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ORIGINAL RESEARCH

Combination of Three Treatment Modes of 1064 nm Nd: YAG Laser in the Treatment of Melasma: A Retrospective Observational Study

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Background: Melasma is a chronic, relapsing pigmentary disorder with a high recurrence rate. While multiple treatment options exist, long-term oral therapies are often limited by poor patient tolerance. Laser therapy offers a non-invasive and convenient alternative; however, Low-fluence QS 1064 nm Nd: YAG monotherapy has shown inconsistent efficacy and frequent relapse. To investigate a more effective laser-based approach, this retrospective study evaluates the clinical outcomes of combining Low-fluence QS 1064 nm Nd: YAG laser, Fractional-mode QS 1064 nm Nd: YAG laser, and Long-pulsed 1064 nm Nd: YAG laser in the treatment of melasma.

Methods: This retrospective observational study enrolled 43 patients with clinically diagnosed melasma, all of whom underwent treatment with a 1064 nm Nd: YAG laser using a combination of three modes: low-fluence QS, fractional-mode QS, and long-pulsed settings. Each patient underwent a total of three treatment sessions. Clinical improvement was assessed using the MASI at baseline and one month after each session. Adverse events were documented throughout the treatment course. Patients were followed for 12 months post-treatment to evaluate recurrence and satisfaction.

Results: MASI scores significantly decreased following the final treatment compared to baseline [13.50 (8.40–19.10) vs 5.86 ± 3.38, $p < 0.001$]. At the 12-month follow-up, the recurrence rate was 18.60%, with a patient satisfaction rate of 72.10%. Post-inflammatory hyperpigmentation occurred in 6.97% of cases, and transient erythema or edema in 46.51%, all of which resolved spontaneously.

Conclusion: In this retrospective observational study, combination therapy with low-fluence QS 1064 nm Nd: YAG laser, fractional-mode QS 1064 nm Nd: YAG laser, and long-pulsed 1064 nm Nd: YAG laser demonstrated favorable efficacy in the treatment of melasma, with low recurrence rates and a low incidence of adverse events. These findings suggest that this combined laser approach is a promising and well-tolerated treatment modality for melasma.

Keywords: melasma, Low-fluence QS 1064 nm Nd: YAG laser, fractional-mode QS 1064 nm Nd: YAG laser, long-pulsed 1064 nm Nd: YAG laser

Introduction

Melasma is a chronic, acquired hyperpigmentation disorder that primarily affects the facial skin, with a marked predilection for women of reproductive age. The condition is more prevalent among individuals with darker skin phototypes, especially those classified as Fitzpatrick phototypes III and IV. In Asian populations, the prevalence of melasma has been reported to reach up to 30%.[1,2] Owing to its complex pathogenesis and high recurrence rate, melasma not only alters facial appearance but also imposes a considerable psychological burden. Current treatment options include oral tranexamic acid, chemical peels, and laser therapies.[3] Although low-fluence Q-swtiched 1064 nm Neodymium-doped Yttrium Aluminium Garnet laser (LQSNY) has shown efficacy in treating melasma,[4] its need for multiple sessions and high recurrence rate may compromise patient compliance and expectations. Further optimization of this modality is needed. Fractional-mode QS 1064 nm Nd: YAG laser (FQSNY) integrates fractional technology with QS 1064 nm Nd: YAG laser, operating on the principle of

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selective photothermolysis. Its fractional delivery preserves untreated skin between microscopic treatment zones (MTZ), facilitating faster healing, reduced inflammation, and a shorter recovery time.[5] Long-pulsed (no Q-switched) 1064 nm Nd: YAG laser (LPNY) reduces vascularity, lowers inflammatory cytokine levels, and diminishes inflammation, while promoting collagen synthesis.[6] Building on LQSNY, FQSNY is used for enhanced treatment in targeted areas, while LPNY reduces inflammation, accelerates healing, and minimizes complications such as post-treatment pigmentation. To our knowledge, no studies have reported the combined use of these three modalities for melasma. This retrospective observational study evaluates the efficacy and safety of this approach, aiming to provide a novel strategy for melasma treatment.

Materials and Methods

This retrospective observational study was approved by the Ethics Committee of the Second Affiliated Hospital of Guangxi Medical University [Approval No. 2022-KY (0552)] and conducted in accordance with the Declaration of Helsinki. Clinical data were used without identifying patient information, and informed consent was obtained from all participants prior to treatment.

Patient Selection Criteria

Inclusion Criteria

1) Two physicians from the Department of Medical Cosmetology diagnosed melasma based on the established criteria;[7]
2) Female patients aged 18 to 60 years who provided informed consent;
3) The treatment utilized a combination of three 1064 nm Nd: YAG laser modalities.

Exclusion Criteria

1) Pregnant or breastfeeding women;
2) Patients with impaired liver, renal, or other major organ function, bone marrow suppression, psychiatric disorders, or severe comorbidities;
3) Patients who underwent other melasma treatments within the last 6 months or during the study;
4) Fewer than 3 treatment sessions;
5) Poor follow-up compliance.

Patient Information

A total of 71 patients who visited the Department of Medical Cosmetology at the Second Affiliated Hospital of Guangxi Medical University from January 2017 to January 2024 were assessed for eligibility. Of these, 28 were excluded: 10 for receiving fewer than 3 treatments and 18 for undergoing multiple treatment modalities during the observation period. Ultimately, 43 patients were included in the study (Figure 1).

Source of Equipment and Medications

FOTONA QX MAX (Model: M031-3A/2), Canon EOS 5D Mark IV camera, and Meibao Moist Burn Ointment (Meibao Pharmaceutical Co., Ltd., Shantou, Guangdong, China).

Treatment

The treatment protocol consisted of three stages. Initially, LQSNY was applied using an R28 handpiece with a 6–8 mm spot size, energy density of 0.80–1.20 J/cm^2, frequency of 5–8 Hz, and three repeated scans. Next, FQSNY was performed with an Fs20A handpiece, 0.50 mm spot size, 0.50 mm interspot distance, energy density of 0.60–1.20 J/cm^2, frequency of 2–8 Hz, and one scan. Finally, LPNY was applied with an R28 handpiece, 6–8 mm spot size, energy density of 15–16 J/cm^2, frequency of 1–2.20 Hz, and three repeated scans. Following each session, a moist burn ointment was applied until complete healing, with a total of three treatments. All procedures were performed by the same physician in the Department of Medical Cosmetology. Patients were advised to apply broad-spectrum sunscreen with SPF 50 throughout the treatment course.

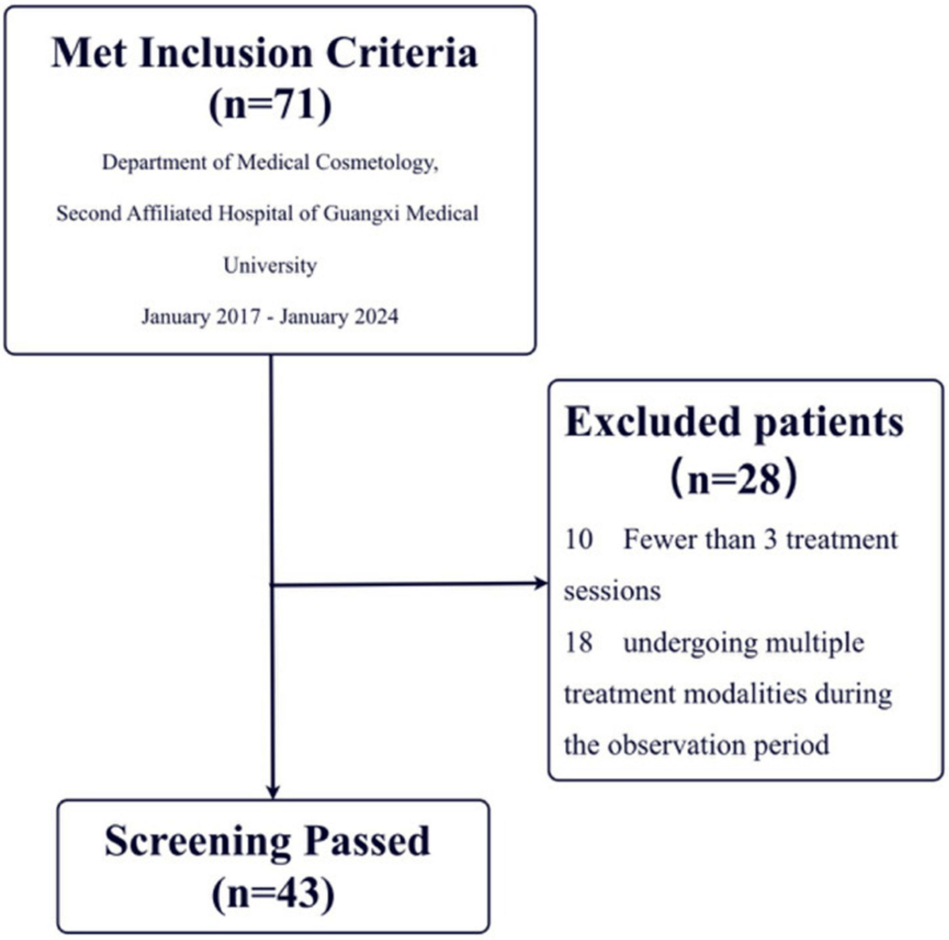

Figure 1 Patient Screening and Enrollment Flowchart.

Treatment Evaluation

The primary outcome was the Melasma Area and Severity Index (MASI) score,[8] evaluating two parameters: color intensity (D) and uniformity (H). Scores range from 0 (none) to 4 (severe), with intermediate scores representing mild (1), moderate (2), and moderate-to-severe (3) levels. The face was divided into four regions—forehead (f), right malar (rm), left malar (lm), and chin (c)—to assess pigmentation involvement. Area involvement (A) was scored based on pigmentation coverage as follows: 1 point for<10%, 2 points for 10–29%, 3 points for 30–49%, 4 points for 50–69%, 5 points for 70–89%, and 6 points for 90–100%. MASI=0.30A(f)[D(f)+H(f)]+0.30A(rm)[D(rm)+H(rm)]+0.30A(lm)[D(lm)+H(lm)]+0.10A(c)[D(c)+H(c)]. At baseline (pre-treatment) and at 1-month intervals following each treatment session, MASI scores were independently evaluated by two clinicians from the Department of Medical Cosmetology not involved in therapeutic procedures. Assessments were performed using standardized photographic documentation, with the final score calculated as the arithmetic mean of both raters' measurements.

Secondary outcomes included recurrence, adverse effects, and patient satisfaction. These parameters were retrospectively collected via online surveys or in-person visits from treatment initiation through one-year follow-up.

Statistical Analysis

Data were analyzed using SPSS version 27.0 (IBM Corp., Armonk, NY, USA). The Kolmogorov–Smirnov test was applied to assess the normality of continuous variables. Data with a normal distribution were expressed as mean±SD, while non-normally distributed data were presented as median (P_{25}, P_{75}) and analyzed using the Wilcoxon signed-rank test. Categorical variables were evaluated using the chi-square test or Fisher's exact test, as appropriate. Ordinal data were also analyzed using

the Wilcoxon signed-rank test. Kaplan–Meier survival analysis was employed to assess the influence of subgroup factors on the time to relapse following treatment. A $p<0.05$ was considered statistically significant.

Results

Patient Characteristics Analysis

The patients were predominantly between 30 and 60 years old, with a mean age of 40.05±6.81 years. The disease duration ranged from 1 to 180 months, with 5.00 months (4.00, 10.00). The primary etiological factors were genetic (16.28%), pregnancy (44.19%), and excessive sun exposure (20.93%). According to the Fitzpatrick skin phototype classification, type III and type IV skin were observed in 41.86% and 58.14% of patients, respectively (Table 1).

Primary Outcome Assessment

The total MASI score before treatment was 13.50 (8.40, 19.10), which significantly decreased to 5.86±3.38 after three sessions ($p<0.001$). The MASI scores for the bilateral malar regions, forehead, and chin were more severe at baseline. After the third treatment, all sub-scores — forehead, right malar, left malar, and chin — showed significant improvement compared to baseline ($p<0.001$) (Table 2). The total MASI score consistently and significantly decreased after each treatment, with more pronounced reductions observed in the right and left malar regions (Figure 2).

Several factors may influence the improvement in MASI scores during treatment, with common factors including skin type, age, duration of disease, and etiology.[9,10] Subgroup analysis of these factors showed no significant differences in skin type or disease duration ($p>0.05$). In terms of age, patients 40 years old showed a more significant improvement in MASI scores after three treatments compared to those ≤40 years ($p<0.05$). Regarding etiology, significant differences in MASI score improvement were observed across the four subgroups: genetic, pregnancy, excessive sun exposure, and other factors. The excessive sun exposure and other factor subgroups showed more notable improvement compared to the genetic subgroup (excessive sun exposure vs genetic, $p=0.01$; other vs genetic, $p=0.038$). Furthermore, the excessive sun exposure subgroup

Table 1 Baseline Characteristics of the Patients

Item	Female
Patients (n)	43
Age (years)	40.05±6.81
Duration (months)	5.00(4.00,10.00)
Etiology (n, %)	
Genetic	7(16.28%)
Pregnancy	19(44.19%)
Excessive sun exposure	9(20.93%)
Other factors	8(18.60%)
Skin Type (n, %)	
Type III	18(41.86%)
Type IV	25(58.14%)

Table 2 Comparison of MASI Scores Before Treatment and After the Third Treatment [mean±SD, M(P_{25}, P_{75})]

Item	Before Treatment	After the Third Treatment	p
Total	13.50(8.40,19.10)	5.86±3.38	<0.001
Forehead	1.20(0.00,3.00)	0.00(0.00,0.60)	<0.001
Right malar	6.00(3.60,7.20)	2.40(1.20,3.60)	<0.001
Left malar	5.40(3.60,8.40)	2.40(1.20,3.60)	<0.001
Chin	0.00(0.00,0.80)	0.00(0.00,0.20)	<0.001

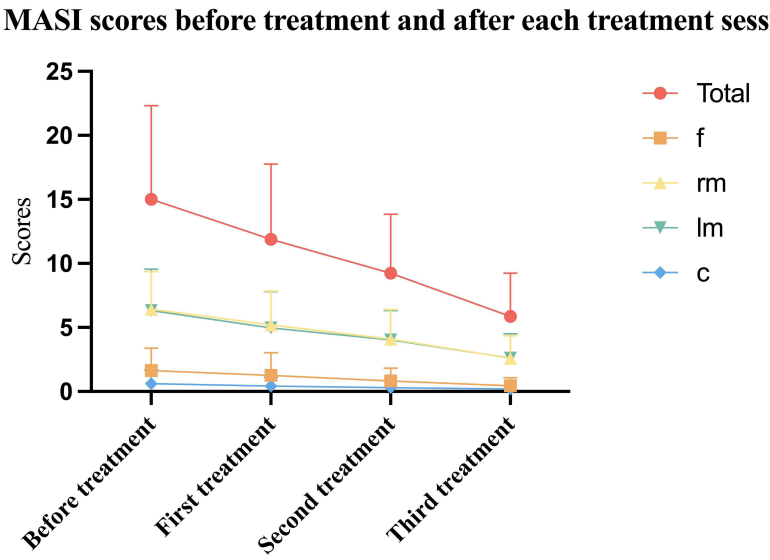

Figure 2 Changes in MASI scores before treatment and after each treatment session. Quantitative analysis revealed a monotonic attenuation of composite MASI scores across treatment cycles. Regional stratification demonstrated consistent amelioration in the frontal, bilateral malar, and mandibular zones, with the left and right malar subunits achieving statistically superior improvement magnitudes relative to adjacent facial compartments.

showed greater improvement than the pregnancy subgroup (p=0.048). No significant differences were found between the genetic and pregnancy subgroups, the pregnancy and other subgroups, or the excessive sun exposure and other subgroups (genetic vs pregnancy, p=0.224; pregnancy vs other, p=0.189; sun exposure vs other, p=0.592) (Table 3).

Secondary Outcome Assessment

Common adverse effects of laser treatment for melasma include post-inflammatory hyperpigmentation (PIH), rebound hyperpigmentation (RH), transient erythema, and scarring.[11] During the treatment period and one-year post-treatment follow-up, three patients developed PIH. One patient developed PIH after the second session, which resolved following extended treatment intervals and strict sun protection, after which treatment was continued. The other two patients developed PIH after the final session, which improved with enhanced skin care and rigorous sun protection over six months. Transient erythema

Table 3 Subgroup Analysis of Multimodal 1064 nm Nd:YAG Laser Therapy for Melasma Based on MASI Scores [mean±SD, M(P_{25}, P_{75})]

Subgroup	Number (n)	Before Treatment	After the Third Treatment	Difference (Pre - Post)	p
Skin Type					
Type III	18	13.18±5.63	5.42±2.87	7.76±3.57	0.196
Type IV	25	13.40(9.90,24.10)	6.18±3.73	7.50(5.85,14.85)	
Age (years)					
≤40	26	12.00(8.10,13.95)	4.98±2.67	6.60(5.18,9.08)	0.007
>40	17	18.94±7.82	7.21±3.97	11.74±5.44	
Duration (months)					
≤12	32	12.90(8.55,17.75)	5.67±3.34	6.75(5.70,11.45)	0.450
>12	11	16.33±7.81	6.43±3.61	9.90±4.96	
Etiology					
Genetic	7	9.99±3.36	3.10(2.40,7.20)	5.77±1.83	0.039
Pregnancy	19	13.61±6.63	5.33±3.34	8.28±4.00	
Excessive sun exposure	9	18.38±7.86	6.31±2.78	12.07±6.19	
Other factors	8	18.93±8.09	8.06±4.16	10.86±5.46	

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Table 4 Adverse Reactions, Recurrence, Recurrence Onset Time, Treatment Interval, and Patient Satisfaction (n)

Item	Patient
Adverse Effects	
Post-inflammatory Hyperpigmentation	3(6.97%)
Rebound Hyperpigmentation	0
Transient Erythema	20(46.51%)
Scar	0
Recurrence (%)	
Recurrence	8(18.60%)
No Recurrence	35(81.40%)
Time to Recurrence (months)	9.50±1.52
Treatment Interval (days)	97.00(58.00, 157.00)
Satisfaction (%)	
Very satisfied	12(27.91%)
Satisfied	19(44.19%)
Neutral	8(18.60%)
Dissatisfied	4(9.30%)

occurred in 20 patients during treatment and resolved spontaneously with improved skin care, with an average resolution time of 11.35±3.73 days. No instances of hypopigmentation or scarring were observed (Table 4).

Eight patients (18.60%) experienced recurrence during the follow-up period after the final treatment, with a mean time to recurrence of 9.50±1.52 months. No recurrences were observed within the first six months post-treatment (Table 4). The treatment intervals ranged from 36 to 224 days, with a median of 97.00 days (58.00, 157.00). An analysis was conducted to evaluate the influence of four factors — skin type, age, disease duration, and etiology — on the remission duration post-treatment. Patients ≤40 years experienced a significantly longer remission period compared to those >40 years of age ($p<0.05$). No significant differences were found for the other factors ($p>0.05$) (Figure 3).

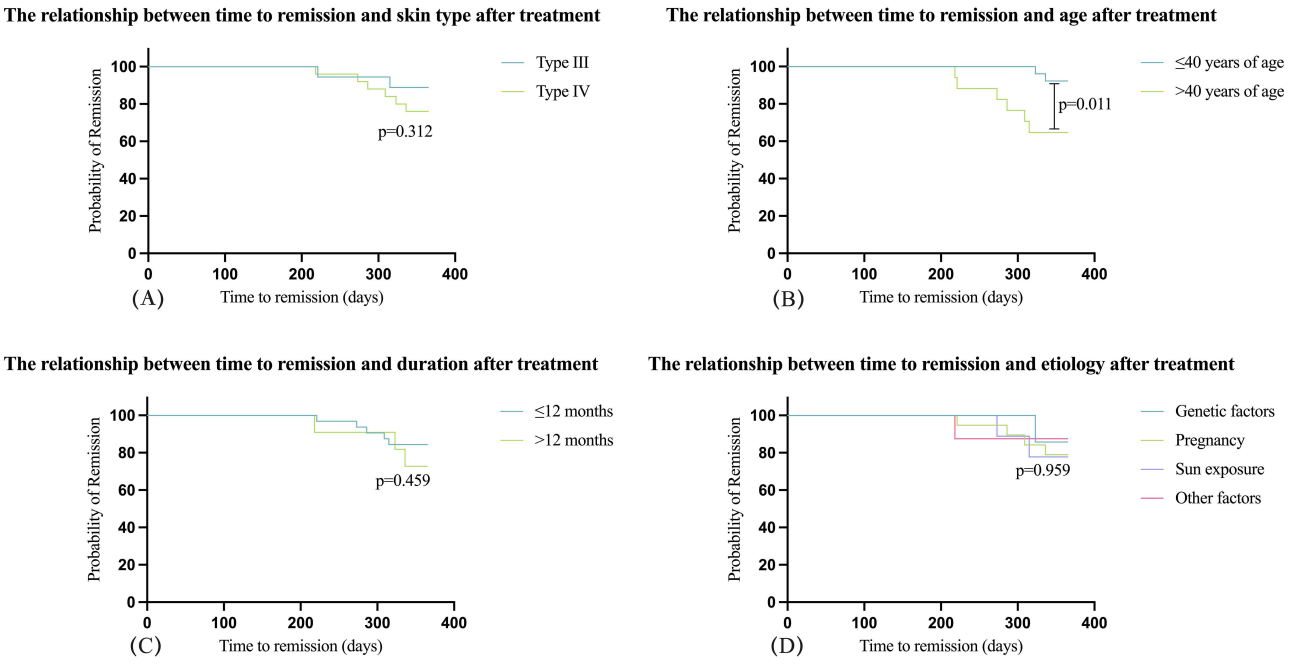

Figure 3 Analysis of the impact of various subgroup factors on the time to remission after treatment. (**A**) Skin typing has no significant impact on the remission time after treatment; (**B**) Age has a significant difference on the remission time after treatment, with patients aged ≤40 years obtaining a longer remission time than >40 years old; (**C**) The course of the disease has no significant impact on the remission time after treatment; (**D**) The cause of the disease has no significant impact on the remission time after treatment.

Patient satisfaction was classified as very satisfied, satisfied, neutral, or dissatisfied. Among the participants, 12 (27.91%) were very satisfied, 19 (44.19%) were satisfied, 8 (18.60%) were neutral, and 4 (9.30%) were dissatisfied. The combined proportion of very satisfied and satisfied patients was 72.10% (Table 4).

Discussion

Multiple treatment options exist for melasma, with oral and topical tranexamic acid proving effective.[12,13] However, many patients show poor tolerance to long-term medication and seek short-term solutions. Consequently, laser therapy has emerged as a preferred alternative. LQSNY is an effective method for treating melasma, capable of disrupting melanophages and inducing melanocyte degeneration. However, it has limitations, including the need for multiple sessions and a high recurrence rate.[14] We aim to improve these shortcomings through combination therapy. FQSNY generates evenly distributed MTZ, leaving the surrounding tissue unaffected. This process stimulates dermal fibroblasts, promotes collagen synthesis and remodeling, thereby enhancing wound healing and restoring the skin barrier.[15] Liu et al[16] demonstrated that melasma lesions predominantly involve increased epidermal melanin, with occasional dermal involvement. Unlike traditional non-ablative lasers, which spare the epidermis and primarily target the dermis, FQSNY selectively eliminates melanin in the epidermis. During the healing process, microscopic epidermal necrotic debris (MENDs) facilitates melanin clearance by acting as a "melanin shuttle".[17] Incorporating FQSNY with LQSNY further optimizes treatment outcomes. This approach delivers lower cumulative energy to melanocytes compared to the total toxic energy required to stimulate or damage them, thereby minimizing the risk of PIH or RH.[5] Melasma lesions are marked by chronic inflammation, which elevates the expression of vascular endothelial growth factor (VEGF), promoting ongoing vascular proliferation. The vascular density in affected skin is more than three times greater than in unaffected areas, and vascularization is closely linked to melanocyte activity in melasma.[18,19] PIH is a frequent complication of laser treatment for melasma and poses significant treatment challenges. LPNY effectively targets blood vessels, mitigates local inflammation, and reduces the incidence of PIH following treatment.

This retrospective observational study demonstrated the efficacy of combining three treatment modalities of the 1064 nm Nd: YAG laser in the management of melasma. After three treatment sessions, MASI scores significantly improved, with notable reductions observed across all facial areas. The scores continued to decline progressively with additional treatments. This treatment approach showed superior results in patients >40 years of age. A large-scale risk factor analysis involving 41,283 melasma patients identified estrogen and progesterone as two of the most significant contributors to disease development.[20] Women aged ≤40 years, typically within their reproductive years, exhibit substantial fluctuations in hormone levels. This inherent hormonal volatility serves as a major trigger and sustaining factor for melasma, profoundly impacting the efficacy of laser therapy. In contrast, women >40 years of age progressively enter perimenopause or menopause, characterized by declining and stabilizing hormone concentrations. This attenuation of a key etiological factor allowed the clinical improvement achieved by laser treatment to manifest more distinctly. However, survival analysis revealed that patients >40 years experienced a shorter remission duration following laser treatment compared to those ≤40 years. This difference may be related to the chronic low-grade inflammatory state that often accompanies skin aging.[21] In individuals over 40, the skin may be characterized by persistent low-level inflammation, and treatment can induce transient disruption of the skin barrier, potentially exacerbating the inflammatory response. Since inflammation is a well-established factor in the pathogenesis of melasma, despite significant initial pigment clearance in older patients, their recurrence rate tends to be higher. The treatment was effective across different melasma etiologies, with the best outcomes observed in cases induced by excessive sun exposure. At the 12-month follow-up, the recurrence rate was 18.60%. In comparison, Gokalp et al[22] reported a recurrence rate of 58.80% at one year following single-modality LQSNY treatment, which was considerably higher than that observed in the present study. Their treatment parameters were as follows: spot size, 6 mm; energy density, 2.50 J/cm²; treatment interval, 2 weeks; and number of sessions, 6 to 10. The combined application of three treatment modalities using the 1064 nm Nd: YAG laser significantly reduced the recurrence rate of melasma. Wattanakrai et al[23] reported complete relapse of melasma in all cases after 12 weeks of single-modality LQSNY treatment. In contrast, the present study observed a significantly delayed recurrence, with an average time to relapse of 9.50±1.52 months. Representative treatment cases are shown in Figures 4–6.

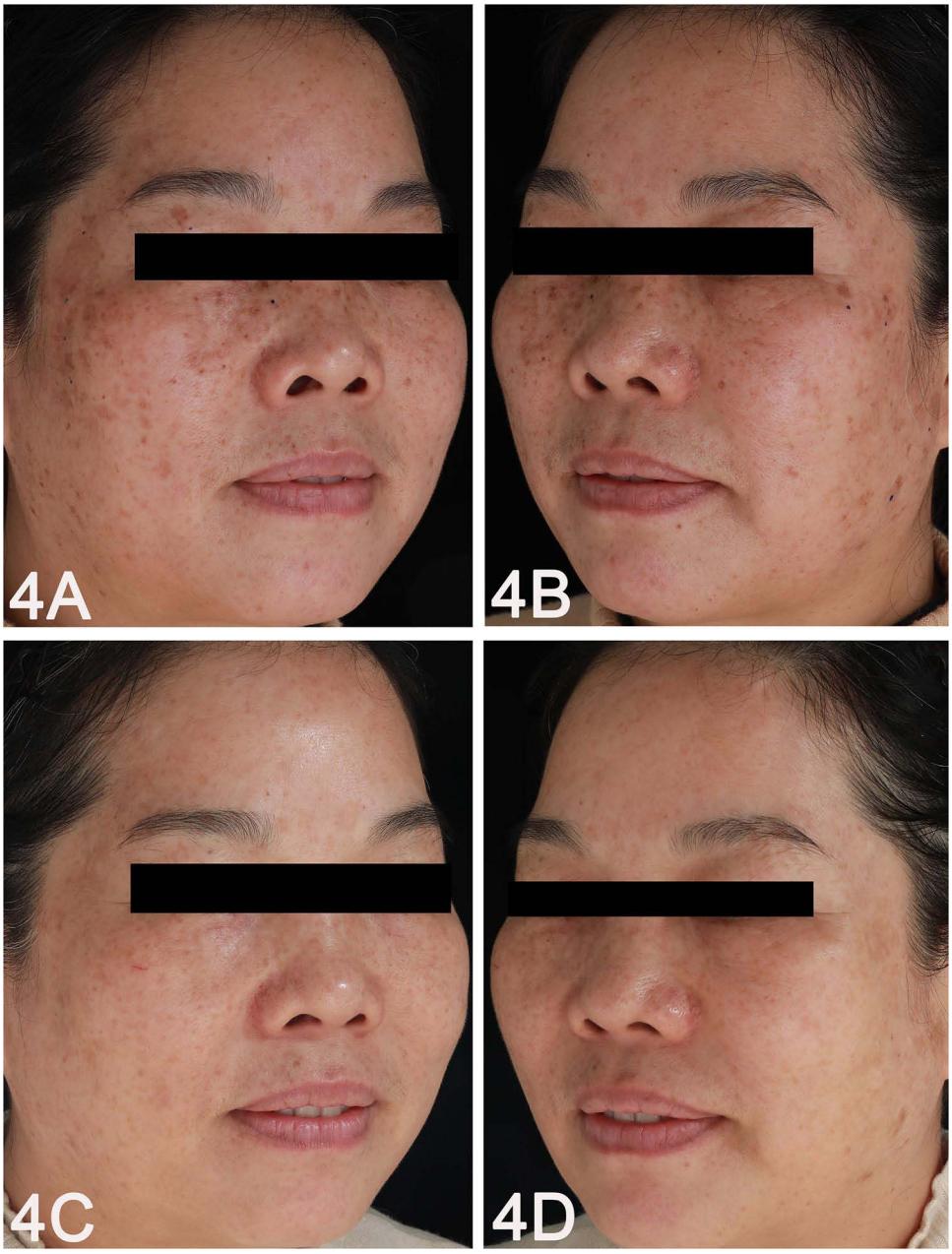

Figure 4 A 48-year-old female patient developed chloasma due to excessive sun exposure. (**A**) Before treatment (right view); (**B**) Before treatment (left view); (**C**) After the third treatment (right view); (**D**) After the third treatment (left view).

The most common complication observed in this study was transient erythema, with an incidence of 46.51%. After FQSNY treatment, some patients also exhibited wound exudation, which was likely due to the selective photothermal effects on capillary endothelial cells or hemoglobin. Postoperatively, the use of burn ointment created a moist healing environment that reduced inflammation, promoted epithelialization, repaired the skin barrier, and facilitated wound healing.[24–26] Transient erythema resolved within two weeks in all patients, effectively preventing prolonged erythema and reducing the risk of PIH. Three patients (6.97%) experienced PIH, which resolved within approximately six months after cessation of laser treatment. The condition improved with close monitoring and enhanced sun protection. Chio et al[27] reported a 14.10% incidence of post-inflammatory hyperpigmentation or hypopigmentation following treatment with LQSNY. Kwon et al[28] reported an 18% incidence of PIH or RH following a combination of LQSNY and fractional microneedling radiofrequency for melasma treatment, compared to 29% with LQSNY monotherapy. The combined

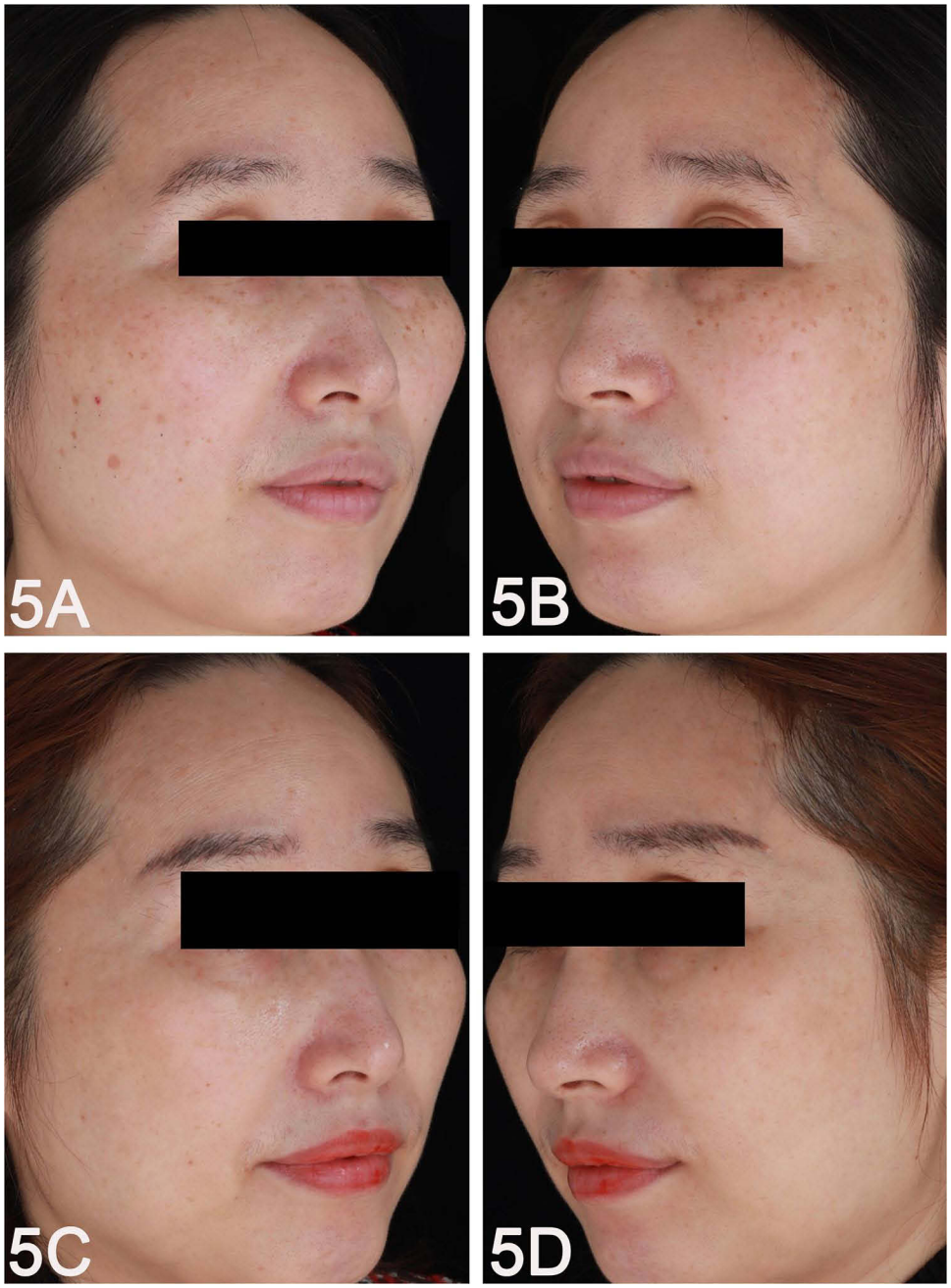

Figure 5 A 37-year-old female patient presented with melasma after pregnancy. (**A**) Before treatment (right view); (**B**) Before treatment (left view); (**C**) After the third treatment (right view); (**D**) After the third treatment (left view).

treatment approach employed in this study effectively minimized complications. In some patients with treatment intervals of 1 to 2 months, no instances of PIH or RH were observed. This method shortened the treatment course and reduced the risk of complications associated with frequent laser treatments, thereby enhancing patient compliance while maintaining efficacy. The combined treatment modality offered advantages of convenience, high efficacy, and superior clinical outcomes, achieving a patient satisfaction rate of 72.10%. This approach may be more acceptable to patients concerned about medication side effects or the high recurrence rate associated with single laser treatments, providing a promising alternative for the laser treatment of melasma.

This study highlighted the efficacy of the combined treatment modality, although further refinement of laser parameters and treatment details is still required. As a retrospective study with a limited sample size and variable treatment intervals,

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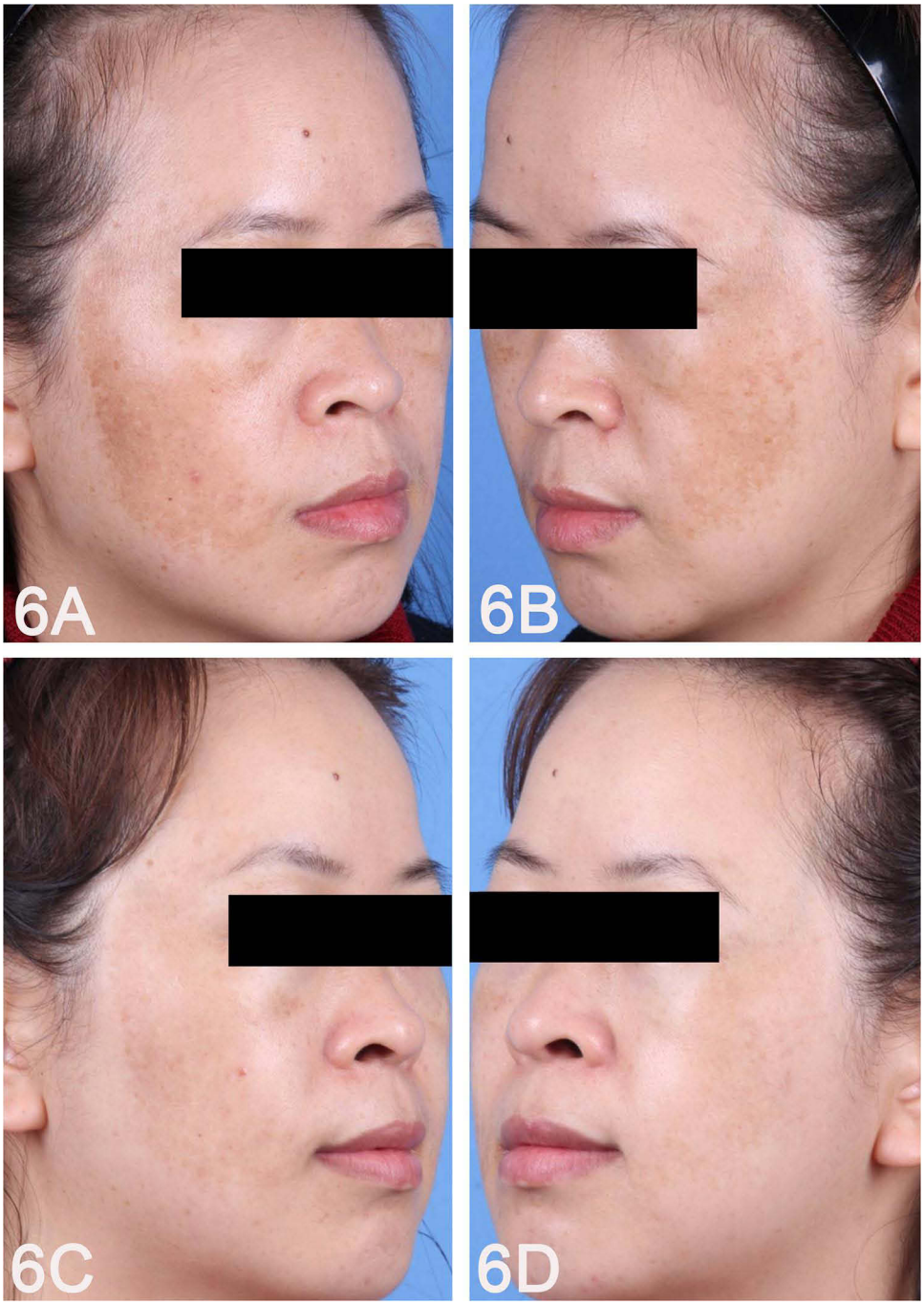

Figure 6 A 43-year-old female patient presented with melasma after pregnancy. (**A**) Before treatment (right view); (**B**) Before treatment (left view); (**C**) After the third treatment (right view); (**D**) After the third treatment (left view).

the results were subject to certain limitations. Future research will involve randomized controlled trials to explore different laser settings and identify the optimal protocol. Additionally, the sample size will be expanded, and objective metrics will be employed to assess outcomes, ensuring the accuracy and clinical applicability of the findings.

Conclusion

Our study demonstrated that the combination of three treatment modalities of the 1064 nm Nd: YAG laser provided favorable clinical outcomes in the treatment of melasma, with a reduced incidence of adverse events and a lower

recurrence rate. Owing to its operational simplicity and favorable patient compliance, this approach represented a promising alternative for routine clinical application.

Abbreviations

QS, Q-swtiched; Nd: YAG, Neodymium-doped Yttrium Aluminium Garnet; LQSNY, low-fluence QS 1064 nm Nd: YAG laser; FQSNY, Fractional-mode QS 1064 nm Nd: YAG laser; MTZ, microscopic treatment zones; LPNY, Long-pulsed 1064 nm Nd: YAG laser; MASI, Melasma Area and Severity Index; PIH, post-inflammatory hyperpigmentation; RH, rebound hyperpigmentation; MENDs, microscopic epidermal necrotic debris; VEGF, vascular endothelial growth factor.

Ethics Approval and Informed Consent

This retrospective observational study, conducted in accordance with the Declaration of Helsinki, received ethical approval from the Institutional Review Board of The Second Affiliated Hospital of Guangxi Medical University [Approval No. 2022-KY -(0552)]. Written informed consent for the use of de-identified clinical data—including photographic documentation obtained during therapeutic procedures—was obtained from all participants prior to treatment initiation.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Passeron T, Picardo M. Melasma, a photoaging disorder. *Pigm Cell Melanoma Res*. 2018;31(4):461–465. doi:10.1111/pcmr.12684
2. Neagu N, Conforti C, Agozzino M, et al. Melasma treatment: a systematic review. *J DermatolTreat*. 2022;33(4):1816–1837. doi:10.1080/09546634.2021.1914313
3. Gan C, Rodrigues M. An update on new and existing treatments for the management of melasma. *Am J Clin Dermatol*. 2024;25(5):717–733. doi:10.1007/s40257-024-00863-2
4. Choi JE, Lee DW, Seo SH, et al. Low-fluence Q-switched Nd: YAG laser for the treatment of melasma in Asian patients. *J Cosmet Dermatol*. 2018;17(6):1053–1058. doi:10.1111/jocd.12760
5. Yue B, Yang Q, Xu J, et al. Efficacy and safety of fractional Q-switched 1064-nm neodymium-doped yttrium aluminum garnet laser in the treatment of melasma in Chinese patients. *Lasers Med Sci*. 2016;31(8):1657–1663. doi:10.1007/s10103-016-2034-4
6. Ogawa R. Long-pulsed 1064 nm Nd:YAG laser treatment for keloids and hypertrophic scars. In: Téot L, Mustoe TA, Middelkoop E, editors. *Textbook on Scar Management: State of the Art Management and Emerging Technologies*. Cham (CH): Springer Copyright 2020, The Author(s); 2020:271–278
7. Cassiano DP, Espósito ACC, Da Silva CN, et al. Update on melasma-part II: treatment. *Dermatol Ther*. 2022;12(9):1989–2012. doi:10.1007/s13555-022-00780-4
8. Pandya AG, Hynan LS, Bhore R, et al. Reliability assessment and validation of the Melasma Area and Severity Index (MASI) and a new modified MASI scoring method. *J Am Acad Dermatol*. 2011;64(1):78–83, e1–2. doi:10.1016/j.jaad.2009.10.051
9. Espósito ACC, Cassiano DP, Da Silva CN, et al. Update on melasma-part i: pathogenesis. *Dermatol Ther*. 2022;12(9):1967–1988. doi:10.1007/s13555-022-00779-x
10. Shankar K, Godse K, Aurangabadkar S, et al. Evidence-based treatment for melasma: expert opinion and a review. *Dermatol Ther*. 2014;4(2):165–186. doi:10.1007/s13555-014-0064-z
11. Lai D, Zhou S, Cheng S, et al. Laser therapy in the treatment of melasma: a systematic review and meta-analysis. *Lasers Med Sci*. 2022;37(4):2099–2110. doi:10.1007/s10103-022-03514-2
12. Godse K, Sarkar R, Mysore V, et al. Oral tranexamic acid for the treatment of melasma: evidence and experience-based consensus statement from Indian experts. *Indian J Dermatol*. 2023;68(2):178–185. doi:10.4103/ijd.ijd_266_22
13. Calacattawi R, Alshahrani M, Aleid M, et al. Tranexamic acid as a therapeutic option for melasma management: meta-analysis and systematic review of randomized controlled trials. *J DermatolTreat*. 2024;35(1):2361106. doi:10.1080/09546634.2024.2361106
14. Mun JY, Jeong SY, Kim JH, et al. A low fluence Q-switched Nd:YAG laser modifies the 3D structure of melanocyte and ultrastructure of melanosome by subcellular-selective photothermolysis. *J Electron Microsc*. 2011;60(1):11–18. doi:10.1093/jmicro/dfq068
15. Habbema L, Verhagen R, Van Hal R, et al. Efficacy of minimally invasive nonthermal laser-induced optical breakdown technology for skin rejuvenation. *Lasers Med Sci*. 2013;28(3):935–940. doi:10.1007/s10103-012-1179-z
16. Liu H, Lin Y, Nie X, et al. Histological classification of melasma with reflectance confocal microscopy: a pilot study in Chinese patients. *Skin Res Technol*. 2011;17(4):398–403. doi:10.1111/j.1600-0846.2011.00517.x
17. Laubach HJ, Tannous Z, Anderson RR, et al. Skin responses to fractional photothermolysis. *Lasers Surg Med*. 2006;38(2):142–149. doi:10.1002/lsm.20254
18. Liu W, Chen Q, Xia Y. New Mechanistic Insights of Melasma. *Clin Cosmet Invest Dermatol*. 2023;16:429–442. doi:10.2147/CCID.S396272
19. Wang Z, Chen Y, Pan S, et al. Quantitative classification of melasma with photoacoustic microscopy: a pilot study. *J Biomed Opt*. 2024;29(Suppl 1):S11504. doi:10.1117/1.JBO.29.S1.S11504
20. Sharma AN, Kincaid CM, Mesinkovska NA. The burden of melasma: race, ethnicity, and comorbidities. *J Drugs Dermatol*. 2024;23(8):691–693. doi:10.36849/JDD.8233

21. Zhang M, Lin Y, Han Z, et al. Exploring mechanisms of skin aging: insights for clinical treatment. *Front Immunol*. 2024;15:1421858. doi:10.3389/fimmu.2024.1421858
22. Gokalp H, Akkaya AD, Oram Y. Long-term results in low-fluence 1064-nm Q-Switched Nd:YAG laser for melasma: is it effective? *J Cosmet Dermatol*. 2016;15(4):420–426. doi:10.1111/jocd.12253
23. Wattanakrai P, Mornchan R, Eimpunth S. Low-fluence Q-switched neodymium-doped yttrium aluminum garnet (1064 nm) laser for the treatment of facial melasma in Asians. *Dermatol Surg*. 2010;36(1):76–87. doi:10.1111/j.1524-4725.2009.01383.x
24. Liang Z, Lai P, Zhang J, et al. Impact of moist wound dressing on wound healing time: a meta-analysis. *Int Wound J*. 2023;20(10):4410–4421. doi:10.1111/iwj.14319
25. Mabvuure NT, Brewer CF, Gervin K, et al. The use of moist exposed burn ointment (MEBO) for the treatment of burn wounds: a systematic review. *J Plast Surg Hand Surg*. 2020;54(6):337–343. doi:10.1080/2000656X.2020.1813148
26. Gong Y, Jiang Y, Huang J, et al. Moist exposed burn ointment accelerates diabetes-related wound healing by promoting re-epithelialization. *Front Med*. 2022;9:1042015. doi:10.3389/fmed.2022.1042015
27. Choi CP, Yim SM, Seo SH, et al. Retrospective analysis of melasma treatment using a dual mode of low-fluence Q-switched and long-pulse Nd:YAG laser vs. low-fluence Q-switched Nd:YAG laser monotherapy. *J Cosmet Laser Ther*. 2015;17(1):2–8. doi:10.3109/14764172.2014.957217
28. Kwon HH, Choi SC, Jung JY, et al. Combined treatment of melasma involving low-fluence Q-switched Nd:YAG laser and fractional microneedling radiofrequency. *J DermatolTreat*. 2019;30(4):352–356. doi:10.1080/09546634.2018.1516858