MedNEXT
Journal of Medical an Health Sciences

REVIEW ARTICLE

DOI: 10.54448/mdnt25301

Major clinical outcomes of pulsed-dye laser treatment for vascular melasma: a concise systematic review

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DOI: https://doi.org/10.54448/mdnt25301
Received: 03-15-2025; Revised: 05-27-2025; Accepted: 06-02-2025; Published: 06-03-2025; MedNEXT-id: e25301

Editor: Dr. Hae Shin Chung, MD, Ph.D.

Abstract

Introduction: In recent years, dermatology has advanced in its treatments with the introduction of laser technology. In particular, the pulsed-dye laser (PDL) has a wavelength of approximately 595 nm and is used to destroy hemoglobin in blood vessels. Melasma is an important target for PDL treatment. **Objective:** It was carried out a concise systematic review to highlight the major clinical studies on the use of pulsed-dye lasers in the treatment of melasma. **Methods:** The PRISMA Platform systematic review rules were followed. The search was carried out from February to April 2025 in the Scopus, Embase, PubMed, Science Direct, Scielo, and Google Scholar databases. The quality of the studies was based on the GRADE instrument and the risk of bias was analyzed according to the Cochrane instrument**. Results and Conclusion:** 87 articles were found, 19 articles were evaluated in full and 09 were included and developed in the present systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 15 studies with a high risk of bias and 27 studies that did not meet GRADE and AMSTAR-2. Most studies did not show homogeneity in their results, with X^2=87.7%>50%. It was concluded that the combination of pulsed dye laser with low-fluence Q-switched Nd: YAG laser can be considered a safe and effective treatment for patients with melasma who present visibly dilated capillaries on dermoscopy. Both pulsed dye laser and intense pulsed light were effective and safe treatment modalities for the lightening of melasma. Furthermore, melasma lesions that present subtle or subclinical telangiectatic erythema can be improved by combining targeted vascular laser therapy and low-level fractional diode laser therapy. A parallel improvement in telangiectatic erythema suggests a relationship between the underlying vasculature and hyperpigmentation.

Keywords: Melasma. Vascular melasma. Pulsed-dye lasers. Clinical studies.

Introduction

In recent years, dermatology has advanced in its treatments with the introduction of laser technology. Lasers have revolutionized the way dermatologists approach a variety of skin disorders, from aesthetic treatments to therapeutic interventions for various skin diseases. The precision and versatility of lasers allow for targeted treatment with a high degree of invasiveness, reducing recovery time and improving patient outcomes [1-3].

In this sense, as an operating mechanism, selective photothermolysis works with the absorption of different wavelengths of light by the chromophores of the skin, producing the desired therapeutic result without affecting the adjacent tissues. The principle of selective photothermolysis is one of the central principles of laser medicine, especially in dermatological and aesthetic treatments. If a laser pulse with a duration shorter than the thermal relaxation time of the target chromophore is used, it is possible to heat and damage the target effectively without heating the adjacent tissues [3,4].

As a corollary of this, selective photothermolysis allows for precise targeting of vascular diseases. The pulsed-dye laser (PDL) has a wavelength of approximately 595 nm and is used to destroy hemoglobin in blood vessels. It is particularly valuable

for the treatment of vascular lesions, such as port-wine stains and telangiectasias, due to its ability to selectively destroy blood vessels without causing much collateral damage to the surrounding skin [1-4].

In this scenario, melasma is an important target for PDL treatment, as it is an acquired pigmentary disease that presents brownish patches on the face, most commonly seen in women. The main etiological factors are genetic influences, exposure to ultraviolet (UV) radiation, and sex hormones, although the exact pathogenesis of melasma is not fully understood. The pathophysiology of melasma is believed to involve excessive melanin production or an increase in the number of melanocytes in the skin [4-7].

Recent studies have suggested that interactions between altered cutaneous vasculature and melanocytes influence the development of hyperpigmentation in melasma, with increased vascularization being one of the main findings. Treatment targeting blood vessels is beneficial in the treatment of melasma. PDL is considered a gold standard treatment for cutaneous vascular lesions and is an effective treatment option in combination with pigment-targeted modalities for patients with melasma in several studies [3-7].

Given this, this study performed a concise systematic review to highlight the main clinical studies of the use of pulsed dye lasers in the treatment of melasma.

Methods

Study Design

This study followed the international systematic review model, following the PRISMA (preferred reporting items for systematic reviews and meta-analysis) rules. Available at: http://www.prisma-statement.org/?AspxAutoDetectCookieSupport=1. Accessed at: 17/03/2025. The AMSTAR 2 (Assessing the methodological quality of systematic reviews) methodological quality standards were also followed. Available at: https://amstar.ca/. Accessed on: 17/03/2025.

Search Strategy and Search Sources

The literature search process was carried out from February to April 2025 and developed based on Web of Science, Scopus, Embase, PubMed, Lilacs, Ebsco, Scielo, and Google Scholar, covering scientific articles from various periods to the present day. The following descriptors were used in health sciences (DeCS/MeSH): "Melasma. Vascular melasma. Pulsed-dye lasers. Clinical studies", and the Boolean "and" was used between the MeSH terms and "or" between the historical findings.

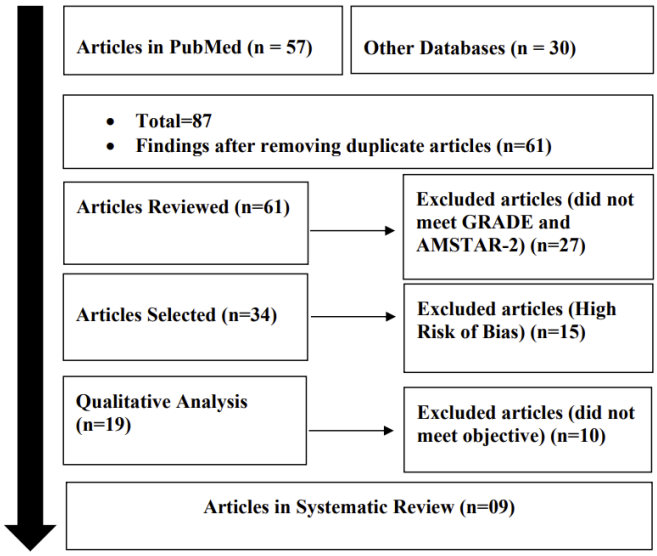
Study Quality and Risk of Bias

Quality was classified as high, moderate, low, or very low regarding the risk of bias, clarity of comparisons, precision, and consistency of analyses. The most evident emphasis was on systematic review articles or meta-analyses of randomized clinical trials, followed by randomized clinical trials. Low quality of evidence was attributed to case reports, editorials, and brief communications, according to the GRADE instrument. The risk of bias was analyzed according to the Cochrane instrument by analyzing the Funnel Plot graph (Sample size versus Effect size), using Cohen's test (d).

Summary of Findings

A total of 87 articles were found and submitted to eligibility analysis, with 09 final studies selected to compose the results of this systematic review. The listed studies were of medium to high quality (Figure 1), considering the level of scientific evidence of studies such as meta-analysis, consensus, randomized clinical, prospective, and observational. Biases did not compromise the scientific basis of the studies. According to the GRADE instrument, most studies presented homogeneity in their results, with X^2=87.7%>50%. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 15 studies with a high risk of bias and 27 studies that did not meet GRADE and AMSTAR-2.

Figure 1. Flowchart showing the article selection process.

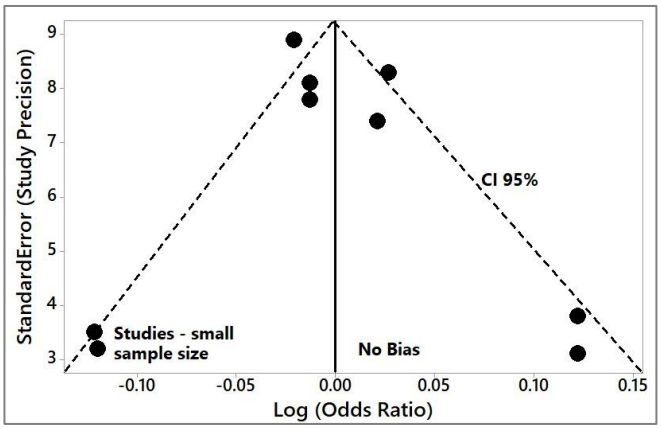


Source: Own Authorship.

Figure 2 presents the results of the risk of bias of the studies using the Funnel Plot, showing the calculation of the Effect Size (Magnitude of the difference) using Cohen's Test (d). Precision (sample size) was determined indirectly by the inverse of the standard error (1/Standard Error). This graph had a

symmetrical behavior, not suggesting a significant risk of bias, both among studies with small sample sizes (lower precision) that are shown at the base of the graph and in studies with large sample sizes that are presented at the top.

Figure 2. The symmetrical funnel plot suggests no risk of bias among the studies with small sample sizes that are shown at the bottom of the graph. High confidence and high recommendation studies are shown above the graph (n=09 studies).



Source: Own Authorship.

Major Clinical Outcomes

In the context of laser treatment of dermatological diseases, it is necessary to provide an overview of the development of laser technology and its applications in dermatology, as well as to present the mechanism, efficacy, and risk characteristics of different laser modalities used in the treatment of skin diseases such as melasma. Over the past 20 years, laser treatment has evolved significantly [4-7]. Compared to historical approaches, innovations such as fractional lasers are more effective, with shorter recovery times. For conditions such as melasma, as well as acne scars, evaluations show high levels of patient satisfaction from diverse populations [8].

It is noted that melasma is an acquired pigmentary disease, and vascular abnormalities are involved in the pathogenesis of melasma. Pulsed-dye laser (PDL) is considered the standard therapy for vascular lesions. Authors Kong, Suh, and Choi (2018) [9] evaluated the efficacy of PDL combined with low-fluence Q-switched Nd: YAG laser (QSNY) in the treatment of melasma. A total of 17 melasma patients were treated with a total of nine QSNY treatment sessions at oneweek intervals. Three additional PDL sessions were performed immediately after QSNY treatment on the mid-face at baseline, week 4, and week 8. The melasma area and severity index (MASI) score was calculated at baseline, one week after the last treatment (week 9) as well as at follow-up 8 weeks after the last treatment (week 16). The MASI scores on the PDL+QSNY and QSNY sides decreased significantly during the study period. There was no significant difference in the change in MASI score between both sides at all time points. However, seven patients who had visibly dilated capillaries on dermoscopy showed significant differences on both sides in terms of changes in MASI score during treatment.

The authors Hassan et al. (2018) [10] compared the efficacy and tolerability of PDL and intense pulsed light in the treatment of melasma. A total of 28 patients with melasma were treated with PDL on the right hemiface (Group A) and with intense pulsed light (IPL) on the left hemiface (Group B). Clinical evaluation was performed according to the modified hemifacial Melasma Area and Severity Index (mMASI). Tissue biopsies were collected from the patients for immunohistochemistry with antibodies against vascular endothelial growth factor (VEGF). The hemifacial mMASI score was significantly reduced after treatment in the studied groups, with no statistically significant difference. The intense pulsed light (IPL) group showed greater treatment efficacy than the PDL group in epidermal melasma and melasma lesions with a vascular component. The expression level and intensity score of VEGF were significantly reduced after treatment in both groups. Both IPL and PDL were effective and safe treatment modalities for lightening melasma.

Furthermore, a retrospective clinical study conducted by authors Geddes, Stout, and Friedman (2017) [11] evaluated the efficacy of treating melasma lesions presenting subtle or subclinical telangiectatic erythema with the 595 nm PDL combined with the 1927 nm low-power fractional diode laser (FDL) over 2 years. The patients evaluated (n = 11) included 10 women and 1 man, with a mean age of 38.7 years and Fitzpatrick skin types II-IV. Each patient presented with melasma lesions with subtle or subclinical telangiectatic erythema identified by spectrocolorimetry. Each patient underwent a series of treatments (average of four) at approximately 4- to 6-week intervals, of PDL followed by FDL. The treatments were performed on the same day, sequentially, with a 10- to 15-minute interval for skin cooling. The following PDL parameters were used: 10-mm spot, 10- to 20-ms pulse duration, 7.5- to 8.5-J/cm² fluence, DCD 30/30. Six of the eleven patients (54%) demonstrated greater than 50% improvement in melasma presentation. Improvement in melasma was generally accompanied by improvement in erythema. No rebound melasma, post-inflammatory changes, or adverse events were observed. Patient satisfaction responses averaged 1.6, with all (10) patients reporting 1 "satisfied" or 2 "very satisfied". The risk of adverse effects is low and overall patient satisfaction is high.

Finally, a prospective study evaluated the efficacy and complications of PDL with compression for the treatment of facial lentigines in Asians. A total of 54 Asian patients with facial lentigines were included in this study. Laser settings included fluences between 9 and 13 J/cm² and a constant pulse duration of 1.5 ms. A total of 38 patients had excellent results, 14 patients had good results, and 2 patients had fair results. Hyperpigmentation was observed in 1 patient. PDL applied with the compression method is effective in the treatment of facial lentigines in Asian patients, with minimal side effects [12].

Limitations

There are few randomized clinical trials or other types of well-designed clinical studies with significant sample sizes on the use of pulsed dye laser alone or in combination with different types of lasers or chemical treatments for treating vascular melasma. However, the existing scientific evidence points significantly to the safety and efficacy of pulsed dye laser use in melasma.

Conclusion

It was concluded that the combination of pulsed-dye laser and low-fluence Q-switched Nd: YAG laser can be considered a safe and effective treatment for melasma patients who present visibly dilated capillaries on dermoscopy. Both pulsed-dye laser and intense pulsed light were effective and safe treatment modalities for the lightening of melasma. Furthermore, melasma lesions that present subtle or subclinical telangiectatic erythema can be improved by combined vascular laser therapy and low-level fractional diode laser therapy. A parallel improvement in telangiectatic erythema suggests a relationship between the underlying vasculature and hyperpigmentation.

CRediT

Author contributions: **Conceptualization**; **Formal Analysis**; **Methodology**; **Project administration**; **Supervision**; **Writing - original draft-**; **Writing-review & editing-** Yoav Ulises Macedo Valverde and Miriam Maria Delbem Bellon.

Acknowledgment

Not applicable.

Ethical Approval

Not applicable.

Informed Consent

Not applicable.

Funding

Not applicable.

Data Sharing Statement

No additional data are available.

Conflict of Interest

The authors declare no conflict of interest.

Similarity Check

It was applied by Ithenticate®.

Application of Artificial Intelligence (AI)

Not applicable.

Peer Review Process

It was performed.

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