

Prospective Comparison Study of 532/1064 nm Picosecond Laser vs 532/1064 nm Nanosecond Laser in the Treatment of Professional Tattoos in Asians

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Background and Aims: Although, the pulse width should be shorter than the thermal relaxation time of the target, nanosecond laser pulses are not short enough for tattoo removal. Complications are common, such as hyper or hypopigmentation, textural changes, and scarring. Moreover, patients with darker skin types are at a higher risk of complications from tattoo removal using these lasers. Picosecond lasers were developed to overcome the limitation of nanosecond lasers. We did a comparison study of a 532/1064 nm picosecond laser vs a 532/1064 nm nanosecond laser to evaluate the clinical efficacy and complications of multi-color tattoos in Asians.

Materials and Methods: Eleven Asian patients with 37 professional tattoos were enrolled in the study. Each patient was treated with a 532/1064 nm nanosecond laser and a 532/1064 nm picosecond laser. The spot size that was used with each laser was 3 mm. Four treatments were performed, with four week intervals between each treatment. Patients were examined a week after the first treatment and 3 months after the last treatment.

Results and Conclusions: All patients tolerated the treatments well. The efficacy of the 1064 nm picosecond laser for black tattoos is significantly better than the other studied lasers. The efficacy of the 532 nm picosecond laser is significantly better than the other studied lasers for red tattoos. The efficacy of the 532 nm picosecond laser is significantly better than the 532 nm nanosecond laser and better than the 1064 nm picosecond laser for green tattoos. Mild to moderate post-inflammatory hyperpigmentation was observed in 35.1%, 24.3% 27.0%, and 21.6% of the tattoos treated with the 532 nm nanosecond laser, the 532 nm picosecond laser, the 1064 nm nanosecond laser, and the 1064 nm picosecond laser, respectively. Paradoxical darkening (5.4%) was observed equally with each type of laser. There was no scar formation in any of the tattoos treated. The 532/1064 nm picosecond laser is more effective than the 532/1064 nm nanosecond laser in the treatment of multi-color tattoos in Asians. The 532 nm picosecond laser is more effective than 1064 nm picosecond laser in every tattoo color, with the exception of black. Paradoxical darkening was observed, even the use of picosecond lasers.

Introduction

Since the introduction of selective photothermolysis, short pulse lasers such as Q-switched lasers (nanosecond lasers) have been used for the treatment of pigmented lesions and tattoos ¹⁾. The diameter of tattoo particles is

smaller than that of melanosomes. Since the pulse width should be shorter than the thermal relaxation time of the target, nanosecond laser pulses are not short enough for tattoo removal. Complications are common, such as hyper- or hypopigmentation, textural changes, and scarring. Patients with darker skin are at a higher risk of complications in tattoo removal using traditional Q-switched lasers ²⁻⁴⁾. Recently, picosecond lasers were investigated for tattoo removal. We did a comparison study of a 532/1064

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nm picosecond laser vs a 532/1064 nm nanosecond laser to evaluate the clinical efficacy and complications when treating multi-color tattoos in Asians.

Materials and methods

Subjects

This is a prospective comparison study of the safety and efficacy of a nanosecond 532/1064 nm Nd:YAG laser versus a picosecond 532/1064 nm Nd:YAG laser for the treatment of multi-color tattoos. Eleven Asian patients between the ages of 24-48 years old (average 35.5 years), with 37 professional tattoos were enrolled in the study (**Table 1**). Patients had to be healthy without a history of skin cancers, keloid scarring, evidence of active infection, congenital or acquired immunodeficiency syndromes, and no history of photosensitivity or taking medications with known phototoxic effects. Pregnant or breastfeeding women were also excluded. This study was approved by a local IRB for the treatment of human subjects. Four males and 7 females were enrolled in the study. Five subjects had Fitzpatrick skin type III and six subjects had Fitzpatrick skin type IV.

Laser Treatment

A 532/1064nm nanosecond laser (AlexTriVantage™, Candela, USA) and a 532/1064 nm pico-second laser (PicoWay™, Candela, USA) were used for laser treatments. The pulse duration of the 532 and 1064 nm nanosecond laser is fixed at 50 nsec. The pulse durations of the 532 and 1064 nm picosecond laser is 375 psec and 450 psec respectively. Each patient was treated with the 532/1064 nm nanosecond laser and the 532/1064 nm picosecond laser. The endpoint for fluence setting is observed immediate whitening of the tattoo pigment. The spot size of each laser is fixed at 3 mm (**Table 2**). Four treatments were performed with 4-6 weeks intervals between treatments. Be-

fore each treatment, a topical anesthesia cream and/or a local injection of anesthetic was administered. All patients were treated afterwards with frequent application of topical ointment (Vaseline®). They were also advised on avoidance of sunlight exposure and use of sunscreen (SPF ≥ 30).

Evaluation

Digital photographic imaging, under the same conditions (light source, room, camera), using a digital camera (Can-



Fig. 1: 28-year-old male patient with black tattoo on the right upper arm. Left) The upper left was treated with the 1064 nm nanosecond, the upper right was treated with the 1064 nm picosecond laser, the lower left was treated with the 532 nm nanosecond laser, the lower right was treated with the 532nm picosecond laser: 532/1064 nm Nd:YAG laser using the 50 ns and 532/1064 nm Nd:YAG laser using the 375/450 psec Right) Clearance of pigment after four treatments. Most significant reduction in areas treated with 1064 nm picosecond laser.

Table 1: Number of tattoos

Color	Black	Red	Green	Others
N	18	6	5	8

Table 2: Laser parameters

Lasers	532 nm NS	532 nm PS	1064 nm NS	1064 nm PS
Pulse duration	50 nsec	375 psec	50 nsec	450 psec
Spot size	3 mm	3 mm	3 mm	3 mm
Fluence	1.6-2.0 J/cm ²	1.4 J/cm ²	5.0 J/cm ²	4.3 J/cm ²

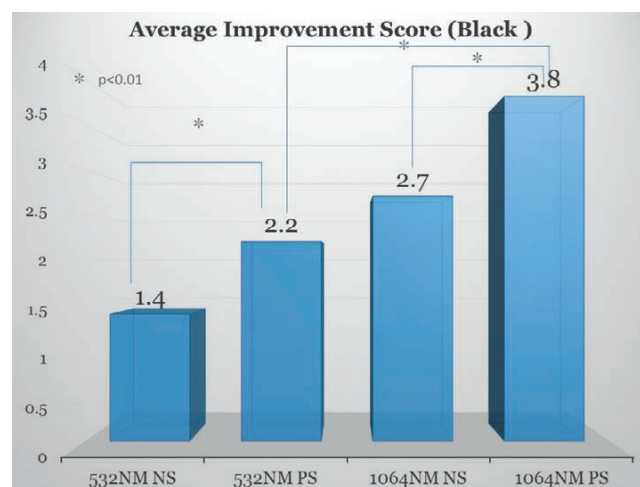


Fig. 2: The efficacy of the 1064 nm picosecond laser is significantly better than the other studied lasers for black tattoos.

on E30, Canon Corp. Japan) was used to assess all patients before and after each treatment session. Patients were examined a week after the first treatment and 3 months after the last treatment. Side-by-side clinical photographs, pre- and post-treatment, were reviewed by two independent clinicians blinded to the sequence of images and treatment parameters. Objective assessments from the photographic images were performed pre-treatment and 3 months month after the final treatment. The improvement of the tattoos of each patient was assessed by

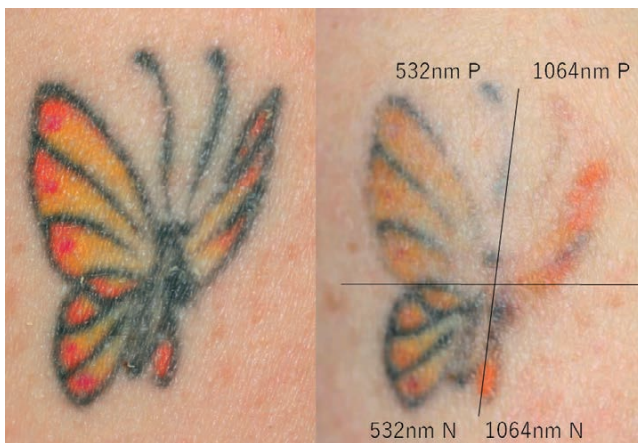


Fig. 3: 44-year-old female patient with black, yellow and red tattoo on the left upper arm. Left) The upper left was treated with the 532 nm picosecond, upper right with the 1064 nm picosecond laser, lower left with the 532 nm nanosecond laser, lower right with the 1064 nm nanosecond laser: 532/1064 nm Nd:YAG laser using the 50 ns and 532/1064 nm Nd:YAG laser using the 375/450 psec Right) Clearance of pigment after one treatment. Most significant reduction in areas treated with picosecond laser. Reduction of red and yellow tattoo was observed using 532 nm picosecond laser.

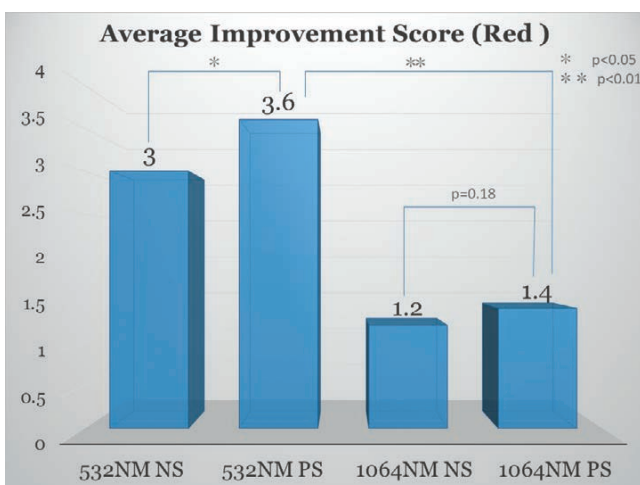


Fig. 4: The efficacy of 532 nm picosecond laser is significantly better than the other studied lasers for red tattoos.

two blinded physician evaluators, and the degree of improvement was based on a 5-point scale, based on the degree of pigment clearance. (0: no improvement, 1: 1 - 25% improvement, 2: 26 - 49% improvement, 3: 51 - 75% improvement, 4: 76 - 100% improvement). Adverse effects, including the occurrence of scarring and hypo- and hyperpigmentation were also evaluated and recorded. Pigmentary alterations and scarring were rated on a 4-point scale (0: none, 1: mild, 2: moderate, and 3: severe hyperpigmentation, hypopigmentation, or scarring).

Results

All patients tolerated the treatments well. The efficacy of the 1064 nm picosecond laser is significantly better than the other studied lasers for black tattoos (**Fig. 1 and 2**). The efficacy of 532 nm picosecond laser is significantly better than the other studied lasers for red tattoos (**Fig. 3 and 4**). The efficacy of the 532 nm picosecond laser is significantly better than both the 532nm nanosecond laser and the 1064 nm picosecond laser for green tattoos (**Fig. 5 and 6**). Mild to moderate post-inflammatory hyperpigmentation was observed in 35.1%, 24.3% 27.0%, and 21.6% using the 532 nm nanosecond laser, the 532 nm picosecond laser, the 1064 nm nanosecond laser, and the 1064 nm picosecond laser respectively (**Table 3**). Mild to moderate hypopigmentation was observed in 24.3% 27.0%, 8.1% and 2.7% using the 532 nm nanosecond laser, the 532 nm picosecond laser, the 1064 nm nanosecond laser, and the 1064 nm picosecond laser respectively. Paradoxical darkening was observed 5.4% in all studied lasers (**Fig. 7**). There was no scar formation.

Discussions

The diameter of tattoo particles (20-200 nm) is smaller than that of melanosomes. Ideally, the pulse width should be shorter than the thermal relaxation time of the intended target. Nanosecond lasers have pulse durations which are not short enough to accomplish the most efficient tattoo removal. With nanosecond lasers, complications are common, such as hyper- or hypopigmentation, textural changes, and even scarring. Patients with darker skin types are at a higher risk of complications in tattoo removal using nanosecond lasers. In 1998, Ross et al. reported the use of nanosecond and picosecond lasers for the treatment of tattoos, and he found that the picosecond laser was more effective than the nanosecond laser⁵⁾. This was the first report of the use of a picosecond laser to treat tattoos in humans. This paper compares a 35 picosecond and a 10 nanosecond laser pulse duration from two Nd:YAG laser systems. Other than the difference in pulse duration, sixteen tattoos were treated with identical treatment parameters. The study reported that 12 of the 16 tattoos were significantly lighter when treated once

with the picosecond laser, when compared to the nanosecond laser. This paper showed that shorter pulses are more effective in clearing tattoos if all other parameters are kept constant. Brauer reported ten subjects with multi-color decorative tattoos that were treated with sub-nanosecond laser pulses (0.75 – 0.9 ns) operating at 755 nm⁶. Spot sizes ranged from 3.0 to 3.6 mm, producing fluences between 2.0 and 2.83 J/cm². The laser operated at a fixed energy of 0.2 J per pulse. Of particular note, in this study, is the rapid clearance of blue and



Fig. 5: 44-year-old female patient with green, purple and black tattoo on the left upper arm. Left) The upper left was treated with the 532 nm nanosecond, the upper right was treated with the 532 nm picosecond laser, the lower left was treated with the 1064 nm nanosecond laser, the lower right was treated with the 1064 nm picosecond laser: 532/1064 nm Nd:YAG laser using the 50 ns and 532/1064 nm Nd:YAG laser using the 375/450 psec Right) Clearance of pigment after four treatments. Most significant reduction in areas treated with 1064 nm picosecond laser and 532 nm picosecond laser in green/purple, in respectively.

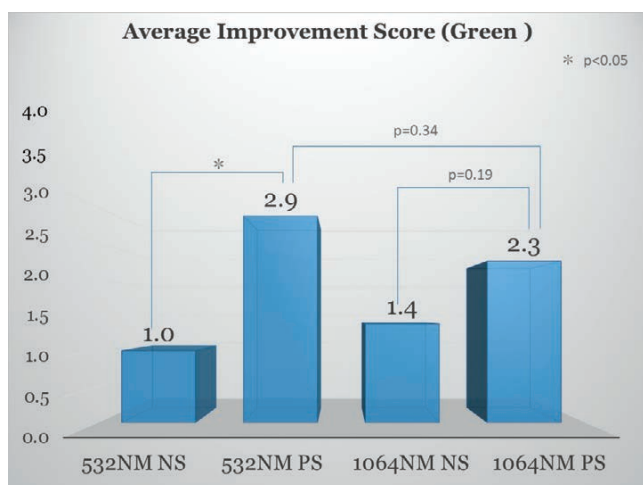


Fig. 6: The efficacy of the 532 nm picosecond laser is significantly better than both the 532 nm nanosecond laser and the 1064 nm picosecond laser for green tattoos

green tattoos. Interestingly, these tattoos were cleared in one or two treatments. Purple inks had greater than 75% clearance after one or two treatments. The remaining colors, including black ink, showed 25% clearance or less after one or two treatments. Alabdulrazzaq reported the first commercially available 532 nm picosecond laser for tattoo removal. In this study, six subjects with multi-color decorative tattoos were treated with sub-nanosecond laser pulses (0.75 – 0.9 ns) operating at 532 nm⁷. Energy densities ranged from 1.1 to 1.4 J/cm² with a range of spot sizes from 2.6 to 3.3 mm. The treatments were safe, with the most common side effects being edema, erythema, crusting, and pain. Of particular note in this study is a consistent reduction in yellow inks, with all six subjects having greater than 75% clearance after 1 to 5 treatments. Pinto et.al reported a randomized, controlled, single-blinded clinical trial of a Nd:YAG 1064 nm picosecond laser versus a Nd:YAG 1064 nm nanosecond laser in black tattoo removal⁸. Twenty-one patients with 30 black tattoos were treated with the picosecond laser and the

Table 3: Complications

Complications	532 nm NS	532 nm PS	1064 nm NS	1064 nm PS
Hyperpigmentation	13/37 (35.1%)	9/37 (24.3%)	10/37 (27.0%)	8/37 (21.6%)
Hypopigmentation	10/37 (27.0%)	9/37 (24.3%)	0/37 (0%)	0/37 (0%)
Texture change	3/37 (8.1%)	0/37 (0%)	2/37 (5.4%)	0/37 (0%)
Scar formation	0/37 (0%)	0/37 (0%)	0/37 (0%)	0/37 (0%)
Paradoxical darkening	2/37 (5.4%)	2/37 (5.4%)	2/37 (5.4%)	2/37 (5.4%)

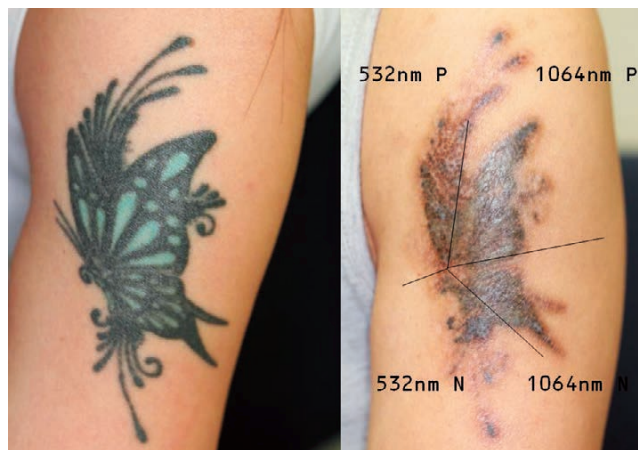


Fig. 7: 48-year-old female patient with black and blue tattoo on the left upper arm. Paradoxical darkening was observed in all studied lasers.

nanosecond laser in a split-study design, consisting of two sessions spaced 6 weeks apart. The average clearance showed no statistical difference between the nanosecond laser and the picosecond lasers. They concluded that there was no statistically significant or clinically relevant difference between the picosecond laser and the nanosecond laser in terms of the therapeutic outcome. One of the limitations of this study is the number of treatment sessions. Treatment sessions varied according to skin type, location, colors, amount of ink, scarring and tattoo layering²⁾. The average number of treatment sessions using the nanosecond laser was 8-10 sessions. Light black tattoos improved after two sessions; however, the response of dark black tattoos was limited after two sessions. In contrast to Pinto's study, four treatment sessions were performed in our study, and the difference using 4 treatments was more obvious than two treatment sessions (**Fig. 8**).

When treating tattoos, the wavelength is selected to maximize absorption by the tattoo chromophore and to maximize depth of penetration. In our study, the clearance of black tattoo using the 1064 nm picosecond laser was best. Other colors have different spectral profiles. 693 nm and 755 nm lasers are effective in the treatment of green and blue tattoos. For red, orange, purple, and yellow tattoos, 532 nm is the best choice⁹⁾. Multi-wavelength picosecond lasers are essential for the successful treatment of multi-color tattoos. In our study, the 532 nm picosecond laser is best in multi-colored tattoos, with the exception black ink. We did not compare 532 nm and 755 nm picosecond lasers, but 755 nm picosecond lasers seem to be better in the treatment of blue and green the-

oretically. Future studies are warranted to evaluate.

To date, no severe complications have been reported when using picosecond lasers. Paradoxical darkening of tattoos has been noticed after laser treatment of red, pink, flesh and white-colored tattoos. Also blue, green and yellow ink can darken after laser treatment. When iron oxide, contained in some tattoos, heats up to its melting point (1,400°C), it changes color from brown to black due to oxidation-reduction reaction. Red (ferric oxide) changes to black (ferrous oxide) and white (Ti4+) changes to black (Ti3+)^{10,11)}. This pigment change can be resistant to additional Q-switched laser therapy. Other color changes can occur after treatment of cosmetic tattoos with a frequency-doubled Nd: YAG laser. Not only nanosecond lasers, but also picosecond lasers have a risk of paradoxical darkening. Paradoxical darkening can be treated using a 755 nm laser or a 1064 nm picosecond laser¹¹⁾. Adjuvant ablative fractional resurfacing can reduce the risk of bullae formation and may reduce the risk of dyspigmentation, especially in dark skin patients¹²⁾. Further prospective studies combining fractional resurfacing and picosecond lasers is warranted.

Conclusions

The 532/1064 nm picosecond laser is more effective than the 532/1064 nm nanosecond laser in the treatment of multi-color tattoos. The 1064 nm picosecond laser is more effective than the other studied lasers in the treatment black ink. The 532 nm picosecond laser is more effective than 1064 nm picosecond laser in every color, exception for black ink.

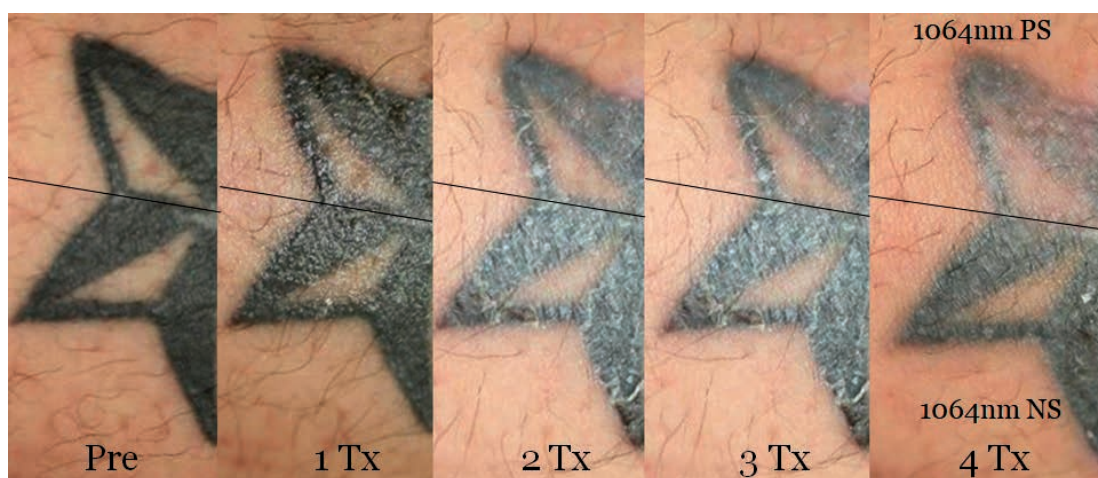


Fig. 8: 28-year-old male patient with black tattoo on the left upper arm. There is slight difference after two treatment sessions. The difference was more obvious after 4 treatment sessions than two treatment sessions.

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