RESEARCH ARTICLE

Comparative study of using the Neodymium-doped yttrium Aluminium Garnet laser alone or in combination with the High Intensity Focussed Ultrasound technique for removing the professional tattoo

Sahar Saadon Baker, Jamal Abduljabar Hasan, Mustafa Al Musawi

Abstract

Objective: To evaluate the effects of combining neodymium-doped yttrium aluminium garnet laser and high-intensity focussed ultrasound techniques to remove a professionally-done tattoo.

Method: The interventional study was conducted from November 2021 to April 2022 at the at the Postgraduate Medical Physics Laboratory of Mustansiriyah University, Baghdad, Iraq, and comprised healthy adults aged 18-60 years who wished to have their tattoo areas from their hands, arms and forearms removed. Each tattoo was divided into 3 areas. The first area was treated with multiple passes of neodymium-doped yttrium aluminium garnet laser with 450mJ. The second area was treated with multiple passes of neodymium-doped yttrium aluminium garnet laser with 450mJ and 850mJ. The third area was treated with multiple passes of neodymium-doped yttrium aluminium garnet laser with 450mJ, followed by 5-10 consecutive strokes of HIFU waves with energy 0.25-0.6mJ, 1.4mm depth, 10MHz and 7MHz frequency, and a second blow of the neodymium-doped yttrium aluminium garnet laser with 450mJ. The intervention lasted 8 sessions, and the time required between the sessions ranged 15-20 days. The percentage of pigmentation was evaluated using the image segmentation method based on fuzzy c-means. Data was analysed using SPSS 24.

Results: Of the 20 subjects, 12(60%) were males and 8(40%) were females. There were 10(50%) subjects aged 17-24 years, 6(30%) aged 25-35 years and 4(20%) aged 36-45 years. The tattoo pigments showed a significant reduction in all the 3 groups ($p<0.05$), but intergroup comparison showed that the reduction was most significant in the group treated with neodymium-doped yttrium aluminium garnet laser plus high-intensity focussed ultrasound ($p<0.05$).

Conclusion: The combination of high-intensity focussed ultrasound and neodymium-doped yttrium aluminium garnet laser led to more positive outcome compared to the use of low- or high-intensity laser alone.

Key Words: Tattooing, Lasers, Forearm, Pigmentation,

(JPMA 74: S340 (Supple-8); 2024) **DOI: https://doi.org/10.47391/JPMA-BAGH-16-78**

Introduction

A tattoo can is an exogenous material that is introduced into the dermal layer of the skin through the use of a needle or other means of mechanical injury, resulting in the manifestation of a visible mark on the skin. Certain tattoos possess an aesthetic quality, but others originate from traumatic experiences or accidents. Additionally, there are tattoos that have been intentionally applied during iatrogenic procedures within radiation ports[1]. Tattoo removal is a procedure that is decades old. Before lasers, tattoos were removed by scraping with a saline solution, peeling with a chemical, or even employing surgical caustics, but all of these left a trace or deformity [2]. A targeted ultra-short thermal burn at 300-400°C is produced using lasers. Due to the elevated heat, surrounding skin structures are damaged. Laser therapy is typically rather painful because of the thermal insult that follows. Long-term results include disfigurement and hyper- or hypo-melanosis[3,4]. Efforts to expedite the removal of tattoos through reduced session numbers have proven unsuccessful, as they result in heightened discomfort, hence exacerbating the presence of undesired pigmentation and scarring[5]. A study used Q-switched lasers. Scars or deformities following the treatment were a drawback[4, 6]. Another tattoo removal method is high-intensity focussed ultrasound (HIFU). It is a new and non-invasive methods that runs from 500kHz to 3MHz. Dermatological methods penetrate skin thicknesses of 1-2mm, which may suggest a 15MHz frequency[7,8].

The HIFU device employs a concentrated acoustic transducer with a concave surface that focusses ultrasonic rays; the energy density is substantially increased, which thus produces a highly localised acute necrosis. Thermal lesion delineation is optimised, meaning it is repeatable and crisp under a specific instrument configuration[7,9,10].

Department of Physiology and Medical Physics, Mustansiriyah University. Baghdad, Iraq.

Correspondence: Sahar Saadon Baker

Email: sahar.saadon.baker@gmail.com

People having an allergy to red pigment might benefit from HIFU.

A professional tattoo is usually placed in the dermis and may have several shades. For a professionally done tattoo, the pressure needs to be much higher than that used by amateurs who use a tattoo machine[11]. The most recent dependent pain score measurement for a patient treated with laser is the visual analogue scale (VAS), which can be used for acute and chronic subjective pain measurements, and is scored from none to worst pain [12,13].

The current study was planned to evaluate the effects of combining neodymium-doped yttrium aluminium garnet (Nd:YAG) laser and HIFU techniques to remove professionally-done tattoos.

Subjects and Methods

The interventional study was conducted from November 2021 to April 2022 at the at the Postgraduate Medical Physics Laboratory of Mustansiriyah University, Baghdad, Iraq, and comprised tattoo samples from healthy adults aged 18-60 years who wished to have their tattoo areas from their hands, arms and forearms removed. Those who had been exposed to any procedure for tattoo removal in the preceding month and those with chronic medical condition or chronic drug intake were excluded. Approval was obtained from the institutional ethics committee, and informed consent was taken from all the subjects.

Each tattoo was divided into 3 areas. The first area was treated with multiple passes of Nd:YAG laser (SK-ELLEY, China) with low (L) fluence 450mJ, spot size 5mm, and pulse width 3-5ns (L+L) using the Rapid 20 minute (R20) method (14). The second area was treated with multiple passes of the laser with L and high (H) fluence 850mJ (L+H). The third area was treated with multiple passes of the laser with 450mJ, followed by 5-10 consecutive strokes of HIFU waves with energy 0.25-0.6mJ, 1.4mm depth, 10MHz and 7MHz frequency (Handel Company, China), and a second blow of the laser with 450mJ (L+HIFU+L).

The R20 method is simply a protocol that uses multiple passes in a single session, instead of using a single pass, over the tattoo with 20-second resting period between the passes to destroy more ink molecules.

The HIFU was properly positioned over the tattoo target, and was set to create ultrasound waves beneath the skin. Patients experienced discomfort when the therapy fired, particularly the HIFU. Pain was measured using VAS[12,13].

A water-gel was used to eliminate the skin surface reflection of HIFU. The percentage of tattoo whitening was measured after laser irradiation for each technique and compared with the colour of the tattoos at the pre-treatment baseline. The sessions were repeated till all ink particles were gone. The intervention lasted 8 sessions, and the time required between the sessions ranged 15-20 days. Patients were photographed as they received each therapy for comparisons. The image processing tool, MATLAB, had a broad range of medicinal applications[15]. Tattoos were transformed into an image and subsequently into numerical numbers. The binary image pixel scale values 0 or 1 were transformed and calculated to determine the percentage of pigment removal.

To evaluate differences between lasers and HIFU treatments, an image segmentation system based on fuzzy c-means (FCM) was used for feature extraction and colour thresholding[16].

Data was analysed using SPSS 24. Data was expressed as frequencies and percentages, or as means ± standard deviation, as appropriate. P<0.05l was considered significant.

Results

Of the 20 subjects, 12(60%) were males and 8(40%) were females. There were 10(50%) subjects aged 17-24 years, 6(30%) aged 25-35 years and 4(20%) aged 36-45 years (Table 1).

Table-1: Demographic data of the subjects (n=20).

Age group (Years)	No. of subjects with professional tattoo	Skin type
17-24	10	II
25-35	6	III
36-45	4	IV
45-60	0	0

Table-2: Intergroup comparison.

	450mJ +450mJ	450mJ + HIFU +450mJ	450mJ +850mJ	p-value
Baseline	57.37 ± 13.06	60.06 ± 14.63	60.24 ± 14.95	0.8433
Session 1	53.89 ± 12.14	52.67 ± 13.09	55.02± 13.21	0.8842
Session 2	50.83 ± 12.11	47.83 ± 11.59	51.60 ± 12.42	0.6675
Session 3	47.28 ± 10.36	44.32 ± 11.05	47.68 ± 12.31	0.6792
Session 4	44.14 ± 10.04	41.23 ± 8.52	43.65 ± 10.61	0.6650
Session 5	41.56 ± 9.14	37.87 ± 7.23	40.54 ± 8.77	0.4713
Session 6	38.03 ± 7.78	33.62 ± 6.59	36.65 ± 8.80	0.2858
Session 7	34.50 ± 6.80	29.55 ± 5.79	32.76 ± 7.78	0.1619
Session 8	31.28 ± 5.76	24.12 ± 5.13	27.96 ± 6.58	0.0069*
p - value	<0.00001**	<0.00001**	<0.00001**	

HIFU: High-intensity focussed ultrasound.

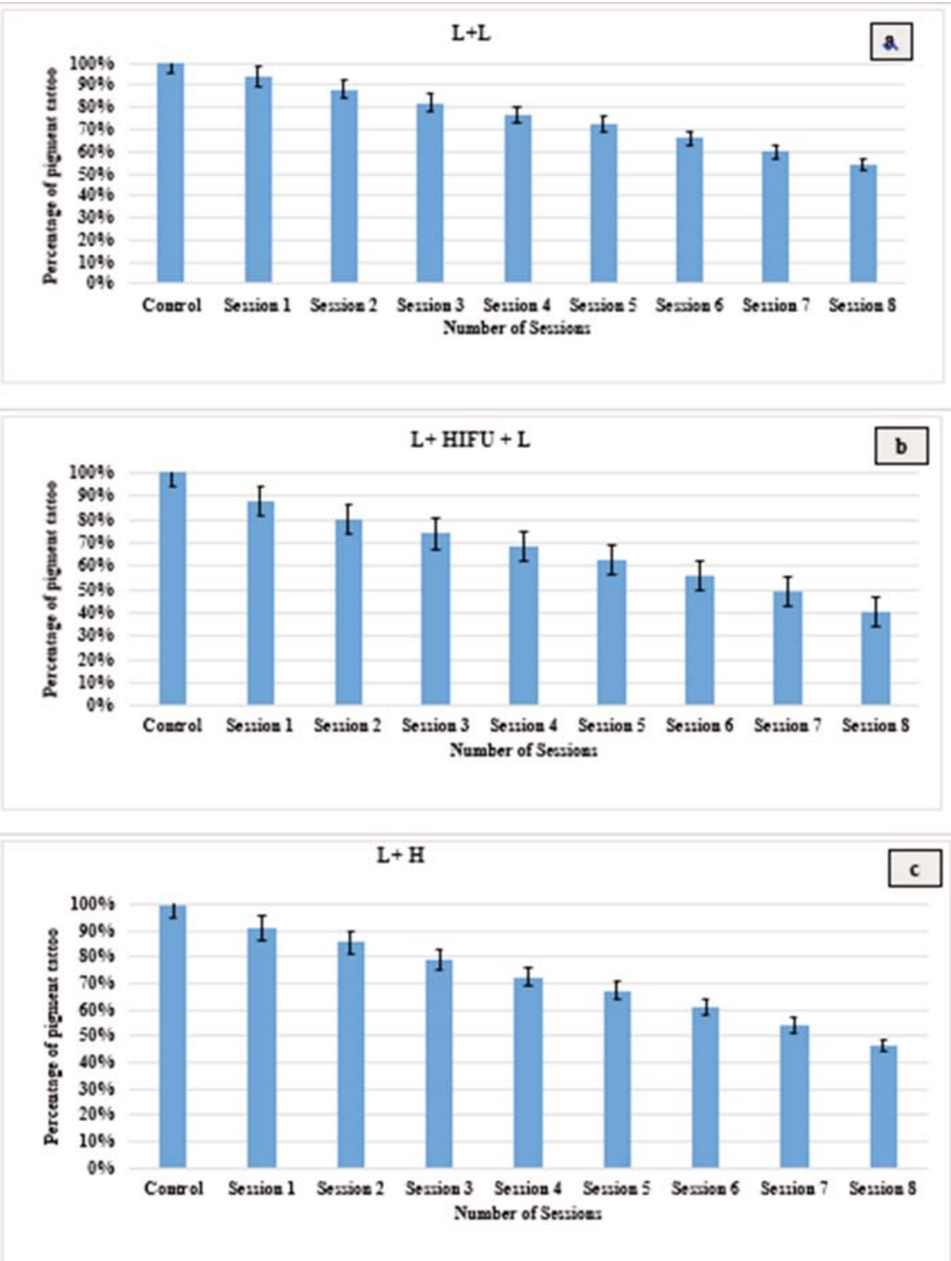

Figure-1: Comparison between the sessions for (a) L+L technique, (b) L+HIFU+L technique, and (c) L+H technique.
L+L: Multiple passes of laser with low-energy 450mJ, L+H: Multiple passes of laser with low-energy 450mJ and high-energy 850mJ, L+HIFU+L: Multiple passes of laser with low-energy 450mJ, followed by strokes of high-intensity focussed ultrasound waves and a second blow of laser with low-energy 450mJ.

The tattoo pigments showed a significant reduction in all the 3 groups ($p<0.05$), but intergroup comparison showed that the reduction was most significant in the group treated with L+HIFU+L group (Table 2). Session-wise comparison of the 3 techniques was also done (Figure 1).

The The adverse effects were low in severity and encompassed symptoms such as erythema, swelling, pain and the formation of crusts (Figure 2).

Discussion

Nd:YAG lasers are often employed in the removal of tattoos as the first line of treatment. After the approach has failed to produce the desired results, HIFU is utilised as a second line[4,16].

The current findings showed that pain caused by lasers was felt for a shorter time than HIFU-related pain. The HIFU may be utilised to target tattooed cells. If variations

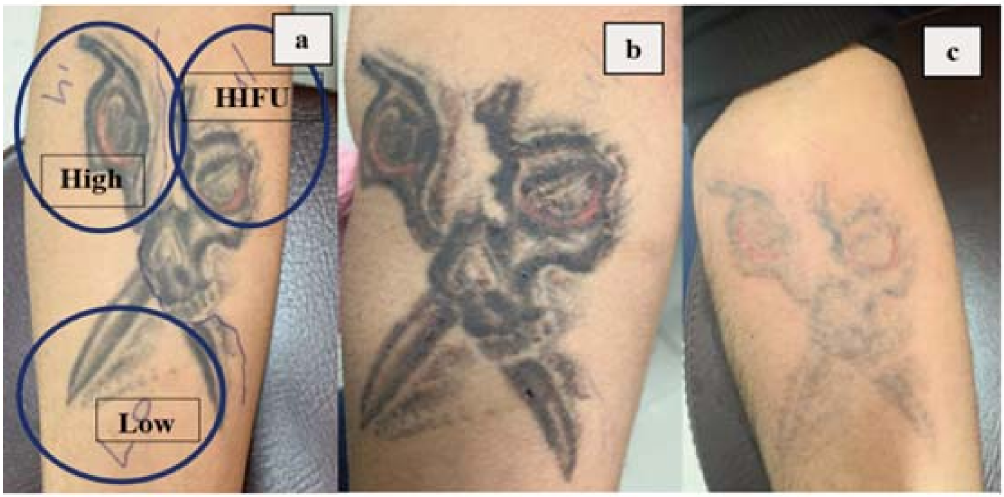

Figure-2: A patient treated with the studied techniques before treatment (a), after the second session (b), and after the last session (c).
High: High-energy laser, Low: Low-energy laser, HIFU: High-intensity focussed ultrasound.

in mechanical and acoustic qualities exist between healthy and tattooed cells, these cells may be selectively disturbed based on differences in mechanical and acoustic properties between healthy and tattooed cells [10,17].

According to the current findings, the L+HIFU+L approach got a higher response than the L+H approach. Because HIFU is a type of ablative surgery, there is a longer wound-healing phase, which means there is a higher risk of scarring[15]. Also, because it is ablative, it is more aggressive and requires a longer treatment time. But because depth control is optimised, HIFU does not involve variable settings, which makes it a good option for individual treatment plans. The ablative nature of HIFU may result in more focussed therapy sessions that take place over a shorter time[10].

A study employed a high frequency of 20MHz as an innovative method for ablating tattoos that were intolerant to colour removal. The strategy led to a reduction in the number of required sessions, and minimised the discomfort experienced by patients undergoing the therapy. The study discovered that this treatment was almost painless, and it advised that the scars be treated with HIFU[13].

Limitation: The current study has limitations as the sample size was not calculated which could have affected the power of the study.

Conclusion

The use of HIFU in conjunction with laser yielded superior outcomes compared to laser alone.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: None.

References

1. AL Saad AM, S. Abdullah AA. Tattoo Removal using (1064 nm and 532 nm) Q-Switched Nd: YAG Laser. J Fac Med Baghdad 2017;59:217-20. DOI: 10.32007/jfacmedbagdad.59387.
2. Teng J. Ultrasound: An alternative solution for removing tattoos. [Online] 2005 [Cited 2024 May 22]. Available from URL: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://dspace.mit.edu/bitstream/handle/1721.1/32961/62859837-MIT.pdf?sequence=2&isAllowed=y
3. Barua S. Laser-tissue interaction in tattoo removal by Q-switched lasers. J Cutan Aesthet Surg 2015;8:5-8. DOI:10.4103/0974-2077.155063.
4. Hutton Carlsen K, Esmann J, Serup J. Tattoo removal by Q-switched yttrium aluminium garnet laser: client satisfaction. J Eur Acad Dermatol Venereol 2017;31:904-9. doi: 10.1111/jdv.14124.
5. Reddy KK, Brauer JA, Anolik R, Bernstein L, Brightman L, Hale E, et al. Topical perfluorodecalin resolves immediate whitening reactions and allows rapid effective multiple pass treatment of tattoos. Lasers Surg Med 2013;45:76-80. doi: 10.1002/lsm.22106.
6. Al Musawi MS, Al-Gailani BT. In Vitro Biostimulation of Low-Power Diode Pumping Solid State Laser Irradiation on Human Serum Proteins. Photobiomodul Photomed Laser Surg 2020;38:667-72. DOI: 10.1089/photob.2020.4873.
7. Bove T, Zawada T, Serup J, Jessen A, Poli M. High-frequency (20-MHz) high-intensity focused ultrasound (HIFU) system for dermal intervention: preclinical evaluation in skin equivalents. Skin Res Technol 2019;25:217-28. DOI: 10.1111/srt.12661.
8. Wang Z, Bai J, Li F, Du Y, Wen S, Hu K, et al. Study of a "biological focal region" of high-intensity focused ultrasound. Ultrasound Med Biol 2003;29:749-54. DOI:10.1016/S0301-5629(02)00785-8.
9. Sasaki GH, Tevez A. Clinical efficacy and safety of focused-image ultrasonography: a 2-year experience. Aesthet Surg J 2012;32:601-12. DOI: 10.1177/1090820X12445576.
10. Day D. Microfocused ultrasound for facial rejuvenation: current perspectives. Res Rep Focus Ultrasound 2014;2:13-7. DOI:

10.2147/RRFU.S49900.
11. In: Raulin C, Karsai S eds. Laser and IPL technology in dermatology and aesthetic medicine. Heidelberg, Germany: Springer Science & Business Media, 2011; pp 1-419.
12. Delgado DA, Lambert BS, Boutris N, McCulloch PC, Robbins AB, Moreno MR, et al. Validation of digital visual analog scale pain scoring with a traditional paper-based visual analog scale in adults. J Am Acad Orthop Surg Glob Res Rev 2018;2:e088. DOI: 10.5435/JAAOSGlobal-D-17-00088.
13. Serup J, Bove T, Zawada T, Jessen A, Poli M. High-frequency (20 MHz) high-intensity focused ultrasound: New ablative method for color-independent tattoo removal in 1-3 sessions. An open-label exploratory study. Skin Res Technol 2020;26:839-50. DOI: 10.1111/srt.12885.
14. Kossida T, Rigopoulos D, Katsambas A, Anderson RR. Optimal tattoo removal in a single laser session based on the method of repeated exposures. J Am Acad Dermatol 2012;66:271-7. DOI: 10.1016/j.jaad.2011.07.024.
15. Shah SD, Aurangabadkar SJ. Newer trends in laser tattoo removal. J Cutan Aesthet Surg 2015;8:25. DOI: 10.4103/0974-2077.155070.
16. Choudhary S, Elsaie ML, Leiva A, Nouri K. Lasers for tattoo removal: a review. Lasers Med Sci 2010;25:619-27. DOI: 10.1007/s10103-010-0800-2.
17. Abbas KF, Al Musawi MS, Kattoof WM. Fast tattoo removal using Q-Switching ND-YAG laser technique with multi pass sessions. J Pak Med Assoc 2021;71(Suppl 8):s161-5.