Dentistry Review 4 (2024) 100146

Contents lists available at ScienceDirect

Dentistry Review

journal homepage: www.elsevier.com/locate/dentre

Management of Physiological Gingival Melanosis by Diode Laser Depigmentation versus Surgical Scalpel: A Systematic Review

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ARTICLE INFO

Keywords:
Gingival melanosis
Oral hyperpigmentation
Diode laser
Surgical blade
Surgical scalpel
Melanin hyperpigmentation

ABSTRACT

Introduction: Pigmented lesions in the oral cavity mucosa, primarily found in African, Asian, and Mediterranean populations, are caused by increased melanin granule production or melanocyte abundance. These lesions typically appear in childhood and increase with age. This study aimed to evaluate, based on the evidence in the literature, the efficacy of diode laser in the treatment of physiological gingival melanosis in terms of clinical and aesthetic variables, based on the patient, compared to conventional surgical therapy such as the scalpel technique.
Materials and methods: Electronic databases (PubMed, Web of Science and Scopus) were examined in March 2024, in the last 10 years. We performed a manual screening of the reference lists of potential studies. The risk of bias was measured with the ROBINS tool.
Results: The search found 840 publications, but 40 of them were duplicates and were therefore excluded. Titles and abstracts of 800 articles were accessed and 646 were excluded. After applying the inclusion and exclusion criteria, we included 12 studies out of the remaining 154. Data were collected from the selected articles and organized into tables for comparison and study.
Conclusions: The diode laser obtained better results in terms of intraoperative bleeding and perception of pain for the patient. However, there were no differences in depigmentation and wound healing intensity. Due to the small research samples and the heterogeneity of the data provided, more studies with a high degree of scientific relevance and with a clear research protocol are needed.

1. Introduction

In the mucosa of the oral cavity, a wide range of pigmented lesions can be found with colors ranging from blue to brown to gray [1–4]. These lesions may be the expression of changes in the normal anatomy of the mucosa (Fig. 1), lesions caused by exogenous and endogenous substances, or even lesions concomitant with systemic diseases [5–10]. Exogenous pigmentation is usually caused by the presence of a foreign material while endogenous pigmentation is usually produced by melanin, hemoglobin, hemosiderin, and/or carotene [11–14]. The mucosal epithelium of the oral cavity is composed of keratinocytes and melanocytes [15–19]. The latter cells are present in the basal layer with cytoplasmic extensions and are responsible for the production of melanin granules ([20–23]. Thus, pigmented lesions may be the expression of an increased production of melanin granules or a greater number of melanocytes within the epithelium of the oral cavity [24–27].

These occur most frequently in populations with cutaneous hyperpigmentation such as African, Asian and Mediterranean populations

Abbreviations: DOPI, Dummett-Gupta oral pigmentation index; LASER, light amplification by stimulated emission of radiation; RCTs, randomized controlled trial; VAS, visual analog scale.

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https://doi.org/10.1016/j.dentre.2024.100146
Received 7 May 2024; Received in revised form 6 July 2024; Accepted 19 July 2024
Available online 21 July 2024

[28]. They are usually already present in childhood and tend to increase with age [28,29].

The physiological pigmentations usually affect the adhered gums, bilaterally and delimited, mainly on the vestibular aspect, lips and tongue [30–33]. One aspect peculiar to this type of condition is that the free gingival margin is usually not involved not even in cases of diffuse pigmentation [32,34–37].

Although gingival melanosis is a benign hyperpigmentation of the gums (Fig. 2) that does not represent a health problem, those who suffer from it seek a remedy for reasons that are not the same purely aesthetic [38–43].

Currently, there are several surgical techniques for this purpose: chemical methods, such as alcohols, phenols, and ascorbic acid surgical procedures such as gingival abrasion, epithelial excision using scalpel, laser, electrosurgery, cryosurgery and radiosurgery [4,44–47].

1.1. Laser

The laser was introduced in 1960 in the specialty of dermatology and was first used in dentistry in the hope of overcoming some drawbacks arising from conventional methods of dental treatments [9,48–50]. The word LASER currently stands for "Light Amplification by Stimulated Emission of Radiation" [8,51–55]. Laser technology is developing very rapidly giving a diversification of lasers in the field of dentistry [56]. This therapy is based on the biological response through energy transfer [57]. The emitted wavelength devices determine the effective depth of penetration [58]. The effects of the laser depend on the type of laser used, as well as the type of tissue, as it can transmit, absorb, scatter or reflect laser light [59–61].

In the oral cavity, the energy of laser photons is absorbed by chromophores, groups of atoms capable of coloring a substance, made up of melanin, hemoglobin, pigmented proteins, hydroxyapatite and water [62–63]. When the energy is absorbed by the water in the cells, the temperature rises and the boiling point is reached, producing water-induced ablation, while when the energy of the laser photons is absorbed by the melanin or chromophores of hemoglobin, cleavage and coagulation occur [19,20,64,65].

1.1.1. Diode laser

The diode laser is a high-power semiconductor laser that emits energy at a wavelength between 800 and 1000 nm and can cut the soft tissues with surgical precision, creating zones of thermal necrosis of less than 1 mm and hemostasis of the affected mucosa [48,66,67]. It is also able to reduce the bacterial load of periodontal pockets. To etch or vaporize soft tissues, the light of this laser is emitted through synthetic sapphire tips in contact mode, transmitted thanks to optical fibers [68, 68] (Fig. 3).

Diode lasers have revolutionized various aspects of dentistry, offering precise and minimally invasive solutions for a wide range of dental procedures [69–72]. These compact, portable devices emit light at specific wavelengths that are absorbed by pigmented tissues, making them particularly effective for soft tissue surgeries, periodontal treatments, and cosmetic procedures [73–77].

In periodontics, diode lasers are commonly used for procedures such as gingivectomy, gingivoplasty, and crown lengthening [78–82]. They enable the dentist to precisely remove excess gum tissue, reshape the gums, and expose more tooth structure for restorative purposes, all with minimal bleeding and discomfort for the patient [67,63,83–85].

Moreover, diode lasers are invaluable tools in endodontics for disinfecting root canals and promoting healing in cases of periapical lesions [1,36,48]. Their bactericidal properties help eliminate bacteria and reduce the risk of post-operative infections, leading to improved treatment outcomes [86–89].

In cosmetic dentistry, diode lasers are utilized for procedures like teeth whitening and gum depigmentation [67,88]. The controlled application of laser energy allows for the efficient removal of stains from enamel surfaces and the reduction of melanin pigmentation in the gums, enhancing the patient's smile aesthetics [90–92].

Overall, the usage of diode lasers in dentistry offers numerous benefits, including enhanced precision, reduced discomfort, faster healing times, and improved patient satisfaction [16,93–95]. As technology continues to advance, diode lasers are poised to play an increasingly integral role in modern dental practice [96–98].

1.2. Surgical scalpel

The surgical scalpel technique is a surgical procedure that involves scraping off the hyperpigmented gingival epithelium and secondary healing of the exposed connective tissue [62,99]. It's simple, cost-effective, and easy to carry out with minimal time and effort [69]. Although surgical removal of the gum has a lower cost and a lower probability of recurrence, it is related to pain, postoperative discomfort, intra- and postoperative bleeding, and the need for a periodontal dressing [100,74].

This procedure is contraindicated in patients with a thinner gingival biotype and narrow papillary areas [60].

The surgical removal of gingival melanosis typically involves the use of a surgical scalpel [101]. This procedure, known as gingivectomy, aims to excise the pigmented tissue from the gums, resulting in a more uniform and lighter appearance [28,102–104].

Before the procedure, the dentist or oral surgeon will thoroughly examine the affected area to determine the extent of pigmentation and plan the surgical approach [47,105]. Local anesthesia is usually administered to ensure the patient's comfort throughout the procedure

Fig. 1. Example of physiological gingival melanosis.

Fig. 2. Benign hyperpigmentation of the gums.

Fig. 3. Diodo Laser that emits energy.

[106–109] .

Once the area is numb, the surgeon carefully uses a surgical scalpel to make precise incisions along the gum line, removing the excess pigmented tissue [54]. Special care is taken to avoid damaging the surrounding healthy tissue and to achieve a symmetrical and aesthetically pleasing outcome [50,110,111].

After the excess tissue is removed, the surgical site is thoroughly irrigated to remove any debris and ensure proper healing [100,112,113]. Depending on the extent of the procedure and the patient's healing response, sutures may be placed to close the incisions and facilitate optimal healing [100,113].

Following the surgery, patients are typically provided with post-operative instructions to promote healing and minimize discomfort [33]. This may include instructions on oral hygiene practices, dietary restrictions, and the use of prescribed medications [42,114,115,70].

This systematic review aims to evaluate the efficacy of diode laser in the treatment of physiological gingival melanosis in terms of clinical and aesthetic variables, comparing them to conventional surgical therapy using a scalpel [116,117,71].

The Variables considered in this systematic review are the intensity of repigmentation, the perception of the pain about treatment received, intraoperative bleeding, and wound healing.

2. Materials and methods

2.1. Search processing

The current systematic review followed the PRISMA and International Prospective Register of Systematic Review Registry procedures (full ID: CRD – 541,390) [118,119]. The following databases: PubMed, Web of Science and Scopus, were examined from 12 March 2024 to 25 March 2024, to search articles of the last 10 years. The search strategy was created by combining terms relevant to the study's purpose.

The following Boolean keywords were applied: (((Gingival Melanosis) OR (Oral pigmentation)) OR (oral melanin)) OR (Oral Hyperpigmentation)) OR (Pigmentation disorder)) OR (Melanotic macula)) OR (Gingival melanin pigmentation)) OR (Pigmented lesion)) OR (Physiological gingival pigmentation)) OR (Physiological pigmentation)) OR (Black gums)) OR (oral mucosa pigmentation)) OR (Melanotic lesion)) OR (pigmentation disease)) AND (Diode Laser)) OR (Laser semiconductor)) OR (semiconductor)) OR (laser therapy)) OR (Laser oral depigmentation)) AND (Surgical blade)) OR (abrasion therapy)) OR (Abrasion depigmentation)) OR (bur abrasion)) OR (mucoabrasion therapy)) AND (melanin depigmentation)) OR (Melanosis depigmentation)) OR (Depigmentation oral)) OR (Gingiva depigmentation).

2.2. Inclusion end exclusion criteria

The reviewers worked in group to assess all relevant studies that analyzed or compared the effects of diode laser or surgical removal by blade on gingival physiologic melanosis, according to the following inclusion criteria:

- Studies that did the research "in vivo" or in "humans";
- Case-controls studies, cohort studies, RCTs;
- Studies that were published in the last 10 years;

Studies that fulfill at least one of the following exclusion criteria were excluded: reviews, case reports and series, letters to the authors; animal models; in vitro studies and research done in patients with pathologic gingival melanosis.

PICO Question

The PICO question addressed was:

"Will the use of diode laser provide more additional clinical and aesthetic benefits in the treatment of gingival melanosis than conventional surgical therapy such as the scalpel technique?"

I. Population: Patients with physiologic gingival melanosis;
II. Intervention: Diode laser as a treatment for pigmented lesion;
III. Comparison: Scalpel technique as a treatment for pigmented lesions;
IV. Outcome: Which treatment has the greatest clinical and aesthetic benefits;

2.3. Data processing

Four independent reviewers (P.M., L.C., D.C., L.B., I.P. and M.G.) assessed the quality of the included studies using specified criteria such as selection criteria, methods of outcome evaluation, and data analysis.

This enhanced '*risk of bias*' tool additionally includes quality standards for selection, performance, detection, reporting, and other biases. Any differences were settled through conversation or collaboration with other researchers (A.D.I., A.M., A.P., A.M.I., G.D.). The reviewers screened the records according to the inclusion and exclusion criteria. Doubts have been resolved by consulting the senior reviewer (F.I.). The selected articles were downloaded into Mendeley (Tables 1–6).

3. Results

3.1. Characteristics of included articles

Fig. 4 shows the flow diagram of a systematic review carried out using the PRISMA reporting criteria. The diagram describes the search strategy, inclusion and exclusion of publications at each stage of detection.

A total of 840 publications were identified in three databases, including PubMed (511), Web of Science (152), and Scopus (177), obtaining 800 records after the duplicates were deleted (40). The title and abstract analysis resulted in the exclusion of 646 articles because they were off-topic. The remaining 154 records were read deleting 142 articles that did not fill the inclusion criteria. The evaluation includes a total of 12 publications for qualitative analysis.

3.2. Study of the variables

Table 3, 4, 5, 6.

3.3. Quality assessment and risk of bias of included articles

The risk of bias in the included studies is reported in Fig. 5. Regarding bias due to confounding, most studies have a medium risk. The bias resulting from measurement is a parameter with low risk of bias. Many studies have a low risk of bias due to participant selection. Post-exposure bias is low in most studies. Bias due to missing data is medium in many studies. The bias resulting from the outcome measurement cannot be calculated due to heterogeneity. The selection bias of the reported results is low in half of the studies and medium in the other half. The final results show that 2 studies have a low risk of bias, 7 have a medium risk of bias, and 2 have a high risk of bias.

4. Discussion

The systematic review undertook a comprehensive synthesis, meticulously amalgamating evidence culled from a diverse array of clinical studies. Through this rigorous process, it illuminated the intricate nuances surrounding the comparative effectiveness of surgical methods *vis-à-vis* diode lasers in the eradication of gingival melanosis. This analytical endeavor not only sheds light on the efficacy of these treatment modalities but also furnishes invaluable insights crucial for informed decision-making in clinical practice.

4.1. Bleeding

Variations in intraoperative bleeding were noticed during the one-month follow-up. Bakutra et al., Chandra et al., Hamzah B.,El Shenawy et al. evaluated intraoperative bleeding [101,120,123,129].

The immediate coagulation capabilities of the laser caused

Table 1
Methodology, characteristics of the studies.

AUTHORS AND YEARS	TYPE OF STUDY	STUDY SAMPLE (N°PATIENTS)	GENDER PROPORTION (M:F)	FOLLOW UP (MONTHS)	AGE OF SAMPLE (years)	VARIABLES
Suragimath G. et al. *2016* [17]	Randomized Comparative Clinical Study	12	7:5	12 months	NA	Intensity of repigmentation, pain,
Bakutra G. et al. 2017 [120]	Clinical study	20	12:8	12 months	NA	pain, bleeding, wound healing
Grover H. et Al. 2014 [121]	Clinical study	20	11:9	3 months	NA	pain
Chandra G. et al. *2020* [101]	Randomized comparative clinical study	20	NA	9 months	NA	pain, bleeding, wound healing
Mahajan G. et al. *2017* [122]	Randomized comparative clinical study	10	NA	9 months	NA	Intensity of repigmentation
Hamzah BF et al. *2022* [123]	Randomized comparative clinical study	20	9:11	4 weeks, 3 years	16–29	Bleeding
Mikhail F. et al. *2023* [124]	Randomized comparative clinical study	24	NA	12 h	>18	Wound healing Pain
Jagannathan R. et al. *2020* [125]	Prospective study	30	15:15	14 months	24–38	Pain
Shah N. et al. *2023* [126]	Clinical Study	64	NA	3 and 6 months.	18 –50	Pain
Mojahedi S. et al. *2023* [127]	Clinical study	21	NA	6 months	25–30	Pain
Mojahedi S. et al. *2023* [128]	Clinical study	19	5:14	3 mouths	25—26	Intensity of repigmentation
*El Shenawy HM.*et al. *2015* [129]	Cohort study	15	7:8	1 week 1 month 3 months	15–45	Bleeding

Table 2
Diode laser characteristics.

Author and year	Diode laser brand	Wave lenght (nm)	Type of wave	Power (W)	Energy (mJ)
Suragimath G. et al.*2016* [17]	Photon Plus; Zolar Tech Technology	980 nm	Continous	0,5 W	12mJ
Bakutra G. et al. *2017* [120]	Piccaso 810 nm Diode Unit, AMD Lasers, Indianápolis, USA	810 nm	Continous	3 W	–
Grover et al. *2014* [121]	FONA, Diode, LaserTM, Sirona,Germay	800–980 nm	Pulsed	2,5 W	-
Chandra G. et al. *2020* [101]	–	810 nm	Continous	1,5 W	–
Mahajan G. et al. *2017* [122]	EPIC	940 nm	Continous	1 W	–
Hamzah BF. et al. *2022* [123]	Diode Epic, BioLaser	940 nm	Continous and Pulsed	1 W	–
Mikhail F. et al. *2023* [124]	Doctor Smile Diode Laser, LAMPDA, Italy	980 nm	Continous	1 W	–
Jagannathan R. et al.*2020* [125]	Biolaser	940nm	Pulsed	1W	–
Shah N. et al. *2023* [126]	Diode laser	810 nm	Continuos	1W	–
Mojahedi S. et al. *2023* [127]	Diodo lasers from ARC Company (Laser GmbH; Nuremberg, Germany)	445 nm - 810 nm	Continuos	1W	–
Mojahedi S. et al. *2023* [128]	Dr Smile diode laser Model: LA5D0001.1; Italy	810 nm	Continuos	1W	–
El Shenawy HM. et al. *2015* [129]	Quanta laser system made in Italy class 4 laser	980 nm	Contact mode	4W	–

Table 3
Intensity of repigmentation.

Authors	Technique	Pre- operative	Follow-up
Suragimath G. et al. *2016* [17]	Scalpel Diode Laser	$M = 2.58$ severe $M = 2.58$ severe	$M = 0.3$ slight $M = 0.83$ slight
Mahajan G. et al.*2017* [122]	Scalpel Diode Laser	$M = 1.84$ moderate $M = 1.76$ moderate	$M = 0.648$ slight $M = 0.451$ slight
Mojahedi S. et al. *2023* [128]	Scalpel Diode laser	$M = 2.4$ severe $M = 1.7$ moderate	$M = 0.52$ slight $M = 0.46$ slight

M (mean); slight, moderate,severe (DOPI* values, repigmentation intensity).
*Dummett-Gupta Oral Pigmentation Index (DOPI):.
1. 0: There is no clinical pigmentation of the gums.
2. 0.031–0.97: Slight clinical pigmentation.
3. 1.0–1.9: Moderate clinical pigmentation.
4. 2.0–3.0: Severe clinical pigmentation.

statistically different findings for the two study groups. At most, patients treated with the diode laser had minor bleeding; in many cases, as the one reported by Hamzah et al., there was no bleeding at all [123]. As a result, the patient had less trauma throughout the treatment and the operator had an easier time. However, some patients—especially in the Bakutra et al. study—experienced severe bleeding after receiving surgical scalpel treatment [120]. Diode laser treatment demonstrated

Table 4
Wound healing.

Authors	Technique	1 day	1 week	1 month
Bakutra G. et al.*2017* [120]	Laser Scalpel	8 (40 %) = partial 12(60 %) = ulcers 4(20 %)= parcial 16(80 %)= ulcers	16 (80 %)= complete 4 (20 %)= parcial 4(20 %) = complete 16 (80 %) = parcial	20(100 %)= complete 20(100 %)= complete
Chandra G. et al.*2020* [101]	Laser Scalpel	- -	13(65 %)= complete 7(35 %)= parcial 11(55 %)= complete 9(45 %)= parcial	20(100 %)= complete 20 (100 %)= complete
Mikhail F. et al.*2023* [124]	Laser Scalpel	- -	7(87 %)= complete 1(13 %)= parcial 6(75 %)= complete 2(25 %)= parcial	- -

A: Complete epithelialization; B: Partial epithelialization; C: Ulcer; D: Necrosis.

Table 5
Bleeding.

Authors	Technique	Bleeding
Bakutra G. et al. 2017 [120]	Scalpel Laser	4(20 %) = slight 12(60 %) = moderate 4 (20 %) = severe 18(90 %) = slight 2 (10 %) = moderate
Chandra G. et al. *2020* [101]	Scalpel Laser	11 (55 %) = slight 9 (45 %) = moderate 20 (100 %)=no bleeding
Hamzah BF. et al. *2022* [123]	Laser (CW mode) Laser (Pulsed mode)	7 (70 %) = no bleeding 3 (30 %)= slight 10 (100 %)= no bleeding
El Shenawy HM. et al. *2015* [129]	Laser	3 (20 %): slight bleeding 12 (80 %) no bleeding

A: No bleed; B: Slight bleeding; C: Moderate bleed; D: Severe hemorrhage.

immediate coagulation capability, leading to minimal to moderate bleeding or even absence of bleeding in some cases. This not only facilitated smoother surgical procedures but also contributed to a less traumatic experience for patients [101,120,123,129].

4.2. Pain

Studies used the VAS Scale to compare postoperative pain between surgical and laser treatments for depigmentation. Pain perception one day and one week following the operation was taken into consideration in all articles on both the Diode Laser approach and surgical procedures [17,101,120,121,124–127]. There were discrepancies between the diode laser and scalpel procedures on the first post-operative day. The laser group's patients typically reported lower pain thresholds, with light pain being the most common. The scalpel group, on the other hand, had mild pain at its worst. The authors of publications on surgical scalpels, Hanaa M. El Shenawy et al., Bakutra, Mojahedi et al., and Faten Fawzy Mikhail et al., reported no pain seven days after surgery [51,120,124,127,129] . However, Suragimath et al., Bakutra et al., Chandra et al. 2020, Jagannathanet et al. 2020, and Shah et al. 2023 reported mild pain after 7 days [17,120,125,126].

Table 6
Pain.

Authors	Tecnique	1 day	7 days
Suragimath G. et al. *2016* [17]	Scalpel Laser	$M = 3.5$ $M = 1.5$	$M = 0{,}4167$ $M = 0{,}0833$
Bakutra G. et al. *2017* [120]	Scalpel Laser	$M = 3.8$ $M = 1{,}8$	0 0
Chandra G. et al. *2020* [101]	Scalpel Laser	14 (70 %): mild pain 6 (30 %): moderate pain 8 (40 %): no pain 12 (60 %): mild pain	17 (85 %): no pain 3 (15 %): mild pain 20 (100 %): no pain
Jagannathanet R. et al. *2020* [125]	Scalpel Laser	$M = 2{,}7$ $M = 0{,}8$	$M = 0{,}8$ $M = 0{,}2$
Shah N. et al. *2023* [126]	Scalpel Laser	$M = 3.5$ $M = 1.5$	$M = 1$ $M = 0$
Mojahedi S. et al. *2023* [127]	Scalpel Laser	15(70 %): mild pain 6 (30 %): moderate pain 8 (40 %):no pain 13 (60 %): mild pain	18 (85 %): no pain 3 (15 %): mild pain 21 (100 %): no pain
Mikhail F. et al. *2023* [124]	Surgical scalpel Diode laser	$M = 3.5$ moderate pain $M = 1{,}5$ mild pain	$M = 0$ no pain $M = 0$ no pain
El Shenawy HM. et al. *2015* [129]	Diode Laser	12 (80 %): no pain 3 (20 %): mild pain	15 (100 %): no pain 0 (0 %): mild pain

*M(medium);%(intergroupal); no pain, mild pain, moderate pain, severe pain, (Visual Analogue scale, VAS).
The "Visual Analog Scale" (VAS), Visual Analog Scale is used to evaluate the subjective pain that the patient reports[120]. The VAS consists of a 10 cm (100 mm) horizontal line, on one end it says "no pain" and on the other "severe pain." The patient is asked to mark the intensity of the pain. The distance of this point, in centimeters, from the left end of the scale was recorded and used as the VAS score:.
0: no pain.
1–3: mild pain.
3.1–6: moderate pain.
6.1–10: severe pain.

4.3. Wound healing

Analysis of wound healing outcomes unveiled intriguing subtleties between the contrasting treatment modalities. These investigations meticulously scrutinized the progression of wound healing at diverse intervals post-surgery. Both Bakutra et al. and Chandra et al. delved into wound recovery after a month, discerning no discernible disparities within the designated time spans [101,120]. Furthermore, Chandra et al.'s exploration revealed uniform healing at one week; however, the immediate post-operative healing status was not evaluated [101]. Bakutra et al. noted that following laser intervention, a remarkable 80 % of patients showcased complete wound closure merely a week post-treatment, whereas 20 % exhibited partial healing [120]. Conversely, employing the traditional scalpel method, 80 % of cases displayed partial healing, with the remaining 20 % demonstrating complete wound closure [124]. These findings underscore the intricate interplay between treatment strategies and wound healing dynamics, warranting further exploration to optimize patient outcomes and refine clinical practices.

4.4. Repigmentation

Despite the meticulous examination of various study designs and the inclusion of diverse patient popula-tions, a strikingly consistent finding emerged: regardless of the modality employed—be it the traditional surgical scalpel or the more contemporary diode laser techniques—there ensued a discernible occurrence of minor repigmentation subsequent to treatment [128]. Remarkably, this phenomenon manifested with such uniformity that no significant differences in repigmentation intensity were discerned during the meticu-lous follow-up period [122]. Such findings underscore a pivotal revelation: both surgical approaches, despite their methodological disparities, exhibit comparably efficacious outcomes in achieving depigmentation goals, thus transcending the initial severity of pigmentation as a determinant of success [17].In summary, the thorough examination carried out in this systematic review offers solid proof of the relative efficacy of diode laser and surgical scalpel methods for gingival depigmentation. When follow-up photos are taken, both groups show slight repigmentation, suggesting that both methods are equally effective in producing depigmentation results [17,122,128]. Although the two treatments seem to have similar wound healing outcomes, the diode laser presents unique benefits in terms of reducing intraoperative bleeding and maybe lowering postoperative pain levels. These results highlight the significance of taking intraoperative and postoperative parameters into account in addition to depigmentation efficacy when choosing the best strategy for gingival depigmentation treatments.

4.5. Clinical implications and aesthetic considerations

It is impossible to overestimate the influence of gingival melanosis on dentofacial aesthetics, which makes efficient treatment choices essential for patients looking to improve their appearance. Techniques using diode lasers and surgical scalpels both provide workable answers with long-term cosmetic advantages. However, several considerations, such as patient preference, postoperative pain, intraoperative bleeding, and effectiveness, should be taken into account while choosing between these procedures. In order to customize the strategy and maximize treatment outcomes, physicians should also evaluate the unique characteristics of each patient as well as their goals for the course of treatment.

4.6. Limitations and future directions

It is important to recognize a few limitations in spite of the systematic review's insightful findings. The presence of heterogeneity in study design, sample size, follow-up protocols, and treatment characteristics among studies impedes the direct comparability of results and restricts their generalizability. Moreover, variations in data analysis techniques and variations in the application of diode lasers complicate attempts to reach firm findings [58,131–133]. Furthermore, some research small sample sizes raise the possibility of bias and highlight the necessity of conducting bigger, better-designed clinical trials. Standardized procedures and cooperative efforts among scientists are necessary to overcome these constraints and progress our knowledge of the relative merits of diode lasers and surgical techniques in the management of gingival melanosis [102,84,134].

In summary, although diode laser and surgical scalpel methods provide good treatment choices for gingival melanosis, the subtle variations in results and the noted drawbacks underscore the clinical complexity of this field. Through acknowledging these constraints and adopting a cooperative research methodology, medical professionals and scholars can strive to improve treatment procedures, maximize patient results, and ultimately elevate the standard of care in cosmetic dentistry.

The more we learn about the implications of treating gingival melanosis, the more clear it is that thorough study is essential to improving our comprehension and strategy. While the systematic review offered here provides a strong starting point, more research is necessary to fully realize the promise of treatment modalities. One avenue of exploration could involve longitudinal studies tracking patients over extended periods to assess the longevity of treatment outcomes.

Furthermore, examining the psychological effects of gingival

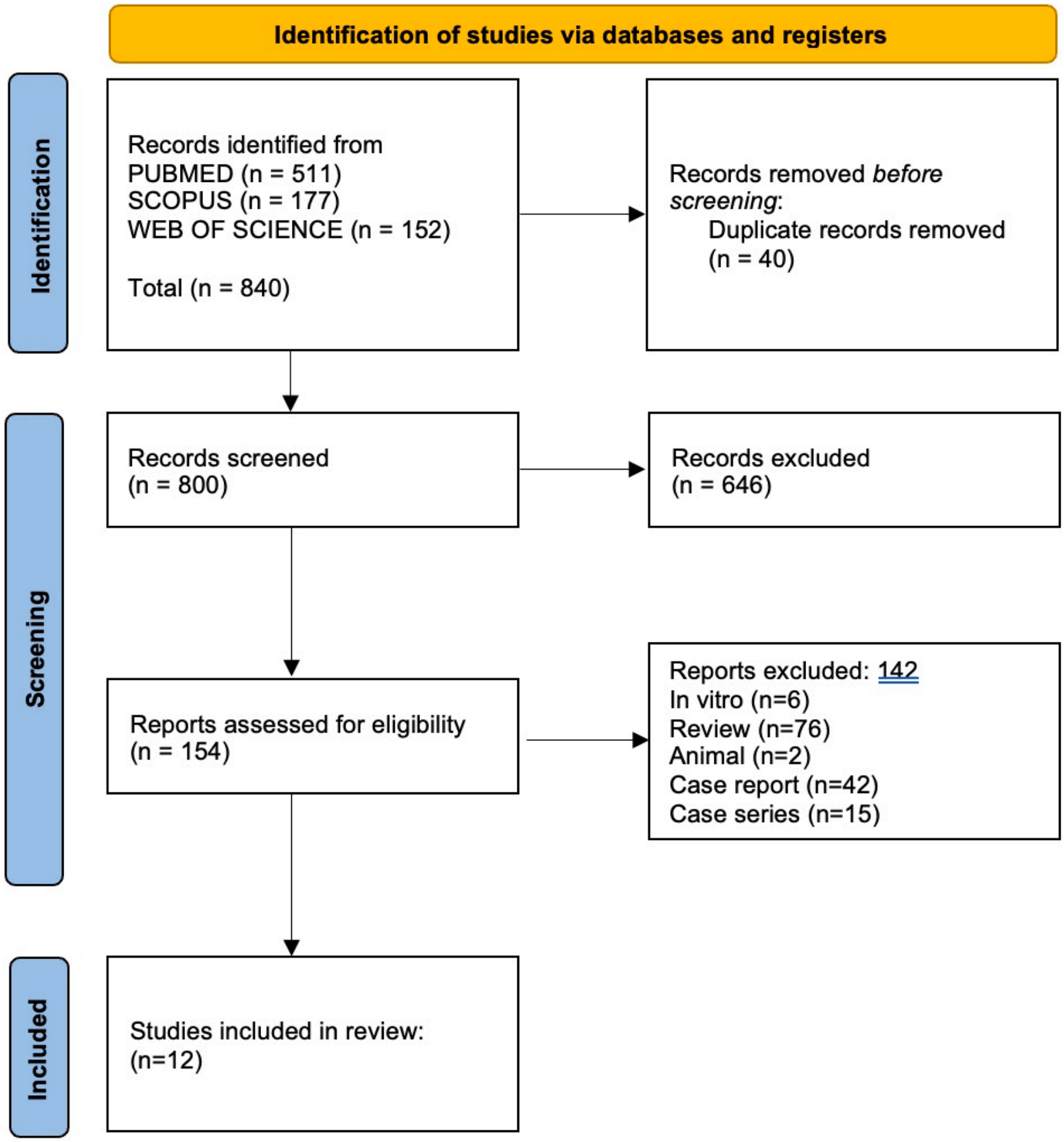

Fig. 4. Literature search Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram and database search indicators [118,130].

melanosis and its management on patients' quality of life may yield insightful information. Additionally, investigating new technologies and incorporating them into treatment plans has the potential to completely transform the industry by providing more effective and patient-centered methods. Essentially, the search for the best course of care for gingival melanosis is still underway, and the secret to realizing its full potential will be sustained cooperation and innovation.

5. Conclusions

In analyzing the outcomes of this systematic review, several key observations emerge regarding the comparison between surgical scalpel and diode laser techniques in gingival depigmentation:

1) Regarding the intensity of repigmentation, there were no differences between the surgical scalpel and diode laser techniques. Both presented slight repigmentation at follow-up.
2) In wound healing, it has not been possible to establish which of the two techniques provided a better postoperative period because both of the techniques showed similar results in the follow up.
3) Intraoperative bleeding was consistently lower with the diode laser in all studies.
4) In terms of pain, gingival depigmentation is not a very painful procedure, but most studies showed that the laser presented less pain compared to the use of a surgical scalpel.

In essence, while both methods demonstrate comparable outcomes in certain aspects such as repigmentation and wound healing, the diode laser exhibits advantages in terms of intraoperative bleeding and pain management, suggesting its potential as a preferred approach in gingival depigmentation procedures.

Funding

This research received no external funding.

Informed consent statement

Not applicable.

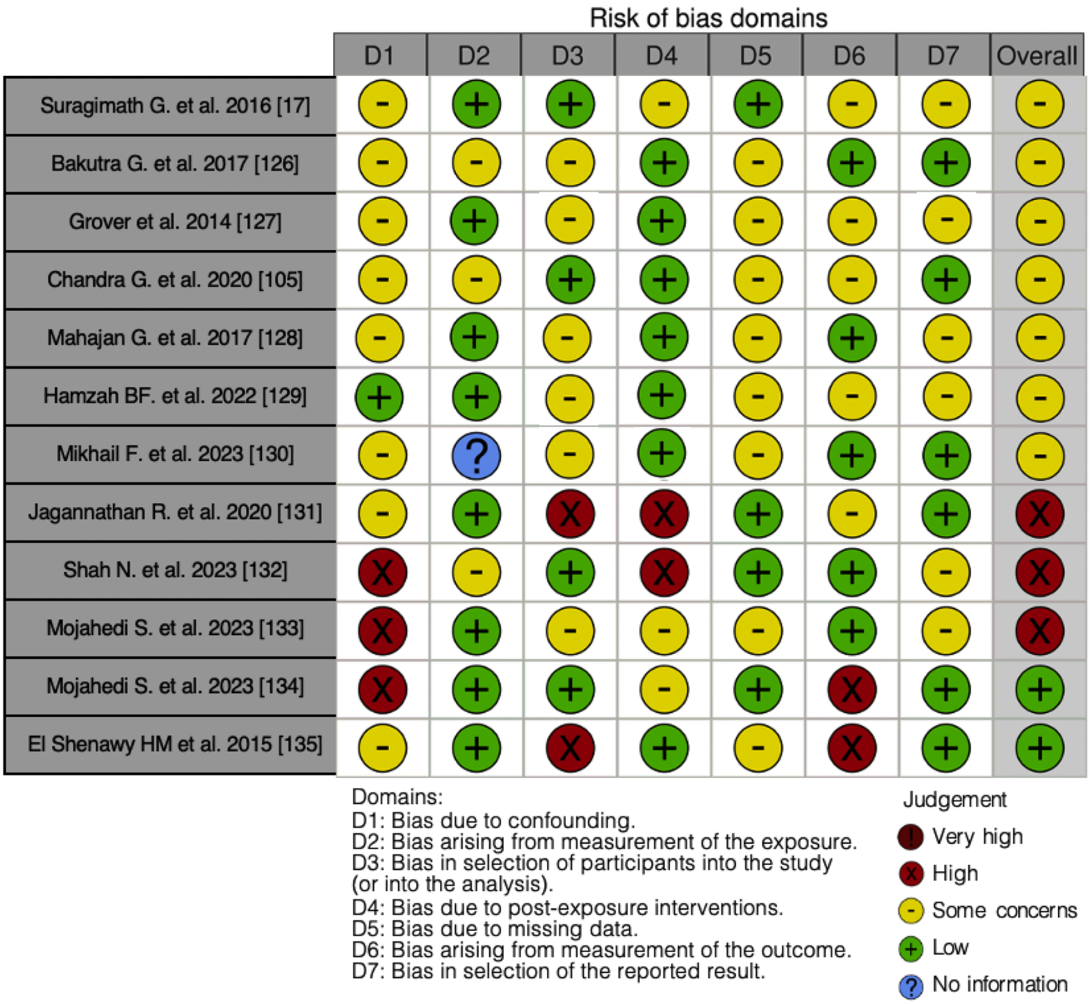

Fig. 5. Bias assessment.

CRediT authorship contribution statement

Francesco Inchingolo: Conceptualization, Methodology, Validation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration. **Alessio Danilo Inchingolo:** Conceptualization, Methodology, Software, Validation, Formal analysis, Resources, Data curation, Writing – original draft, Writing – review & editing, Supervision, Project administration. **Irene Palumbo:** Conceptualization, Resources, Data curation, Writing – review & editing, Supervision. **Mariafrancesca Guglielmo:** Conceptualization, Resources, Writing – review & editing, Supervision. **Liviana Balestriere:** Conceptualization, Methodology, Data curation, Writing – original draft, Writing – review & editing, Supervision. **Lucia Casamassima:** Conceptualization, Methodology, Resources, Writing – original draft, Writing – review & editing, Supervision. **Danilo Ciccarese:** Conceptualization, Formal analysis, Data curation, Writing – original draft, Visualization. **Pierluigi Marotti:** Conceptualization, Formal analysis, Data curation, Writing – original draft, Visualization. **Antonio Mancini:** Methodology, Formal analysis, Writing – review & editing. **Andrea Palermo:** Conceptualization, Methodology, Software, Formal analysis, Resources, Writing – review & editing, Visualization, Supervision. **Angelo Michele Inchingolo:** Conceptualization, Methodology, Validation, Formal analysis, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration. **Gianna Dipalma:** Conceptualization, Methodology, Software, Validation, Formal analysis, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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