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Review Article

A Systematic Review of the Role of Soft Tissue Lasers in Enhancing Esthetic Dental Procedures

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ABSTRACT

Clinicians specializing in esthetic dentistry play an important role in enhancing both oral health and the appearance of patients' smiles, offering significant clinical benefits such as sterile treatment conditions and improved patient comfort. Among the various techniques, laser ablation stands out as a highly effective, minimally invasive, and well-tolerated method for gingival depigmentation. Research suggests that laser photon energy is absorbed by specific chromophore components within oral tissues, including melanin, pigmented proteins, hemoglobin, hydroxyapatite, and scales. The present review study aimed to investigate the role of soft tissue lasers in improving esthetic dentistry procedures. To assess the effectiveness of soft tissue dental lasers, a systematic literature review was conducted using databases such as Medline, PubMed, and ScienceDirect, including studies published between 2010 and 2023. The key search terms included "dental laser," "soft tissue," and "systematic review." The article selection process was structured according to the PRISMA framework. 10 studies met the inclusion criteria and 9 studies showed that laser-based treatments yielded significantly better outcomes compared to conventional surgical procedures. These findings highlight soft tissue lasers as a reliable and efficient option for esthetic dental procedures, offering a viable alternative to traditional methods that may carry a higher risk of inflammation and infection.

Keywords: Soft tissue, Esthetic dentistry, Dental lasers, Systematic review

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Introduction

The term LASER stands for Light Amplification by the Stimulated Emission of Radiation and has revolutionized cosmetic dentistry by providing clinicians with effective tools for various treatments [1]. These advancements allow dental practitioners to enhance both the aesthetics and health of patients' smiles while offering significant clinical benefits such as sterile procedures and greater patient comfort [2]. The foundational concepts of lasers align closely with the principles of esthetic dentistry, making them a valuable therapeutic tool in modern dental practice [3].

The introduction of lasers into the medical and dental fields dates back to the 1960s when Goldman *et al*. pioneered their use [4]. However, early applications were hindered by excessive heat damage, limiting their clinical feasibility. In 1961, W. R. Bennet and D. R. Herriott developed the 1st helium-neon laser, which paved the way for further research [5, 6]. Later, in 1985, Pick, a leading figure in periodontology, conducted research on laser gingivectomy, demonstrating its potential for clinical use.

Lasers function by converting light waves of varying frequencies into emissions within the ultraviolet, visible, and infrared spectrums. These concentrated energy beams fall within the electromagnetic spectrum, which encompasses a broad range of wavelengths, from long radio waves to short gamma rays [7]. When focused at close range, laser beams generate high levels of heat and energy, enabling their use in precision-driven medical and dental applications. The present review study aimed to investigate the role of soft tissue lasers in improving esthetic dentistry procedures.

Laser applications in esthetic dentistry

Gingival depigmentation

Among the various applications of lasers in esthetic dentistry, laser ablation is considered the most effective and minimally invasive method for gingival depigmentation [8, 9]. Studies indicate that chromophore components within oral tissues—such as melanin, hemoglobin, hydroxyapatite-pigmented protein, and scales—can save laser photon energy [10, 11]. Different wavelengths in the electromagnetic spectrum interact with these chromophores, facilitating targeted tissue modification [12].

During the process, water molecules in the tissue absorb the laser photon energy, heating up to the boiling point and triggering water-induced ablation, which results in a controlled micro-explosion of the affected cells [13]. High-powered lasers are commonly employed in gingival depigmentation due to their ability to generate heat, increase tissue kinetic energy, and induce thermal interactions. This process leads to various tissue effects, including coagulation, carbonization, vaporization, necrosis, and denaturation, making lasers a highly effective alternative to traditional surgical methods for esthetic dental treatments.

Gingival aesthetic reshaping

Today, many patients seek cosmetic dental treatments to enhance their smiles, focusing on gingival symmetry, tooth proportions, and crown height balance. As a result, soft tissue lasers have become essential tools in addressing four primary concerns: adjusting crown height asymmetries, refining gingival contour, improving tooth proportionality, and performing crown lengthening procedures. Among the various laser types, diode lasers are frequently utilized in a continuous mode at 0.8 to 1.2 W with specialized tips to achieve precise soft tissue modifications.

A well-defined gingival contour plays a crucial role in the overall esthetic success of orthodontic and restorative treatments. The gingival form, which refers to the curvature of the soft tissue around a tooth, should maintain symmetry for an optimal appearance. For instance, the gingival zeniths of the maxillary and mandibular lateral incisors are ideally positioned in parallel alignment to create a balanced and natural look [14].

Crown lengthening for esthetic enhancement

The crown lengthening procedure is a widely used technique to correct esthetic imbalances such as excess gingival display (commonly called a gummy smile) and altered passive eruption or to enhance the final appearance of restorative dental work. Traditional methods for clinical crown lengthening often involve gingivectomy without or with osseous resection surgery. Additionally, modern alternatives like osseous surgery and laser-assisted gingivectomy with an apically positioned flap provide effective solutions for improving soft tissue architecture [15].

Materials and Methods

To compile relevant studies, a systematic review was performed using databases such as Medline, PubMed, and ScienceDirect, covering research published between 2010 and 2023. The search was conducted using key terms including "dental laser," "soft tissue," and "systematic review" **(Table 1)**. The process of article selection and screening was documented following the PRISMA framework, as outlined in **Figure 1**.

Table 1. Study selection criteria

Included studies	Excluded studies
Randomized control trials and case-control studies	Systematic reviews, meta-analyses, expert opinions, or narrative reviews
Published between 2010 and 2023	Studies outside this publication period
Focused on soft tissue and dental lasers	Studies involving hard tissue or conventional techniques
Written in English	Published in languages other than English
Conducted on human subjects (in vivo)	Performed in laboratory settings (in vitro)

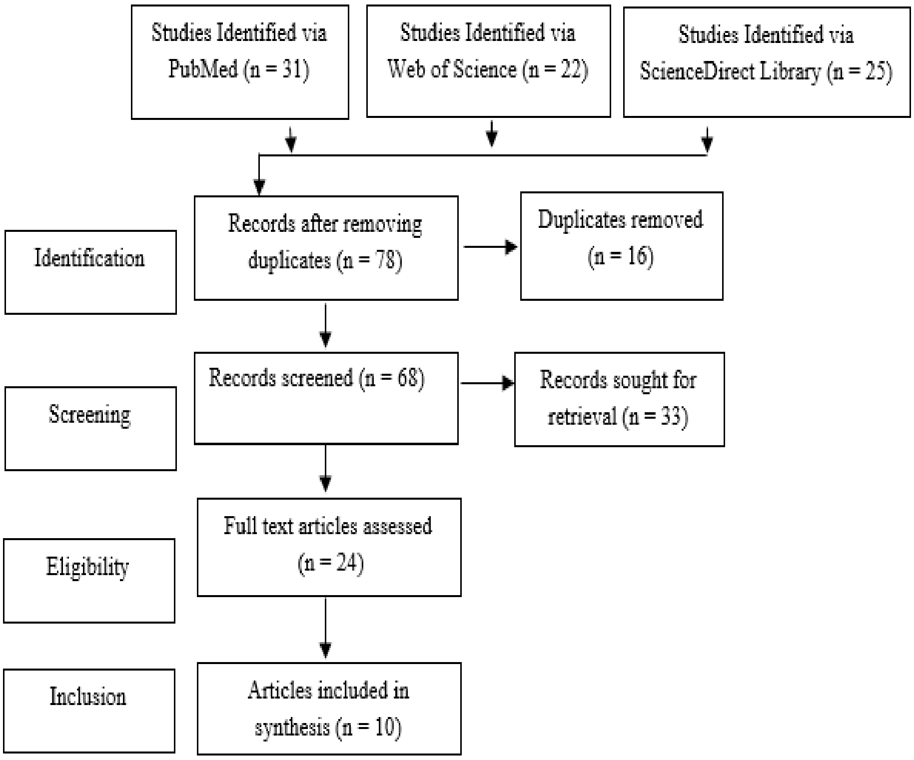

Figure 1. PRISMA flow diagram

The Cochrane risk of bias assessment method was employed to evaluate the quality of the included studies **(Table 2)**.

Table 2. Cochrane risk of bias assessment summary

Study	Randomization bias	Allocation concealment bias	Selection bias (control selection and baseline similarity)	Blinding (performance bias)	Blinding (detection bias – outcome assessors)	Selective reporting bias	Confounding bias accounting
Fornaini *et al*. [16]	+	+	+	+	+	+	-
Farista *et al*. [17]	+	+	+	+	+	+	-
Kaur *et al*. [18]	+	+	+	+	_	+	+
Gupta *et al*. [19]	+	+	+	+	+	+	-
Soliman *et al*. [20]	+	+	+	+	+	-	+
Pai *et al*. [21]	+	+	+	-	+	+	+
Patel *et al*. [22]	+	+	+	+	+	+	+
Azma *et al*. [23]	-	+	+	+	+	+	-
Derikvand *et al*. [24]	+	+	+	+	-	+	+
Tuncer *et al*. [25]	-	+	+	+	+	+	-

Results and Discussion

Table 3. Effectiveness of soft tissue dental lasers in esthetic dentistry

Author(s)	Study objective	Number of patients	Laser type and wavelength (nm)	Power output (W)	Key findings
Gupta *et al.* [19]	Evaluated the effectiveness of a semiconductor diode laser for treating gingival hyperpigmentation.	1	980	2-4	No infections or major post-op complications like pain or bleeding.
Pai *et al.* [21]	Investigated the efficiency of a diode laser for removing oral fibromas.	2	810	1	The procedure was safe and quick, with minimal discomfort and post-op issues.
Soliman *et al.* [20]	Assessed the soft tissue diode laser for managing oral hyperpigmentation.	20	808	1-2	Most participants reported no swelling, pain, or tissue damage post-treatment.
Fornaini *et al.* [16]	Studied patient response and effectiveness of KTP laser surgery for soft tissue procedures.	52	532	1	The treated area healed well, with minimal thermal damage to surrounding tissue.
Derikvand *et al.* [24]	Examined the versatility of a 980 nm diode laser in dental procedures.	5	980	1.5	All patients experienced smooth post-op recovery with positive surgical outcomes.
Kaur *et al.* [18]	Investigated the role of soft-tissue diode lasers in treating oral mucosal lesions.	2	810	3	Laser therapy proved more effective than traditional methods in precision, hemostasis, and patient comfort.
Azma *et al.* [23]	Analyzed the impact of diode laser in soft tissue oral surgeries.	2	940	1.5-3.5	Minor discomfort due to smoke and odor, but complete healing was observed within a month.
Farista *et al.* [17]	Compared diode laser functional crown lengthening with conventional scalpel techniques.	14	940	1.5	No statistically significant difference ($P > 0.14$) between the two methods on day 10 post-op.
Patel *et al.* [22]	Evaluated diode laser vs traditional surgery in labial frenectomy procedures.	20	980	10	Both methods resulted in similar wound-healing outcomes.
Tuncer *et al.* [25]	Investigated histological effects of thermal damage in CO_2 laser vs. conventional soft tissue surgery.	43	CO_2	3-4	No intraoperative or post-op complications occurred with either method.

As shown in **Table 3**, the study conducted by Fornaini *et al.* [16] focused on evaluating the features of a low-power KTP laser-assisted surgery, examining both patient compliance and the characteristics of the intervention. The research explored the use of the KTP laser (532 nm), a recently introduced wavelength in dental applications, operating at low power (1 Watt - CW). The study wanted to assess the intervention's duration and the levels of postoperative and intraoperative pain, which were measured using a Numeric Rating Scale. The results indicated that using the KTP laser at low power effectively managed pain during cosmetic procedures, as evaluated by Visual Analog Scale (VAS) assessments. A total of 52 patients (27 males, 25 females; mean age of 23 years and 16 months) with benign oral soft tissue conditions were treated. The outcome revealed excellent healing, with minimal or no tissue damage such as scorching, indicating the effectiveness of the low-power laser.

In a clinical trial by Farista *et al.* [17], the primary aim was to compare the clinical effectiveness of diode laser-assisted functional crown lengthening surgery to the traditional scalpel technique. The study included 14 participants, aged between 20 and 40 years, who were divided into 2 groups. One group received treatment with a 940 nm diode laser, while the other underwent scalpel surgery. The laser unit, with a 400-m disposable tip, was applied in contact mode with a power range of 0.8 to 1.5 watts in continuous mode. The laser was used to gently remove gingival tissue, exposing the desired tooth structure. Statistical analysis using an unpaired t-test and ANOVA showed that patients in the laser group had significantly lower VAS scores for pain on the third and seventh days post-treatment ($P = 0.002$). However, by the tenth day, there was no significant difference between the two groups ($P > 0.14$), suggesting similar outcomes in the long term.

Kaur *et al*. [18] aimed to assess the efficacy of a soft-tissue diode laser for treating oral mucosal ulcers. Two patients were treated: one, a 28-year-old woman, presented with an enlarging gum growth over the past two years, and the second, a woman in her 40s, had a growing lesion in the left retromolar area. Both were treated with the diode laser using a 300 m fiber tip, an 810 nm wavelength, and 3 W of power for 60 seconds. No pain was reported during or after the procedure, and the minimal application of local anesthesia meant that no stitches or antibiotics were required. The results demonstrated rapid healing with no swelling or bleeding, affirming that laser treatments provided an efficient alternative to traditional methods. The procedure offered easy cleaning, quick ablation, and effective hemostasis, all while being more comfortable for the patient both during and after the operation. This suggests that laser therapy may offer superior benefits in comparison to conventional techniques.

Gupta *et al*. [19] conducted a study to understand the efficiency of semiconductor diode laser treatment for gingival hyperpigmentation. Using a 980 nm wavelength semiconductor diode laser at 2-4 W, the procedure was aimed at depigmenting the mandibular and maxillary anterior gingiva, extending to the 2nd premolar on both sides. A 23-year-old male patient visited the periodontics division at the Institute of Dental Studies and Technology in Modinagar, presenting with overly pigmented gingiva but no other health concerns. The procedure, which took 20-25 minutes, successfully removed the pigmented epithelium from the mandible and maxilla. After the laser treatment, the tissue appeared fresh, with no signs of bleeding or carbonization. No infections or significant postoperative complications such as pain or swelling were reported. A follow-up 15 months later revealed no recurrence of pigmentation, demonstrating the long-term success of the treatment.

Soliman *et al*. [20] aimed to investigate the effectiveness of soft tissue diode lasers for treating oral hyperpigmentation. The study involved 20 patients, mostly with gummy smiles and highly pigmented areas in their labial, gingivae, and cheek mucosa. In most cases (18 patients), two sessions were needed to eliminate the melanotic lesions. Patients were monitored at one, two, and three-week intervals. The treatment was conducted using an 808 nm, 400-m diameter fiber laser. After one week, 40% of patients showed excellent responses, 50% had very good results, and 10% required a third session due to a poor response. In those who responded well, the restoration of normal mucosal and gingival texture and color was achieved, with optimal aesthetic outcomes by the third week after treatment. Notably, the majority of patients experienced no postoperative pain, swelling, or complications.

Pai *et al*. [21] investigated the effectiveness of a diode laser for excising fibromas. The study involved three female patients, aged 28, 36, and 45 years, who presented with different oral fibromas. Following the application of topical anesthesia, the lesions were removed using an 810 nm diode laser set at a continuous output power of 1 W. The treatment was quick, and the soft tissue healing was satisfactory with no scarring observed in the treated areas. The results highlighted the diode laser as a safe, fast, and minimally painful procedure with no significant postoperative issues, making it an effective choice for fibroma excision.

Patel *et al*. [22] conducted research comparing the efficacy of diode laser surgery versus traditional surgical methods for labial frenectomy procedures. The study included 20 patients, aged 16 to 40 years, with papillary or papillary penetrating frenal attachments in the anterior maxillary region. Half of the patients underwent diode laser treatment, and several factors, including pain, inflammation, swelling, complexity, and wound healing, were assessed at intervals of 1 week, 1 month, and 3 months. The diode laser was used in contact mode at a power of 10 W and a wavelength of 980 nm. Results showed that patients treated with the diode laser experienced significantly less postoperative pain ($P = 0.0001$) and required fewer analgesics ($P = 0.001$) compared to those who underwent traditional surgery. The wound healing in the diode laser group was significantly better at one week and one month, though by the three-month mark, there were no notable differences between the two groups regarding healing time. This suggests that diode laser surgery may offer immediate advantages in pain reduction and healing, though long-term results may be comparable to traditional methods.

Azma et al. [23] conducted a study to assess the use of diode lasers in soft tissue oral surgery. The study focused on a 53-year-old female patient who had developed an exophytic lesion on the buccal mandibular gingiva approximately eight months before her referral to the dentistry faculty at Guilan Medical University. The planned treatment involved an excisional biopsy and histological analysis of the lesion. For the procedure, a class IV diode laser operating at 3.5 W CW and a wavelength of 810 nm was used. The lesion was successfully excised, and the healing process was remarkable, with epithelial repair completed just ten days post-surgery. In a second case, a 26-year-old female patient was referred due to concerns over worsening gingival color when smiling. A diode laser (Ezlase 940 nm, 1.5 W CW, 400 m fiber) was used with a sweeping motion to treat the condition. Despite minor discomfort from the smoke and the burning smell, the treatment was effective, and the patient's epithelium fully healed after one month, with no further complications.

In a case study by Derikvand *et al*. [24], the aim was to explore the versatility of the 980 nm diode laser in dentistry. 5 patients were referred to a private practice for treatment. After reviewing their medical histories and conducting oral examinations, a therapeutic plan was developed for each case. Diode laser surgery, with a 1.5 W CW output power at a wavelength of 980 nm, was recommended for all patients. The procedure went smoothly with no postoperative complications, and follow-up visits revealed favorable results in all cases, showcasing the diode laser's potential for successful dental surgeries.

Tuncer *et al*. [25] examined the impact of collateral thermal damage on histological diagnosis and compared the effectiveness of CO2 laser treatment to traditional surgery for oral soft tissue conditions. Forty-three patients, with an average age of 54, were randomly assigned to either CO2 laser treatment or conventional surgery using a scalpel. The laser's power was set to 3-4 W in continuous wave mode, adjusted based on the lesion's size, and performed under local anesthesia. Remarkably, only 42% of patients in the laser group required additional local anesthesia after receiving topical anesthesia, compared to all patients in the traditional surgery group. No intraoperative or postoperative complications occurred in either group. Histological examination of 39 tissue samples revealed that collateral thermal damage from the laser did not affect the histopathological diagnosis, emphasizing the CO2 laser's safety and precision.

Finally, the study highlighted the advantages of using the 532 nm wavelength diode laser at low power (1 watt) for soft tissue surgery in the oral cavity. This approach facilitates excellent healing, effective ablation, and efficient pain management with minimal postoperative discomfort. Although the study suggests that more research with a larger patient sample is needed, the use of this wavelength and its associated parameters holds promise for treating a wide range of oral conditions, offering a more comfortable and effective alternative to traditional methods [26].

Our study focused on participants who had sufficient attached gingiva to undergo a straightforward gingivectomy, either with a scalpel or a laser. When comparing the two methods, both were successful in achieving adequate gingival tissue removal and enhancing the visibility of the dental structure. However, patients in the laser group experienced less bleeding, resulting in reduced discomfort and clearer visualization of the surgical area. In contrast, the scalpel group had more bleeding, which led to painful procedures and hindered the visibility of the operating region. This improved visibility allowed for a more thorough evaluation of the exposed tooth structure [27].

The advantages of using a laser over traditional scalpel methods are numerous, including minimal swelling, a bloodless surgical site, reduced scarring and coagulation, quicker procedures, fewer sutures, and minimal to no postoperative pain. Additionally, the laser provides an immediate disinfecting effect on the surgical area without causing mechanical stress to the tissue. Lasers work by delivering energy that can heat, coagulate, weld, denature proteins, and vaporize tissues, similar to electrocauterization, but with more targeted effects [28].

Compared to Nd: YAG lasers, diode lasers produce more heat but penetrate the tissue less deeply. The diode laser's compact size, affordability, and superior performance make it an appealing choice for soft tissue surgeries. Importantly, it has no adverse effects on the root surface, which makes it suitable for use near dental hard tissue. The researcher's experience with Q-switched Nd: YAG lasers has also shown promising results, as Q-switching allows for higher pulse energies, longer pulse durations, and lower pulse repetition rates making it effective for various dental applications [29].

For patients with pigmented gingiva, different treatment methods were employed. Following surgery, periodontal packs were required for seven to ten days to protect the exposed tissue, with complete healing of the incision site taking about six weeks, leaving a small scar [30]. Laser surgery for soft tissue lesions is faster, more precise, less painful, and produces less scarring compared to traditional methods. In the case described above, the patient reported no pain during or after the procedure and was satisfied with the results. Diode laser treatments work through photochemical, thermal, or plasma-mediated processes, leading to the breakdown or ablation of biological tissues [31].

In our study, patients who underwent diode laser surgery experienced significantly less postoperative pain on days one and seven compared to those who had knife surgery. Additionally, the laser group used fewer analgesics. These findings align with previous research suggesting that diode laser therapy during frenectomy procedures results in reduced postoperative discomfort and a better recovery experience than traditional scalpel surgeries [32]. Several other studies [33-35] have also highlighted the benefits of diode lasers in dentistry, particularly for managing soft tissue mucogingival issues related to orthodontic treatment. Patients who underwent diode laser surgery required less anesthetic, experienced quicker hemostasis without the need for sutures, and enjoyed better postoperative comfort and healing.

However, there are some drawbacks to diode laser use, including delayed healing in larger lesions and tissue charred in smaller lesions compared to scalpel surgery. Furthermore, laser plumes generated during the excision of exophytic lesions caused by human papillomavirus may pose a risk of contaminating the operator's upper respiratory tract [36, 37].

Conclusion

Soft tissue lasers offer a highly effective alternative for aesthetic dental treatments. They present a successful option to traditional dental methods, which often carry a higher risk of infection and inflammation.

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