14(4): 379-383.
- [5] Reed, C. E. 2000. Tattoo in Early China. *Journal Of The American Oriental Society*. 120(3): 360-376.
- [6] Thomas, N., Cole, A., and Douglas, B. 2005. *Tattoo: Bodies, Art and Exchange in the Pacific and the West*. Reaktion Books.
- [7] Koch, J. R., Roberts, A. E., Armstrong, M. L., and Owen, D. C. 2004. Correlations of Religious Belief and Practice with College Students "Tattoo-Related Behavior". *Psychological Reports*. 94: 425-430.
- [8] Clabaugh, A. W. 1975. Tattoo Removal by Superficial Dermabrasion: Five-Years Experience. *Plast Reconster Surg*. 55: 401-405.
- [9] Fitzpatrick, E. R., Whitney, D. T., Goldman, P. M. and Satur, M. N. 1996. Pulsed Carbon Dioxide Laser, Trichloroacetic Acid, Baker-Gordon Phenol, and Dermabrasion: A Comparative Clinical and Histologic Study of Cutaneous Resurfacing in a Porcine Model. 132(4): 469-471.
- [10] Kossida, T., Rigopoulos, D., Katsambas, A. and Anderson, R. R. 2011. Optimal Tattoo Removal in A Single Laser Session Based On The Method Of Repeated Exposures. *American Journal*. 66(2): 271-277.
- [11] Lau, P. S., Bidin, N., Krishnan, G., Anaybbaleg, S. M., Marsin, F. M., Sum, M. B., Baktiar, H., Nassir, H. Z., Chong, P. L. and Hamid, A. 2015. Wound Treatment on a Diabetic Rat Model by A808 nm Diode Laser. *Laser Physics*. 25(7): 075601.
- [12] Beade, M. K., Levine, J. V. and Ashinoff, R. 2001. Laser Removal of Tattoos. *American Journal of Clinical Dermatology*. 2(1): 21-25.
- [13] Bernstein, F. E. 2015. A Widespread Allergic Reaction to Black Tattoo Ink Caused by Laser Treatment. *Lasers in Surgery and Medicine*. 47(2): 180-182.
- [14] Ohshiro, T. 2015. History of the World Federation of Societies for Laser Medicine and Surgery (WFLSLS) and Its Non-Profit Organization (NPO-WFLSLS). *Laser Ther*. 24(1): 9-14.
- [15] Irkoren, S., Demirdover, C., Akad, B. Z. and Gorgu, M. 2011. The Q-Switched Nd: YAG Laser in Tattoo Removal and the Effect of Lymphatic Elimination: An Experimental Study in Rabbits. *Surgical Science*. 2: 262-268.
- [16] Hassan, S., Hamoudi, W., Ibrahim, T. and Haroun, R. 2014. Non-Ablative Tattoo Removal Using Fundamental and Second Harmonic Nd:YAG laser (Tattoo Ink Clearance Response). *Iraqi Journal of Applied Physics*. 10: 21-26.