Comparison of submillisecond pulse (FRAC3) and long-pulse 1064 nm Nd:YAG laser hair removal

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Abstract

Background: Laser hair reduction gained popularity in the last decade and is presently the most frequently used long-term hair removal method. It works on the principle of selective photothermolysis—the laser damages the hair follicle without damaging the skin. Shorter Nd:YAG pulses are also effective in hair reduction, while maintaining better comfort for the patient.

Aims: The aim of this study was to compare the short and long pulsed methods of Nd:YAG for facial hair removal on darker Fitzpatrick skin types (IV–V).

Patients/Methods: This prospective split face, evaluator-blinded comparison of short-pulse Nd:YAG laser versus long-pulse Nd:YAG laser study included 10 untanned healthy women. There were two outcome measers, two blinded dermatologists compared baseline photographs with those taken 3 months after last session and FotoFinder was used to compare the terminal hair count reduction at the baseline and 3 months after 6th session.

Results: Both blinded assessors observed significant hair reduction with both lasers; excellent results were achieved in 20% with long pulse and in 55% with short pulse. Both treatment options showed reduction in number of terminal hair with statistical significance using FotoFinder. Comparison of the efficacy of the two pulse durations measured by percent reduction in the number of terminal hair 3 months after the last session showed no significant difference between the groups.

Conclusion: Hair reduction using 1064 nm Nd:YAG is a safe and effective method of hair reduction especially in darker skin types. We have shown that short pulses are better or at least equally safe and effective as the "gold standard" long pulses.

KEYWORDS
ethnic skin, laser hair removal, Nd:YAG laser

INTRODUCTION

Excess hair growth is a common problem for both genders and is usually very distressing, resulting in negative impacts on psychological aspect and quality of life. Many different hair removal methods that can be used at home, but offer only short-term results, such as chemical depilation, waxing, shaving, and plucking, are widely used to reduce the number of unwanted hair. Permanent results can be achieved...
with electrolysis, which is less frequently used due to long and painful sessions with scarring and high associated costs. Laser hair reduction (LHR) gained popularity in the last decade and is presently the most frequently used long-term hair removal method, due to fewer side effects, lesser time consumption, longer hair free interval, and decreased pain. Various laser wavelengths are presently used for LHR: Alexandrite (755 nm), diode lasers (810 nm), Nd:YAG (1064 nm), and intense pulsed light system (IPL). Nd:YAG (1064 nm) lasers have the deepest penetration and appear to be safe in skin of color patients with less side effects reported, compared with other wavelengths. LHR works on the principle of selective photothermolysis—the laser light is selectively absorbed by melanin, which is abundant in the hair shaft, and damages the hair follicle without damaging the skin. The theory states that the pulse duration should be equal or shorter to the thermal relaxation time (TRT) of the hair shaft in order to be effective in hair follicle destruction. The TRT of the hair shaft is estimated to be between 10 and 100 ms, so, the most commonly used Nd:YAG hair removal pulse duration ranges between 15 and 50 ms with fluences between 25 and 70 J/cm² using 6–20 mm spot size. Recent studies showed that shorter Nd:YAG pulses with pulse width of 0.6–3.5 ms are also effective in hair reduction, while maintaining better comfort for the patient. This can be attributed to higher peak power when shorter pulse are used. Therefore, lower fluence can be used while maintaining the efficacy and having less pain and side effects even without cooling of the treatment area. On the contrary, the short pulse duration is having a better efficacy when targeting fine hair and that was not possible with longer pulse duration Nd:YAG. The aim of this study was to compare the short- and long-pulsed methods of Nd:YAG for facial hair removal on darker Fitzpatrick skin types (IV–V).

2 | MATERIALS AND METHODS

2.1 | Participants

This prospective study was conducted in single private dermatology center (Cutis Academy of Cutaneous Sciences, Bangalore, India). It included 10 untanned healthy women. Only women older than 18 years and with brown or black terminal hair were included. Exclusion criteria were intense tan or sunburn, history of scarring, active cutaneous infection or inflammation, diagnosis of PCOS, pregnancy, breastfeeding, use of photosensitive drugs, previous laser or electrolysis treatment and epilation or waxing in the period of 2 months prior to the start of the study.

2.2 | Procedure

This was a prospective, split face, evaluator-blinded comparison of short-pulse Nd:YAG laser versus long-pulse Nd:YAG laser. Two different laser systems have been used for the two pulse modalities: Clarity (Lutronic) for the long-pulse modality (20–30 ms) was used on the left side of the face; and SP Dynamis (Fotona) for the short-pulse FRAC3 modality (0.6–1.6 ms) on the right side of the face for all patients. The treatment consisted of a single pass with minimal overlapping and 100% coverage of the area with excessive hair growth. Each participant was photographed using a digital camera (Canon EOS 1100D, Canon Inc.) before they underwent a series of six treatment sessions at 6 week intervals. The parameters used in both systems were within the recommended range by the manufacturer for the patients' skin type. Local anesthesia was not applied, and the area of the treatment was shaved before the start of each laser procedure. Right side of the patients' face was treated with FRAC3 pulses (0.6–1.6 ms), 9 mm spot size, fluence 10–25 J/cm², and frequency 2 Hz. Left side of the patients' face was treated with long pulse durations (20–30 ms) with 10 mm spot size, fluence 24–36 J/cm², and frequency 1 Hz. A single pass over the treated area was performed. All of the standard safety measures were taken during the laser procedure. Cooling with the CryoMini (Zimmer MedizinSysteme GmbH) was used during the procedure. Patients were asked about any side effects before each of the subsequent sessions and at the last follow-up, 3 months after the last treatment (Figures 1–3).

The efficacy of the treatment was evaluated using different methods. Two blinded dermatologists compared baseline photographs to those taken 3 months after last session. The reduction in hair thickness and number was scored on a four point grading scale; poor (0%–25% reduction), moderate (26%–50%), significant (51%–75%), and excellent (76%–100%). Objective evaluation was done using FotoFinder (FotoFinder Systems), comparing the terminal hair count reduction at the baseline and 3 months after 6th session. Statistical significance of improvement after each treatment option, compared with baseline, was tested using paired-samples t-test; while the independent samples t-test was used for testing the difference of the effects between the short and long pulse laser hair removal option. Chi-square test was used for comparison of assessments made by blinded dermatologists (IBM Corp. Released 2020. IBM statistics for Windows, Version 27.0: IBM Corp).

Patients graded their discomfort level using 10-point visual analog scale (VAS) for each side. They were also asked to choose the side of the face where they observed better effect and were more satisfied with at the last follow-up.

3 | RESULTS

The mean age of patients was 25.6 years, ranging from 18 to 40 years. Majority (80%) of participants had Fitzpatrick skin type 4 and the remaining two participants had FP 5. All participants completed the planned 6 treatment sessions, which were 45 days apart on average, as well as the follow-up 3 month after 6th session.

There was high variability in baseline values of terminal hair (0–44), according to FotoFinder results. The mean baseline terminal hair count was 15.3 (95% CI 3.34–27.0) on the left side (long pulse) and 9.3 (95% CI 0.0–18.7) on the right side (FRAC3). There was no significant difference (p = 0.384) in terminal hair count between the sides at baseline (Table 1).

| Side       | Mean Baseline Count | 95% CI       |
|------------|---------------------|--------------|
| Left       | 15.3                | 3.34–27.0    |
| Right      | 9.3                 | 0.0–18.7     |
Both treatment options showed reduction in number of terminal hair with statistical significance ($p < 0.0005$) (Table 1). Comparison of the efficacy of the two pulse durations measured by percent reduction in the number of terminal hair 3 months after the last session showed no significant difference ($p = 0.990$) between the groups.

There was no significant difference in pain perception between the two treatments ($p = 0.216$). Both treatments were graded with a median pain level value of 3 (values ranging from 1 to 4 for the short pulses; and 2 to 4 for the long pulses, respectively). Besides erythema that lasted up to few hours, there was no serious or long-term side effects reported by the patients on any of the visits and at the 3 month follow-up. When asked to name the side of the face where they observed better effect and were more satisfied with the results, five women (50%) chose the right side (FRAC3), 4 (40%) chose the left side (long pulse) and one patient could not decide.

4 | DISCUSSION

Both short (FRAC3) and long pulse durations of the Nd:YAG lasers have proven effective and safe in facial hair removal in darker skin types. We have been doing hair removal for many years using different devices and wavelengths with an overall good success rate, but it was our subjective experience that short (FRAC3) Nd:YAG pulses outperform the long pulse Nd:YAG options. This study was conducted in order to test our observations as objectively as possible. To achieve this, we used three different outcome measures; besides subjective evaluation of two blinded assessors and patient self-assessment, we also used an objective method using FotoFinder. The median value of hair reduction was graded as excellent (>75%) for FRAC3 side and as significant (50%-75%) for long pulse side according to two blinded assessors (Table 2). This difference was
statistically significant \( (p = 0.015) \). All these results are in agreement with published data, which show high variability in hair reduction. Fournier et al.\(^{19}\) used a 3.5 ms Nd:YAG pulse with average fluence of 47 J/cm\(^2\) and achieved 60% hair reduction 1 month and 24% reduction 3 months after a single procedure. Khatri et al.\(^{16}\) achieved even better results using even shorter pulses (0.65 ms); around 80% reduction in hair count, great patient satisfaction and no long-term side effects. Desai treated Indian skin type using sub-millisecond Nd:YAG pulses (0.3 ms) and showed more than 50% hair reduction at 6 months follow-up and an average pain score of 2.8 out of 10. This clinical findings were explained by Lukac et al.\(^{20}\) based on the mathematical modeling and in vivo tests. To the best of our knowledge, only one split case study comparing short- and long-pulse Nd:YAG for hair removal has been done so far. Eltarky et al.\(^{21}\) have showed that multiple pass, low fluence, short pulse Nd:YAG hair removal improves the efficacy, reduces patient discomfort, and in most cases, eliminates the need for skin cooling. In contrast to the results by the two blinded evaluators, the reduction was lower when only the number of terminal hair measured by FotoFinder was taken into account; 40.7% for long pulse and 32.9% for FRAC3 side (Table 3), but there was no statistically significant difference between the two treatment options. The lower hair reduction observed with FRAC3 using this method could be attributed to the fact that two patients had a baseline terminal hair measurement of 0 on the FRAC3 side. This is most probably due to the measurement error, since both of these patients asked for hair removal and had macroscopically visible unwanted hair. Therefore, only one of the used methods confirms our observation of short pulse (FRAC3) superiority over long pulse Nd:YAG hair removal. The discrepancy in results from different evaluation methods can probably be attributed to the small sample size and high variability in baseline values of terminal hair (0–44) according to FotoFinder results. This study is consistent with our experience in the last few years regarding safety of the procedure—there were only minimal short lasting side effects, such as erythema and perifollicular edema. Serious side effects, such as burns with blisters

| Improvement     | Long pulse [%] | FRAC3 [%] |
|-----------------|----------------|-----------|
| Poor [0%-25%]   | 0              | 0         |
| Moderate [25%-50%] | 25             | 0         |
| Significant [50%-75%] | 55             | 45        |
| Excellent [75%-100%] | 20             | 55        |

TABLE 2: Assessment of baseline photographs to those taken 3 months after last session by 2 blinded evaluators, presented as % of patients receiving a particular grade of improvement (n = 10*; results present average improvement grade of two evaluators)
and crusts that could result in scarring, were not observed.22 These findings can be attributed to lower fluence used due to higher peak power achieved with shorter pulses. Another advantage of shorter pulses is also better efficacy when targeting fine hair and which is not possible with longer pulse duration Nd:Yag.16,17,20

5 | CONCLUSION

Hair reduction using 1064 nm Nd:YAG is a safe and effective method of hair reduction especially in darker skin types. We have shown that short pulses are more or at least equally effective and safer as long pulses and that the “gold standard” concept should be rethought. More studies using short pulses should be used in order for this to happen in the future.

AUTHOR CONTRIBUTIONS

BS.C., C.S., L., and P. J. designed and performed the research study. BS.C., C.S., L., P. J., and A.Z. analyzed the data. A.Z. wrote the paper.

CONFLICT OF INTEREST

The authors whose names are listed immediately below certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancy, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), nor non-financial interest (such as personal or professional relationships, affiliations, knowledge, or beliefs) in the subject matter or materials discussed in this manuscript.

ETHICAL APPROVAL

Laser hair removal is an established state-of-the-art technique. Different lasers are used worldwide. We have used both lasers/modalities in this study for a few years but never in an organized “split” study; so, no approval from the local Ethics committee has been sought. All the subjects have been informed about the different modalities used and willingly participated and gave consent to using their data.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author, A.Z., upon reasonable request.

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How to cite this article: Byalakere Shivanna C, Shenoy C, Lalitha S, Jaju P, Zorman A. Comparison of submillisecond pulse (FRAC3) and long-pulse 1064 nm Nd:YAG laser hair removal. J Cosmet Dermatol. 2022;21:3393-3397. doi: 10.1111/jocd.15100