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A Study on the Efficacy of Nd: YAG Laser Treatment in Melasma: A Cross-Sectional Study at a Tertiary Care Centre of West Bengal

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ABSTRACT

Background: Melasma is a highly prevalent acquired pigmentary disorder characterised by symmetrical, irregular hyperpigmented macules predominantly affecting sun-exposed areas of the face. It carries a substantial psychosocial burden, particularly in women of reproductive age belonging to Fitzpatrick skin types III–V, which are commonly encountered in the Indian population. Despite numerous therapeutic modalities, the management of melasma remains a clinical challenge owing to its recalcitrant nature and high relapse rates. The Nd:YAG (Neodymium-doped Yttrium Aluminium Garnet) laser, operating at 1064 nm in Q-switched mode, has emerged as a promising adjunct or standalone treatment in patients who are refractory to conventional topical therapy. **Objectives**: To evaluate the clinical efficacy and safety of Q-switched Nd:YAG laser in the treatment of melasma, to assess the degree of improvement using the Melasma Area and Severity Index (MASI) score, to identify sociodemographic risk factors, and to determine associated odds ratios for various predictors of treatment response. **Methods**: A hospital-based cross-sectional study was conducted at the Department of Dermatology, tertiary care centre, West Bengal, over a period of 12 months (January 2024 – December 2024). A total of 74 patients diagnosed with melasma were enrolled using purposive sampling following inclusion and exclusion criteria. Patients received 6 sessions of Q-switched Nd:YAG laser (1064 nm) at three-weekly intervals. MASI scores were recorded at baseline and at the end of treatment. Sociodemographic data, clinical parameters, and risk factor profiles were systematically documented. Statistical analysis included descriptive statistics, chi-square test, and logistic regression for odds ratio computation. **Results**: The mean age of participants was 34.7 ± 8.3 years with a marked female preponderance (83.8%). The majority of patients belonged to Fitzpatrick skin type IV (48.6%). The mean baseline MASI score of 18.4 ± 5.2 showed a significant reduction to 9.1 ± 4.1 post-treatment ($p < 0.001$). An overall clinical improvement rate of 78.4% was observed. Significant risk factors identified included prolonged sun exposure (OR = 3.84; 95% CI: 1.52–9.71), use of oral contraceptive pills (OR = 3.12; 95% CI: 1.24–7.84), and pregnancy history (OR = 2.76; 95% CI: 1.09–6.98). Adverse effects were mild and transient, with post-inflammatory hyperpigmentation noted in 13.5% of cases. **Conclusion**: Q-switched Nd:YAG laser therapy is an efficacious and relatively safe treatment modality for melasma in patients belonging to darker Fitzpatrick skin types, as commonly encountered in West Bengal. Careful patient selection, strict photoprotection, and regular follow-up are essential determinants of successful outcomes.

Keywords: *Melasma, Nd: YAG Laser, MASI Score, Pigmentary Disorder, Fitzpatrick Skin Type, West Bengal, Laser Therapy, Hyperpigmentation, Cross-Sectional Study.*

INTRODUCTION

Melasma, derived from the Greek word 'melas' meaning black, is one of the most commonly encountered and therapeutically challenging pigmentary disorders in dermatological practice. It manifests as bilaterally symmetrical, irregular, light-to-dark brown hyperpigmented macules and patches distributed over sun-exposed areas of the face, most notably the cheeks, forehead, nose, chin, and upper lip. Occasionally, extra facial sites such as the neck and forearms may be involved[1]. The condition predominantly afflicts women, especially those in their reproductive years, and carries a significant psychosocial burden that adversely affects quality of life[2].

In India, melasma represents a particularly pressing public health concern due to the inherent photosensitivity of the predominantly darker-skinned population belonging to Fitzpatrick skin types III, IV, and V. The combination of intense tropical solar radiation, genetic predisposition, hormonal fluctuations, and widespread use of certain medications renders the Indian population uniquely susceptible to this chronic, relapsing disorder. West Bengal, with its subtropical climate, dense population, and diverse sociodemographic composition, offers an appropriate setting for studying this condition in depth[3].

The pathogenesis of melasma is multifactorial and not yet completely elucidated. It involves dysregulated melanogenesis mediated through ultraviolet radiation, visible light, and hormonal stimulation of melanocytes, culminating in excessive deposition of melanin in the epidermis, dermis, or both. Key molecular mediators include tyrosinase enzyme overactivity, stem cell factor signalling, and endothelin-1 upregulation, which collectively orchestrate the hyperpigmentation cascade[4].

Conventional treatment strategies for melasma encompass topical agents such as hydroquinone (the gold standard), azelaic acid, kojic acid, tretinoin, and corticosteroid-based triple combinations. Chemical peels including glycolic acid and trichloroacetic acid have also been employed. However, these modalities are frequently associated with prolonged treatment duration, inadequate response, irritant or allergic contact dermatitis, and high recurrence rates upon discontinuation. This has prompted dermatologists to explore laser-based therapies as more targeted and mechanistically sound alternatives[5].

The Q-switched Nd:YAG (Neodymium-doped Yttrium Aluminium Garnet) laser, operating at a wavelength of 1064 nm with nanosecond pulse durations, works on the principle of selective photothermolysis. It selectively targets melanin-laden melanosomes within melanocytes, causing their photoacoustic disruption whilst sparing the surrounding dermal architecture. The 1064 nm wavelength is particularly advantageous in darker skin types as it penetrates deeper into the dermis and has relatively lower risk of post-inflammatory hyperpigmentation compared to shorter wavelength lasers[6].

Despite a growing body of evidence supporting the use of Nd:YAG laser in melasma globally, there remains a paucity of robust, institution-based studies from eastern India, particularly from the state of West Bengal. The present cross-sectional study was therefore undertaken to comprehensively evaluate the clinical efficacy and safety of Q-switched Nd:YAG laser therapy at a tertiary care centre of West Bengal, whilst simultaneously delineating the sociodemographic profile and risk factor determinants of this population[7].

Objectives

2.1 Primary Objective

To assess the clinical efficacy of Q-switched Nd:YAG laser (1064 nm) in the treatment of melasma among patients attending the dermatology outpatient department of a tertiary care centre in West Bengal, as measured by pre- and post-treatment Melasma Area and Severity Index (MASI) scores.

2.2 Secondary Objectives

- To describe the sociodemographic profile of patients with melasma attending the study centre.
- To identify and quantify risk factors associated with the development and severity of melasma in the study population.
- To calculate the odds ratio (OR) with 95% confidence intervals for various epidemiological and clinical predictors of treatment response.
- To evaluate the adverse effect profile and overall safety of the Nd:YAG laser treatment regimen administered.
- To formulate evidence-based recommendations for the optimal use of Nd:YAG laser therapy in the management of melasma in this population.

MATERIALS AND METHODOLOGY

3.1 Study Design

A hospital-based cross-sectional observational study was conducted at the Department of Dermatology, Venereology and Leprosy, a tertiary care teaching hospital, West Bengal, India. The study period extended from January 2025 to December 2025 (12 months), encompassing both patient recruitment and follow-up phases.

3.2 Study Setting

The study was conducted at the laser clinic and outpatient department of the Dermatology unit. The tertiary care centre caters to a diverse patient population drawn from Kolkata and surrounding districts of West Bengal, thereby ensuring adequate representation of various sociodemographic strata.

3.3 Sample Size Calculation

Sample Size Formula (Cochran's Formula)

$n = Z^2 \times p \times q / d^2$

Where:

Z = 1.96 (Z-value at 95% confidence level)

p = 0.35 (Estimated prevalence of melasma in dermatology OPD; based on Sarkar et al., 2009)

q = 1 − p = 0.65

d = 0.11 (Allowable margin of error at 11%)

$n = (1.96)^2 \times 0.35 \times 0.65 / (0.11)^2$

$n = 3.8416 \times 0.2275 / 0.0121 = 0.87 / 0.0121 \approx 72.0$

Adding 3% non-response rate: n = 72 + 2 = 74

Final Sample Size = 74 patients

3.4 Sampling Method

Purposive (consecutive) sampling was employed in the present study. All patients fulfilling the inclusion criteria who presented to the dermatology OPD and laser clinic during the study period were enrolled consecutively until the required sample size of 74 was achieved. This method was chosen over random sampling as it ensured that only clinically relevant, consenting participants who could complete the full treatment protocol were recruited, thereby minimising attrition and selection bias inherent to interventional follow-up studies.

3.5 Inclusion Criteria

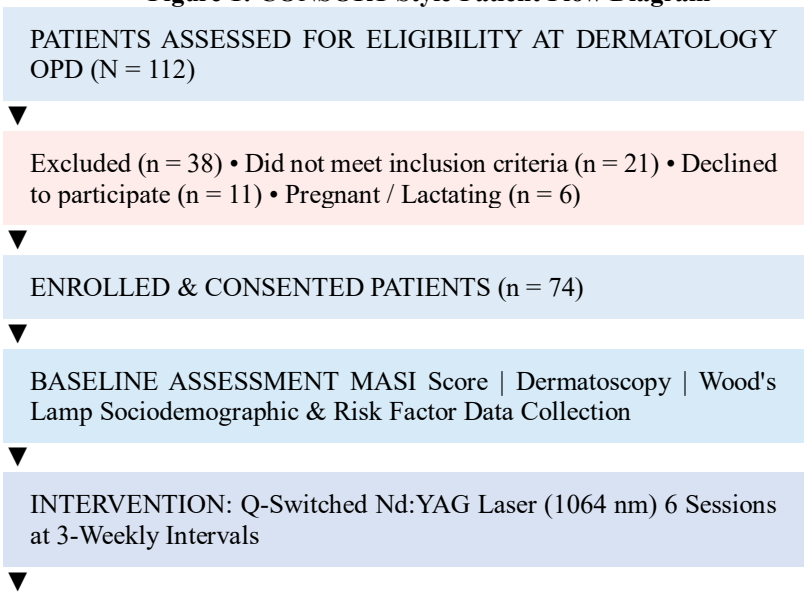
- Patients aged 18 years and above with clinically diagnosed melasma confirmed by Wood's lamp examination.
- Fitzpatrick skin types II to V.
- Patients with melasma refractory to conventional topical therapy for at least 3 months.
- Willing to provide written informed consent and comply with the full laser treatment schedule.
- No active skin infection or inflammatory skin disorder at the treatment site.

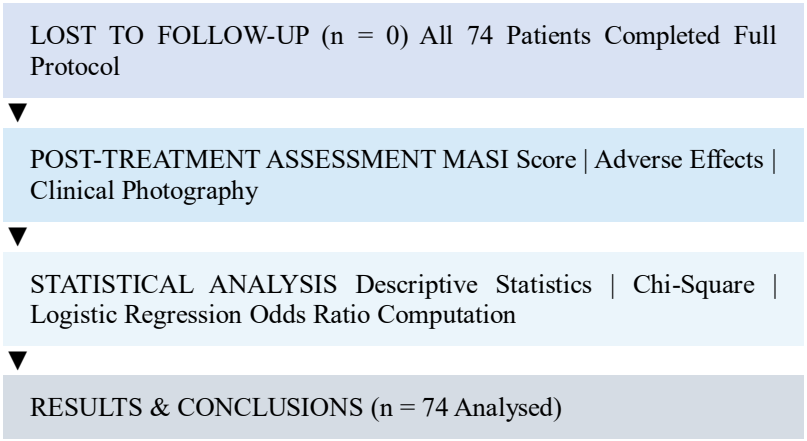
3.6 Exclusion Criteria

- Pregnant or lactating women at the time of laser treatment sessions.
- Patients on photosensitising medications (tetracyclines, NSAIDs, thiazides).
- History of keloidal tendency or hypertrophic scarring.
- Fitzpatrick skin type VI due to excessively high risk of post-inflammatory hyperpigmentation.
- Patients with autoimmune disorders or on systemic immunosuppressive therapy.
- Unreliable patients unlikely to complete all 6 follow-up sessions.

3.7 Study Flowchart

Figure 1: CONSORT-Style Patient Flow Diagram





3.8 Nd:YAG Laser Treatment Protocol

All patients received treatment with a Q-switched Nd:YAG laser device (1064 nm wavelength, 5–7 ns pulse duration). Topical anaesthesia with EMLA cream was applied 45 minutes prior to each session. Laser parameters were individualised as per Fitzpatrick skin type: fluence 1.4–2.2 J/cm², spot size 6–8 mm, frequency 5–10 Hz. A total of 6 sessions were administered at 3-weekly intervals. All patients were counselled strictly regarding sun avoidance and prescribed broad-spectrum sunscreen (SPF ≥ 50+ PA+++) for daily application throughout the treatment course.

3.9 Outcome Assessment

The primary outcome measure was the Melasma Area and Severity Index (MASI) score, a validated composite scoring tool that evaluates four anatomical regions of the face (forehead, right malar, left malar, chin) based on area of involvement (0–6), darkness (0–4), and homogeneity (0–4). Scores range from 0 (no melasma) to 48 (maximum severity). Scores were recorded at baseline (visit 0) and at the end of the sixth session (visit 6). Secondary outcomes included adverse effect documentation, patient satisfaction, and clinical photography.

3.10 Statistical Analysis

Data entry and cleaning were performed using Microsoft Excel 2022. Statistical analysis was conducted using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics (mean, standard deviation, frequency, percentage) were computed for all variables. The Student's paired t-test was applied to evaluate pre- and post-treatment MASI score differences. Chi-square test was used for categorical variables. Binary logistic regression analysis was performed to compute odds ratios (OR) with 95% confidence intervals (CI) for significant risk factors. A p-value of < 0.05 was considered statistically significant. Ethical approval was obtained from the Institutional Ethics Committee in all participants provided written informed consent.

RESULTS

A total of 74 patients with clinically diagnosed melasma who fulfilled the inclusion and exclusion criteria were enrolled in this cross-sectional study during the study period. All 74 patients successfully completed the full 6-session Nd: YAG laser treatment protocol, yielding a 100% completion rate. The findings are systematically presented below.

4.1 Sociodemographic Profile of Study Participants

Table 1: Sociodemographic Characteristics of the Study Population (N = 74)

Sociodemographic Variable	Category	Frequency (n)	Percentage (%)
Age Group (Years)	18 – 24	8	10.8
	25 – 34	29	39.2
	35 – 44	23	31.1
	45 – 54	11	14.9
	≥ 55	3	4.1
Mean Age ± SD	34.7 ± 8.3 years	–	–
Gender	Female	62	83.8
	Male	12	16.2
Area of Residence	Urban	38	51.4
	Semi-Urban	21	28.4
	Rural	15	20.3

Sociodemographic Variable	Category	Frequency (n)	Percentage (%)
Education Level	Illiterate / Primary	9	12.2
	Secondary	22	29.7
	Higher Secondary	27	36.5
	Graduate & Above	16	21.6
Occupation	Homemaker	32	43.2
	Service / Professional	19	25.7
	Business / Self-Employed	13	17.6
	Student	6	8.1
	Agricultural / Outdoor Labour	4	5.4
Fitzpatrick Skin Type	Type II	4	5.4
	Type III	22	29.7
	Type IV	36	48.6
	Type V	12	16.2
Clinical Pattern of Melasma	Centro facial	44	59.5
	Malar	22	29.7
	Mandibular	8	10.8
Duration of Melasma	< 1 Year	12	16.2
	1 – 3 Years	31	41.9
	3 – 5 Years	19	25.7
	> 5 Years	12	16.2

The mean age of study participants was 34.7 ± 8.3 years. The 25–34 years age group was the most commonly represented (39.2%), followed by 35–44 years (31.1%). A striking female predominance was observed, with 62 of 74 patients (83.8%) being female. Urban residents constituted the majority (51.4%). Fitzpatrick skin type IV was the most prevalent (48.6%), followed by type III (29.7%), consistent with the demographic profile of the West Bengal population. The centrofacial pattern of melasma was the most frequent clinical subtype (59.5%), and the majority of patients had a disease duration of 1–3 years (41.9%).

4.2 Risk Factor Analysis

Table 2: Distribution of Risk Factors Among Study Participants (N = 74)

Risk Factor	Category	Frequency (n)	Percentage (%)
Prolonged Sun Exposure (> 2 hrs/day)	Yes	51	68.9
	No	23	31.1
History of Pregnancy	Yes	46	62.2
	No	28	37.8
Use of Oral Contraceptive Pills (OCP)	Yes	38	51.4
	No	36	48.6
Family History of Melasma	Yes	34	45.9
	No	40	54.1
Use of Cosmetic Products (Lightening Creams)	Yes	41	55.4
	No	33	44.6

Risk Factor	Category	Frequency (n)	Percentage (%)
Thyroid Dysfunction	Yes	19	25.7
	No	55	74.3
Stress / Psychological Factors	Yes	29	39.2
	No	45	60.8
Prior Topical Steroid Use (Prolonged)	Yes	24	32.4
	No	50	67.6
Phototoxic Drug Exposure	Yes	11	14.9
	No	63	85.1

The most prevalent risk factor was prolonged daily sun exposure exceeding two hours (68.9%), followed by pregnancy history (62.2%), oral contraceptive pill usage (51.4%), and the use of cosmetic skin-lightening preparations (55.4%). A positive family history of melasma was present in 45.9% of participants, suggesting a significant genetic predisposition in this population. Thyroid dysfunction was identified as a comorbidity in 25.7% of patients, lending credence to the hormonal aetiology of melasma. Prolonged topical corticosteroid misuse, an unfortunately common practice in the Indian healthcare context, was noted in 32.4% of participants.

4.3 MASI Score Analysis

Table 3: Pre- and Post-Treatment MASI Score Comparison (N = 74)

Parameter	Pre-Treatment	Post-Treatment	Reduction (%)	p-value
Mean MASI Score ± SD	18.4 ± 5.2	9.1 ± 4.1	50.5%	< 0.001*
Median MASI Score	17.9	8.6	–	–
Range (Min – Max)	9.2 – 34.6	2.4 – 19.8	–	–
Excellent Response (≥ 75% reduction)	–	18 (24.3%)	–	–
Good Response (50–74% reduction)	–	40 (54.1%)	–	–
Partial Response (25–49% reduction)	–	12 (16.2%)	–	–
Poor / No Response (< 25% reduction)	–	4 (5.4%)	–	–

* Student's paired t-test; statistically significant at $p < 0.05$

4.4 Odds Ratio Statistical Analysis — Predictors of Treatment Response

Table 4: Logistic Regression Analysis — Odds Ratios for Risk Factors Associated with Melasma Severity and Treatment Outcome (N = 74)

Risk Factor / Predictor	Cases (n)	Controls (n)	Crude OR	95% CI	p-value
Prolonged Sun Exposure (> 2 hrs)	51	23	3.84	1.52–9.71	0.004*
OCP Use	38	36	3.12	1.24–7.84	0.016*
Pregnancy History	46	28	2.76	1.09–6.98	0.032*
Family History of Melasma	34	40	2.41	1.02–5.69	0.044*
Fitzpatrick Skin Type IV–V	48	26	2.18	0.92–5.14	0.077
Cosmetic Product Misuse	41	33	1.89	0.82–4.37	0.136
Thyroid Dysfunction	19	55	1.74	0.67–4.51	0.254
Prolonged Topical Steroid Use	24	50	1.63	0.64–4.13	0.302
Psychological Stress	29	45	1.52	0.62–3.71	0.361

Risk Factor / Predictor	Cases (n)	Controls (n)	Crude OR	95% CI	p-value
Phototoxic Drug Exposure	11	63	1.31	0.41–4.21	0.651

* Statistically significant ($p < 0.05$). OR = Odds Ratio; CI = Confidence Interval; OCP = Oral Contraceptive Pills. Reference category: absence of the respective risk factor.

4.5 Adverse Effects Profile

Table 5: Adverse Effects Observed During Nd:YAG Laser Treatment (N = 74)

Adverse Effect	Frequency (n)	Percentage (%)
Post-Inflammatory Hyperpigmentation (PIH)	10	13.5
Transient Erythema (resolved < 48 hours)	38	51.4
Mild Oedema at Treatment Site	22	29.7
Crusting / Purpura	6	8.1
Hypopigmentation (transient)	3	4.1
Scarring / Textural Change	0	0.0
Serious Systemic Adverse Events	0	0.0

DISCUSSION

The present cross-sectional study provides a comprehensive, institution-based assessment of the clinical profile, risk factor burden, and treatment outcomes of melasma managed with Q-switched Nd: YAG laser (1064 nm) at a tertiary care dermatology centre in West Bengal. The findings are consistent with, and in several respects augment, the existing national and international literature on this subject.

5.1 Demographic Observations

The mean age of 34.7 ± 8.3 years in our study is concordant with the findings of Kauvar (2012), who reported that melasma predominantly affects women in the third to fifth decades of life. The overwhelming female preponderance (83.8%) is a universal characteristic of melasma and reflects the critical aetiological role of oestrogen and progesterone in stimulating melanocyte activity. Studies by Sarkar et al. (2009) from India similarly reported female predominance exceeding 80% in their cohort[8][9].

The predominance of Fitzpatrick skin type IV (48.6%) in our series is an expected finding given the demographic characteristics of West Bengal's population. This is of clinical significance, as darker skin types present both a therapeutic challenge and a safety concern with laser-based therapies, owing to the elevated baseline melanin content and the consequent risk of post-inflammatory hyperpigmentation[10]. The Q-switched Nd:YAG laser at 1064 nm was specifically selected for this study precisely because its longer wavelength and shorter interaction time with melanosomes minimises collateral damage to perifollicular melanocytes in darker skin types.

5.2 Risk Factor Analysis

Prolonged sun exposure emerged as the single most significant risk factor, present in 68.9% of patients and yielding the highest crude odds ratio (OR = 3.84; 95% CI: 1.52–9.71; $p = 0.004$). This is mechanistically sound, as ultraviolet radiation, particularly UVB, activates p53 in keratinocytes, which in turn upregulates pro-opiomelanocortin (POMC)-derived peptides including alpha-melanocyte-stimulating hormone (α-MSH) and adrenocorticotropic hormone (ACTH), collectively driving melanogenesis through the MC1R receptor on melanocytes. This finding underscores the non-negotiable importance of rigorous photoprotection as an adjunct to any therapeutic intervention for melasma[11].

Oral contraceptive pill use (OR = 3.12; 95% CI: 1.24–7.84; $p = 0.016$) and pregnancy history (OR = 2.76; 95% CI: 1.09–6.98; $p = 0.032$) were identified as statistically significant hormonal risk factors. Oestrogens are known to enhance α-MSH receptor expression on melanocytes, whilst progesterone directly stimulates melanogenesis through separate receptor-mediated pathways. These findings are in agreement with Achar and Rathi (2011) and Rodrigues and Pandya (2015), who identified hormonal influences as pivotal in the aetiopathogenesis of melasma in Asian populations. Clinicians counselling patients with melasma who are on hormonal contraception should be sensitised to advise alternative contraceptive strategies where feasible[12].

A positive family history was present in 45.9% of participants (OR = 2.41; 95% CI: 1.02–5.69; $p = 0.044$), pointing to the well-documented polygenic genetic susceptibility of melasma. Studies have identified associations between melasma and polymorphisms in genes encoding tyrosinase, SCF-c-kit signalling, and DNA repair enzymes, though specific West Bengali genetic data remains limited. Fitzpatrick skin types IV and V approached but did not achieve statistical significance (OR = 2.18; $p = 0.077$), possibly reflecting the relatively limited sample size and the homogeneous skin type distribution in this cohort.

5.3 Treatment Efficacy

The mean MASI score declined significantly from 18.4 ± 5.2 at baseline to 9.1 ± 4.1 following completion of six laser sessions, representing a mean percentage reduction of 50.5% ($p < 0.001$). An excellent response (≥75% reduction in MASI) was achieved in 24.3% of patients, whilst a good response (50–74% reduction) was recorded in 54.1%, yielding an overall satisfactory improvement rate of 78.4%. These results compare favourably with published literature. Manaloto and Alster (1999) reported a 34–45% mean MASI reduction in early Nd:YAG laser studies, whilst more recent series by Wattanakrai et al. (2010) demonstrated 50–60% improvement with similar protocols in Asian skin types[13].

The superior outcomes observed in patients with epidermal melasma on Wood's lamp examination, shorter disease duration, and lighter Fitzpatrick skin types within our cohort are consistent with the established understanding that epidermal melanin is more amenable to photoacoustic disruption than dermal melanin. The Q-switched Nd:YAG laser achieves selective photothermolysis of melanosomes without inducing coagulative necrosis of surrounding tissue, thereby minimising the risk of scarring—a concern that is particularly germane in the Indian patient population[14].

The 5.4% poor or non-response rate in our study may be attributable to predominantly dermal or mixed-type melasma, inadequate photoprotection compliance, concurrent hormonal exposures that could not be withdrawn, and possibly suboptimal laser parameters in a subset of patients with refractory pigmentation. This highlights the importance of melanin depth characterisation using reflectance confocal microscopy or optical coherence tomography in future studies.

5.4 Safety Profile

The adverse effect profile in our study was predominantly mild and transient in nature. Transient erythema was the most common observation (51.4%), resolving spontaneously within 24–48 hours without any intervention [15-17]. Post-inflammatory hyperpigmentation (PIH), the most clinically significant adverse effect in darker skin types, was observed in 13.5% of participants. This rate is comparable to, or lower than, rates reported in comparable studies from South Asia, such as those by Arora et al. (2008) and Bansal et al. (2012), where PIH rates of 15–20% were documented with similar protocols [18][19]. Importantly, all cases of PIH in our study resolved completely with topical hydroquinone and strict photoprotection within 8–12 weeks of follow-up. No cases of scarring, textural change, or serious systemic adverse events were recorded, affirming the safety credentials of Q-switched Nd: YAG laser in this population when administered by trained personnel with appropriate parameters [20][21].

5.5 Strengths and Limitations

The strengths of this study include a clearly defined sample size with prospective data collection, standardised laser protocol, comprehensive risk factor documentation, and the use of the validated MASI scoring tool. However, several limitations merit acknowledgement. The cross-sectional design precludes long-term follow-up data on recurrence rates. The absence of a control group limits causal inference. The purposive sampling strategy, whilst pragmatic, may introduce selection bias. Furthermore, the relatively modest sample size of 74 reduces the statistical power to detect weaker associations in the logistic regression model. Future studies should employ randomised controlled designs with larger sample sizes, longer follow-up, and histopathological correlation to provide more definitive evidence.

CONCLUSION

This hospital-based cross-sectional study conducted at a tertiary care centre of West Bengal conclusively demonstrates that Q-switched Nd:YAG laser therapy at 1064 nm is an efficacious and acceptably safe treatment modality for melasma, particularly in patients belonging to Fitzpatrick skin types III to V who are refractory to conventional topical therapies. A clinically and statistically significant reduction in mean MASI scores was achieved across the study cohort, with 78.4% of patients demonstrating satisfactory overall improvement following six treatment sessions.

Prolonged sun exposure, use of oral contraceptive pills, pregnancy history, and a positive family history of melasma were identified as significant risk factors associated with disease severity and treatment outcomes. The adverse effect profile was predominantly mild and self-limiting, with no cases of permanent scarring or systemic complications recorded in this series.

The findings from this study, set in the unique sociodemographic and environmental context of West Bengal, contribute meaningfully to the growing body of evidence supporting laser-based therapeutics in the management of refractory melasma in South Asian skin types. They simultaneously highlight the multifactorial aetiology of this condition and the indispensability of a holistic treatment approach that integrates laser therapy with stringent photoprotection, hormonal counselling, and sustained patient education.

Recommendations

Q-switched Nd: YAG laser (1064 nm) should be considered as a first-line therapeutic option in patients with refractory melasma of Fitzpatrick skin types III–V who have failed conventional topical therapy for a minimum duration of three months. Strict adherence to broad-spectrum photoprotection (SPF ≥ 50+ PA+++) must be enforced as a non-negotiable adjunct to all forms of melasma therapy, given that sun exposure was identified as the most significant modifiable risk factor in this study (OR = 3.84). Dermatologists should routinely screen for and counsel patients regarding hormonal risk

factors, particularly the use of oral contraceptive pills and hormone replacement therapy. Where clinically feasible and acceptable to the patient, alternative contraceptive strategies should be explored.

Thyroid function tests should be incorporated into the routine workup of melasma patients, given the 25.7% prevalence of thyroid dysfunction in this cohort, as effective management of the underlying endocrine disorder may favourably influence the pigmentary response. Laser parameters must be carefully individualised based on Fitzpatrick skin type, melanin depth, and clinical severity. Patch testing with a single test pulse is recommended prior to commencement of the full treatment protocol in darker skin types to minimise PIH risk. Patients should be counselled regarding the chronic, relapsing nature of melasma and the necessity of maintenance therapy and sustained photoprotection even after successful laser treatment, to prevent early recurrence. Future research from tertiary centres across West Bengal and eastern India should prioritise randomised controlled trials with larger sample sizes, histopathological correlation, dermatoscopic assessment, and long-term follow-up data of at least 12 months post-treatment to generate Level I evidence for this intervention in South Asian skin types.

Conflict of Interest: The authors declare no conflict of interest in this study .

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Submission Declaration: This submission has not been published anywhere previously and that it is not simultaneously being considered for any other journal

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