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Original Research Article

Efficacy and safety of Q-Switched Nd : Yag laser in tattoo removal at tertiary care center in Gujarat

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ABSTRACT

Introduction: Tattooing has been practiced for at least two thousand years. Much effort has been exerted in attempting to make tattoos brighter, more colourful and stable. In the present, it is believed that laser therapy is the best method in cosmetic terms of tattoo removal.
Aims: Evaluate the efficacy and safety of Q switched ND YAG laser in tattoo removal.
Materials and Methods: This was a "randomized, prospective, interventional" single centre study carried out in dermatology outpatient department of GMERS Medical College, Gandhinagar, Gujarat, a tertiary care teaching hospital in western India. Total 89 patients with tattoo of red, green, blue and black colour in scripted on different parts of their body according to inclusion and exclusion criteria were enrolled for a period of 1 year and 5 months (January 2016 -May 2017) in our study.
Results: Majority of the participants (58.5%) were from 21-25 years of age group. Mean age of participants was found out to be 21.9 years. Amature tattoo 63(70.8%) were outnumbered then professional tattoo 26(29.2%). Blue-black tattoo (92.1%) was more common than red-green (7.9%) colour tattoo. Most common reason for tattooing was fashion (69.7%). More than three fourth participants (78.7%) needed $\geq$ 6 sittings for tattoo removal. In 13.5% participants, it was $\geq$10 sittings while in others (7.8%) it was 3-5 sittings.
Conclusion: Excellent response was seen in amature tattoo group as comparison to professional tattoo group and almost all of the study participants were either satisfied or very satisfied. Only minor adverse reactions were reported after tattoo removal.

1. Introduction

Tattooing has been practiced for at least two thousand years. Much effort has been exerted in attempting to make tattoos brighter, more colourful and stable. [1]

Today, excellent tattooing equipment and nearly one hundred colors of commercial tattoo dyes are used in making tattoos. Scientists and doctors have been searching for a successful means of removing or concealing tattoos, using traditional methods such as rubbing with salt, intradermal injection of chemical irritants, retattooing with flesh coloured pigment or using modern techniques such as irradiation by laser light. Reasons for tattoo removal include inability to obtain sophisticated employment, a desire for dissociation from previous imprisonment, 'or to improve social state and the distaste of family and friends. Sometimes there is a need to remove medical complications caused by the tattoo. [2]

Laser tattoo removal was initially reported by Goldman *et al* [3–5] who performed experimental treatment of many lesions, including tattoos, with different lasers. non-Q-switched and Q-switched ruby, carbon dioxide and argon lasers, and lasers combined with chemicals have all been studied for the removal of tattoo. Other laser used in tattoo removal include Q-switched Nd : YAG 1064 nm, Q switched Frequency doubled Nd YAG Laser 532 nm, Q switched Ruby 694 nm, Q switched Alexandrite 755 nm. Q switched Nd YAG 1064 nm. The principal laser-skin interactions observed in dermal melanocytosis by Q-switched ND: YAG laser treatment is based on photothermal and photomechanical interactions induced by

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selective photothermolysis.[6] In the present, it is believed that laser therapy is the best method in cosmetic terms of tattoo removal. The major disadvantage is the high cost of the equipment; slow tedious treatment is a second disadvantage.

2. Aims

Evaluate the efficacy and safety of Q switched ND YAG laser in tattoo removal

3. Objectives

To study the effectiveness of Q switched ND YAG laser in amateur and professional tattoos removal. To compare the efficacy of 1064nm Q switched ND YAG laser in blue -black tattoo removal at fluences of 7 j/cm sq. and 9 j/cm sq. To study the efficacy of 4 j/cm sq of 532 nm Q switched ND YAG laser in red tattoo removal in Indian skin as per serial photographic documentation and to study the immediate and delayed adverse events in Q Switched ND YAG laser tattoo removal.

4. Materials and Methods

This was a " randomized, prospective, interventional " single centre study carried out in dermatology outpatient department of GMERS Medical College, Gandhinagar, Gujarat, a tertiary care teaching hospital in western India. The study protocol was presented and approved by an IEC (Protocol no. 39/2015). Patients were explained clearly about the nature and purpose of the study in the language they understood. Written informed consent and photographs were obtained for medical records before enrolling the patients for the study. Total 89 patients with tattoo of red, green, blue and black colour in scripted on different parts of their body selected by purposive sampling were enrolled for a period of 1 year and 5 months (January 2016 -May 2017) in our study.

4.1. *Inclusion Criteria*

All the Subjects with tattoo of red, green, blue and black color inscripted on different parts of their body with ready to give written consent.

4.2. *Exclusion Criteria*

Age less than 15 Years, Pregnant / lactating females, associated photo aggravated skin disease and medical illness for e.g. SLE, History of allergy or sensitivity to ink pigment, staphylococcal infection, herpes simplex virus infection, unstable vitiligo, psoriasis, Patient with tattoo granuloma, keloids and colloidal tendency, bleeding abnormalities and /or on anticoagulant therapy and Subject s with unrealistic expectations.

5. Data Analysis

Collected data was entered in the excel data sheet and data analysis was done with the help of Epi. Info.7.2 software.

5.1. *Data collection methods*

After detailed history and thorough clinical exam ination of tattoo patients, we have used 1064/532nm Q switched ND YAG laser. We divided the patient into two groups. Group A patients with Black and blue tattoo, we used the 1064nm wavelength, 5Hz repetition rate and 3mm spot size whereas Group B patients with Red/ Green tattoo, we used 532 nm wavelength, 5Hz repetition rate and 2mm spot size.

5.2. *Randomization*

All the subjects who satisfy the inclusion and exclusion criteria has been recruited and subjects with black/blue and red/green tattoo have been separated. 1) Black/blue tattoo; Subjects has been separated according to the type of tattoo i.e., professional and amateur tattoo. Subjects of both the types of tattoo have been randomly and equally divided into two groups. Subjects in one group have been treated with 7 j/cm sq. while subjects in the other group have been treated with 9 j/cm sq. 2) Red /green tattoo ; All the subjects with red/green tattoo have been treated with 4 j/cm^2. Prior consent of the patient has been taken before the study. Immediately after the procedure subjects have been given ice packs to reduce pain, erythema and oedema. Subjects have been explained about photo protection. Wound care was consisting of local antibiotics (fusidic acid ointment) and sunscreen lotion. Digital photographs have been taken before each treatment. Treatment sessions have been planned at every 4 weeks interval till the clearing of tattoos. At each visit patient has been evaluated for percentage of clearing and side effects such as pigmentary changes and scarring if any has been noted down. Patients have been observed in follow up for 12 to 18 months after the last session to assess the outcome of Q switched laser.

- Grading of improvement in tattoo removal at each visit

6. Description

7. Results and Discussion

A total number of 100 subjects attending OPD from January 2016 to May 2017, requested for tattoo removal. Out of these, 89 subjects were included i n our study. Majority of the participants (n=52, 58.5%) were from 21-25 years of age group, followed by 16-20 years of age group (n=28, 31.5%). Mean age of participants was found out to be 21.9 years with SD of 3.4 years. Mean age in present study was quite comparable with the similar study done by Asilian A et al,[7] SG Parasramani et al[8] , Majid I et al[9] and Zawar VP et al[10] where mean age was 26.3, 25.2, 27.0 & 23.0 years respectively. Contrast result was found in similar study done

Table 1:

Grade	Description	Percentage of Clearing
5	Clear	More than 95 percentage
4	Excellent	76-95
3	Good	51-75
2	Fair	25-50
1	Poor	Less than 25

by Bansal C et al,[11] Bencini PL et al,[12] Zhou X et al,[13] Kirby W et al[14] and Wang ECE et al.[15]

Among 89 patients 71, (79.8%) were male whereas females were 18, (20.2%). Male to female ratio was found out to be 1:0.25. Study included males more than females in the study which is comparable with the study done by Bencini PL et al[12] but not comparable with study done by Asilian A et al,[7] Zawar VP et al,[10] Aurangabadkar S et al,[16] Wang ECE et al[15] and Bansal C et al[11] where female participants were more than male participants.

Among the study participants, 93.2% (n=83) were unemployed while remaining (n=06,) 6.8%were employed. Fitzpatrick skin type IV 77, (86.5 %) was most common followed by type III 07, (7.9%), an d type V 05, (5.6%) among 89 subjects. Study observed that highest number of participants have Fitzpatrick skin type IV followed by skin type III & V. These findings are comparable with the similar study done by Bencini PL et al,[12]Zhou X et al,[13] Bansal C et al,[11] Wang ECE et al[15] and Eric F et al.[17]

Most common type of tattoo among study participants was Amateur tattoo 63 (70.8%) while professional was 26(29.2%). Present study found amateur tattoo more that profession tattoo among participants which is comparable with the findings of similar study done by Jones A et al,[18] Klimer et al,[19] Ferguson & August et al[20] and Werner et al.[21] But this finding is not similar with the study done by Kirby & Alston et al.[14]

82 study participants (92.1%) had blue-black and rest were 7 had Red -green (7.9%). Black pigments are the easiest to remove due to their relative small size, lack of metallic elements, and ability to absorb every wavelength of light. Red pigments are also considered easily removable in comparison to other colors, such as green and yellow based on their composition as well. Red pigments are known to contain a mixture of metallic and carbon elements with a smaller percentage of titanium dioxide, leading to its ease in removal.[22] Similar findings were observed in study done by Bensini PL et al[12] and Eric FB et al.[23]

Majority of the participants (n=65, 72.9%) had tattoo on forearm, followed by tattoo on hand (n=24, 26.9%). Other sites were arm (n=09, 10.1%), shoulder (n=05, 5.6%), chest (n=01, 1.1%), back (n=02, 2.2%), chin (n=01, 1.1%) and wrist (n=01, 1.1%). Present study was found highest number of tattoo on forearm followed by hand but contrast results were found in similar study done by Bensini PL et al,[12]Majid I et al[9] and Wang ECE et al[15] where highest tattoo found on face.

Reason for tattooing among study participants shows the most common reason for tattooing was fashion (n=62, 69.7%) followed by religious (n=11, 12.4%), peer pressure (n=09, 10.1%) and relationship (n=07, 7.8%)

As in shown in Table 2, More than half (n=52, 58.5%) participants had removed their tattoo due to recruitment in army. Stringent discipline in army must be a reason for people pursuing to remove the tattoo. Other reasons for tattoo removal were change of employment (n=04, 4.5%), change of partner (n=06, 6.7%), family pressure (n=06, 6.7%), police recruitment (n=02, 2.2%), other new employment (n= 12, 13.6%), improved self-esteem (n=01, 1.1%). Together, recruitment in army or police and change in employment or new employment accounted as s reason for 83.3% of the study participants for removing their tattoo.

In our study, 92.1% (n=82) participants were exposed to wavelength of 1064nm by ND: YAG laser for tattoo removal. 7(7.9%) were exposed to wavelength of 532 nm by ND: YAG laser Table 3. Present study used 1064nm by ND: YAG laser for tattoo removal in more than 90% participants. Similar study done by Kim YJ et al,[24] Asilian A et al,[7] Cencic B et al,[25] Kilmer et al,[19] Levin & Geronemus et al,[26] Werner et al[21] and Ho WS et al[27] used 1064nm by ND: YAG laser and study done by Gorsic M et al[28] used 532nm ND: YAG laser and study done by Anderson RR et al[29] and Alsaad AF et al[30] used both type of ND: YAG laser for tattoo removal.

Fluence used for tattoo removal as in shown in table 3, 42.8% (n=38) participants, it was 9 J/cm^2. In 50.5% (n=45) participants, it was 7 J/cm^2 and in 6.7% (n=06) study participants it was 4 J/cm^2. Laser beam diameters were available from 2 to 10 mm which allows maximal fluences of up to 11 J/cm2 for 1,064 nm and 5.5 J/cm2 for 532 nm. Present study used 9-7 J/cm^2 fluence of ND: YAG laser for the treatment of tattoo. Similar study done by Aurangabadkar S et al,[16] Ho WS et al,[27] Vibhagool et al,[31] Westerhof et al,[32] Baba et al[33] and Kim YJ et al[24] also used same fluence of ND: YAG laser in their study.

70 participants (78.7%) needed $\geq$ 6 sittings for tattoo removal. In 12(13.5 %) participants, it was $\geq$10 sittings while in 7(7.8%) it was 3-5 sittings. None of the study participants had their tattoo removed in 1 or 2 sittings Table 5 . Present study achieved success in almost $\frac{3}{4}$ patients in tattoo removal treatment which quite comparable

with similar study done by Jones A et al,[18] Fergusion & August et al,[20] Parasramani SG et al,[8] and Vibhagool et al.[31] Contrast result was found in similar study done by Ho WS et al,[27] Aurangabadkar S et al,[16] Wang ECE et al,[15] Reda et al,[34] Westerhof et al,[32] Baba et al[33] and Kim YJ et al.[24] Success rate of tattoo removal is depending up on site, number, type, type of treatment, number of session, skin type, amount of ink used in tattoo, color of tattoo and age of tattoo.[14]

Table 6 compares the efficacy of fluence 7 J/cm^2 vs 9 J/cm^2 of ND: YAG laser in amateur tattoo removal at different sessions. Response was graded as poor, fair, good, excellent and clear based on percentage reduction in pigmentation. At the end of 2nd session 41.7%(n=15) had poor response and 58.3%(n=21) had fair response with fluence 7 J/cm^2 while 11.5%(n=03) had poor response, 73.1%(n=19) had fair while 15.4% (n=04) had good response with fluence 9 J/cm^2. This increased response with fluence 9 J/cm^2 was found to be statistically significant. Similarly, after 4th session statistically significant better response was seen with fluence 9 J/cm^2 as compared to fluence 7 J/cm^2. After 6th session, 81.9% (n=18) had excellent response and 9.1% (n=02) had clear response with fluence 9 J/cm^2. While with fluence 7 J/cm^2, only 54.3% (n=19) had excellent response. This observed difference in response was also found to be statistically significant**.**

Table 7 shows the comparison of the efficacy of fluence 7 J/cm^2 vs 9 J/cm^2 of ND: YAG laser in professional tattoo removal at different sessions. At the end of 2nd session, 100% (n=09) had poor response with fluence 7 J/cm^2 while 91.7% (n=11) had poor response and 8.3% (n=01) had fair response with fluence 9 J/cm^2. This difference in response was found to be statistically non-significant. Similarly, after 6th session, no statistically difference was observed with fluence 9 J/cm^2 as compared to fluence 7 J/cm^2 with regards to grading of response. After 10th session, 66.4% (n=04) had good response and 33.3% (n=02) had fair response with fluence 9 J/cm^2. While with fluence 7 J/cm^2, all 100% (n=04) had good response. This observed difference in response was also found to be statistically non-significant.

Table 8 compares the response between amateur and professional blue-black tattoo with fluence 7 J/cm^2 and 9 J/cm^2 at the end of 6th session. With fluence 7 J/cm^2 45.7% (n=16) had good response and remaining 54.3% (n=19) had excellent response in amateur tattoo group, whereas in professional tattoo group, all 100% (n=01) had good response. However, no statistically significant association was observed between amateur and professional group at 7 J/cm^2. But with fluence 9 J/cm^2, a statistically significant association was observed between amateur and professional group. Excellent response was seen in 81.9% (n=18) of amateur tattoo group, while it was seen only in 8.3% (n=01) of professional tattoo group**.**

Table 9 shows comparison of response between professional red-green and blue-black tattoo removal at the end of 10th session. In red green tattoo group, at the end of 10th session, 20% (n=02) had fair response while 80% (n=08) had good response. Whereas in blue black tattoo group, 50% (n=01) had fair response while 50% (n=01) had good response. There was no statistically significant association observed between red green and blue-black tattoo with regard to grading of response.

Among the adverse reaction after tattoo removal, two-third participants (74.2%, n=66) faced pain as an immediate reaction followed by erythema and oedema (68.5%, n=61). Pinpoint bleeding as an immediate reaction was seen in 11.2% (n=10) study subjects. As an early reaction 2.2% (n=02) faced burn and blisters. A total of 19.1%(n=17) had delayed reactions. Among them, 12.4%(n=11) faced hypo pigmentation and 6.7%(n=06) had darkening. Present study observed immediate adverse effect among 2/3 participants and delayed adverse effect observed in 2/5 participants. These findings are comparable with the similar study done by Ho WS et al,[27] Westorhof et al[32] and lower rate of adverse events observed in similar study done by Levine & Geronemus et al,[26] Ferguson & August et al,[20] Werner et al,[21] Kimler et al,[19] Kirby & Alston et al,[14] Aurangabadkar S et al,[16] Kono T et al,[35] Reda et al[34] and Baba et al.[33]

In our study, none of the participants were left with scar after tattoo removal. 44 (49.4%) participants were very satisfied while 42(47.2 %) were satisfied and only 3.4% were not satisfied after the tattoo removal.

8. Conclusion

Amateur tattoo removal requires lesser sessions as compared to professional tattoo. Most of the participants were exposed to 106 4 nm wavelength for tattoo removal, while fluence used was 9 J/cm^2, 7 J/cm^2 and 4 J/cm^2. Most of the participants in our study required six or more sitting for tattoo removal. A statistically significant improved grading of response was observed in amateur tattoo removal with fluence 7 J/cm^2 as compared to 9 J/cm^2 at the end of 2nd, 4th and 6th session. With 7 J/cm^2, there was no statistically significant association observed between amateur and professional group with respect to grading of response. But with fluence 9 J/cm^2, a statistically significant association was observed between amateur and professional group. At the end of 10th session, there was no statistically significant association observed between red green nd blue-black tattoo with regard to grading of response.

Table 2: Reason for tattoo removal among study participants (N=89)

Reason for tattoo removal	Number	Percentage
Army recruitment	52	58.5
Change of employment	04	04.5
Change of partner	06	06.7
Family pressure	06	06.7
Police recruitment	02	02.2
Other new employment	12	13.6
Improve self esteem	01	01.1
Other reasons	06	06.7

Table 3: Wavelengths of ND: YAG laser used for removal of tattoo among study participants (N=89)

Wavelengths of Nd YAG laser used for removal of tattoo (nm)	Number	Percentage
1064	82	92.1
532	07	07.9

Table 4: Fluence of ND: YAG laser used for removal of tattoo among study participants (N=89)

Fluence of ND: YAG laser used for removal of tattoo (J/cm2)	Number	Percentage
09	38	42.8
07	45	50.5
04	06	06.7
02	00	00.0

Table 5: Total number of sittings done for removal of tattoo among study participants (N=89)

Total number of sittings done for removal of tattoo	Number	Percentage
1-2	00	00.0
3-5	07	07.8
≥ 6	70	78.7
≥ 10	12	13.5

Table 6: Comparison of efficacy of fluence 7 J/cm^2 vs 9 J/cm^2 in amateur tattoo removal at different sessions

After Session	Grading of response	Fluence		value
		7 J/cm2 N (%)	9 J/cm2 N (%)	
2nd	Poor (Grade 1, <25%)	15 (41.7)	03 (11.5)	= 0.02, (df = 4)
	Fair (Grade 2, 25-50%)	21 (58.3)	19 (73.1)	
	Good (Grade 3, 51-75%)	00 (00.0)	04 (15.4)	
	Excellent (Grade 4, 76-95%)	00 (00.0)	00 (00.0)	
	Clear (Grade 5, >95%)	00 (00.0)	00 (00.0)	
	Total	36 (100.0)	26 (100.0)	
4th	Poor (Grade 1, <25%)	00 (00.0)	01 (03.9)	= 0.00
	Fair (Grade 2, 25-50%)	13 (36.1)	02 (05.6)	(df = 4)
	Good (Grade 3, 51-75%)	23 (63.9)	16 (61.6)	
	Excellent (Grade 4, 76-95%)	00 (00.0)	07 (26.9)	
	Clear (Grade 5, >95%)	00 (00.0)	00 (00.0)	
	Total	36 (100.0)	26 (100.0)	
6th	Poor (Grade 1, <25%)	00 (00.0)	00 (00.0)	= 0.00
	Fair (Grade 2, 25-50%)	00 (00.0)	01 (04.5)	(df = 4)
	Good (Grade 3, 51-75%)	16 (45.7)	01 (04.5)	
	Excellent (Grade 4, 76-95%)	19 (54.3)	18 (81.9)	
	Clear (Grade 5, >95%)	00 (00.0)	02 (09.1)	
	Total	35 (100.0)	22 (100.0)	

Table 7: Comparison of efficacy of fluence 7 J/cm^2 vs 9 J/cm^2 in professional tattoo removal at different sessions

After Session	Grading of response	Fluence 7 J/cm2 N(%)	9 J/cm2 N(%)	value
2nd	Poor (Grade 1, <25%)	09 (100.0)	11 (91.7)	= 0.99
	Fair (Grade 2, 25-50%)	00 (00.0)	01 (08.3)	(df = 4)
	Good (Grade 3, 51-75%)	00 (00.0)	00 (00.0)	
	Excellent (Grade 4, 76-95%)	00 (00.0)	00 (00.0)	
	Clear (Grade 5, >95%)	00 (00.0)	00 (00.0)	
	Total	09 (100.0)	12 (100.0)	
6th	Poor (Grade 1, <25%)	01 (12.5)	01 (08.3)	= 0.99
	Fair (Grade 2, 25-50%)	06 (75.0)	07 (58.4)	(df = 4)
	Good (Grade 3, 51-75%)	01 (12.5)	03 (25.0)	
	Excellent (Grade 4, 76-95%)	00 (00.0)	01 (08.3)	
	Clear (Grade 5, >95%)	00 (00.0)	00 (00.0)	
	Total	08 (100.0)	12 (100.0)	
10th	Poor (Grade 1, <25%)	00 (00.0)	00 (00.0)	= 0.99
	Fair (Grade 2, 25-50%)	00 (00.0)	02 (33.3)	(df = 4)
	Good (Grade 3, 51-75%)	04 (100.0)	04 (66.4)	
	Excellent (Grade 4, 76-95%)	00 (00.0)	00 (00.0)	
	Clear (Grade 5, >95%)	00 (00.0)	00 (00.0)	
	Total	04 (100.0)	06 (100.0)	

Table 8: Comparison of response between amateur and professional blue-black tattoo with fluence 7 J/cm^2 and 9 J/cm^2 at the end of 6^{th} session

Fluence	Grading of response	Number of subjects (%) Amateur	Professional	P value*
7 J/cm2	Poor (Grade 1, <25%)	00 (00.0)	00 (00.0)	= 0.99
	Fair (Grade 2, 25-50%)	00 (00.0)	00 (00.0)	(df = 4)
	Good (Grade 3, 51-75%)	16 (45.7)	01 (100.0)	
	Excellent (Grade 4, 76-95%)	19 (54.3)	00 (00.0)	
	Clear (Grade 5, >95%)	00 (00.0)	00 (00.0)	
	Total	35 (100.0)	01 (100.0)	
9 J/cm2	Poor (Grade 1, <25%)	00 (00.0)	01 (08.3)	= 0.00
	Fair (Grade 2, 25-50%)	01 (04.5)	07 (58.4)	(df = 4)
	Good (Grade 3, 51-75%)	01 (04.5)	03 (25.0)	
	Excellent (Grade 4, 76-95%)	18 (81.9)	01 (08.3)	
	Clear (Grade 5, >95%)	02 (09.1)	00 (00.0)	
	Total	22 (100.0)	12 (100.0)	

Table 9: Comparison of response between professional red-green and blue-black tattoo removal at the end of 10^{th} session

Grading of response	Number of subjects (%) Red-green tattoo	Blue-black tattoo	P value*
Poor (Grade 1, <25%)	00 (00.0)	00 (00.0)	= 0.99
Fair (Grade 2, 25-50%)	02 (20.0)	01 (50.0)	(df = 4)
Good (Grade 3, 51-75%)	08 (80.0)	01 (50.0)	
Excellent (Grade 4, 76-95%)	00 (00.0)	00 (00.0)	
Clear (Grade 5, >95%)	00 (00.0)	00 (00.0)	
Total	10 (100.0)	02 (100.0)	

9. Source of Funding

None.

10. Conflict of Interest

None.

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