The Effectiveness of Laser Therapy for Oral Mucosal Diseases: A Systematic Review

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Abstract

The use of lasers in dentistry aims to overcome the disadvantages experienced in conventional treatment procedures. In the Oral Medicine field, the laser can be used as a primary or adjunctive therapy for oral mucosal diseases. This review aimed to evaluate the effectiveness of laser therapy in patients with a diagnosis of oral mucosal diseases, including oral mucositis, oral leukoplakia, oral lichen planus (OLP), and recurrent aphthous stomatitis (RAS).

This research was a systematic review that followed the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines. The articles were obtained from the PubMed database from 2016 to 2021 with no age and sex restrictions. The inclusion criteria include the article was written in English, the study was conducted on humans designed with a Randomized Controlled Trial, Clinical Trial, or Cohort Study, and the research subjects were patients with oral mucositis, or oral leukoplakia, or OLP, or RAS. Exclusion criteria included comments, letters to editors, case reports, review articles, and conference papers. The initial search identified 316 articles, then 72 full-text articles were examined, and only 13 of them met the inclusion criteria.

The clinical outcomes of all studies analysed indicated that laser therapy could reduce pain and bleeding, exhibit anti-inflammatory and antibacterial effects, accelerate the healing process, and reduce complications and recurrence rate of oral lesions including oral mucositis, oral leukoplakia, OLP, and RAS. Laser therapy is an advanced modern technology that has been proven to be effective in the treatment of oral mucosal diseases with many advantages.

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Introduction

In dentistry, lasers have been used in aesthetic recontouring of the gingiva, removal of inflamed and hypertrophic tissue, elongation of soft tissue crowns, frenectomy, and photo-stimulation of both herpetic and aphthous lesions.[1] Lasers are used in several fields of dentistry including oral medicine, orthodontics, periodontics, and oral surgery.[1,2,3,4,5]

A device that gives off light through amplification of the optical part based on the emission that has been stimulated by electromagnetic radiation is called a laser. The word "laser" stands for "light amplification by stimulated emission of radiation".[2] Einstein stated that the emission of radiation promotes the lasers and is a natural process. Einstein's theory of spontaneous and simulated radiation emission explains the three characteristics of lasers: monochromatic, coherent, and collimated.[1,6]

The use of lasers in dentistry can be divided based on the type of active laser media, solid, liquid, gas, and semiconductor media, which will determine what laser type to be emitted. Lasers can also be divided based on the amplifying medium used, such as solid lasers and gas lasers. In addition, lasers can be classified according to tissue application, namely soft tissue lasers and hard tissue lasers, or based on the wavelength and risks associated with the application of the laser. [1]

The helium-neon laser, which is promoted by green wavelengths and some infrared wavelengths, was the first gas laser. ErYAG, NdYAG, and CO_2 lasers are categorized as hard

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lasers as they can be used for soft and hard tissue applications. A CO_2 laser is one of the most powerful types of lasers, this type of laser transfers energy to CO_2 molecules, converting electrical power into laser output power. A CO_2 laser is fast and hydrophilic, eliminating soft tissue, and haemostasis with shallow depth of penetration and maximum absorption, but CO_2 laser has disadvantages such as expensiveness, bulkiness, and can damage the hard tissue. [1]

Neodymium exhibits increased efficiency in laser types when combined with yttrium-aluminium-garnet (YAG) or glassy materials. In addition to having decent haemostasis, the NdYAG laser is very absorbable by pigmented tissues, making it very effective in excisional surgery and soft tissue coagulation. The two wavelengths that the erbium laser has are the ErYAG lasers and the ER laser, the CrYSGG (yttrium scandium gallium garnet). The highest water absorption and high hydroxyapatite affinity manage it to be the best option for the treatment of hard tissue and the ablation of soft tissue with a high-water percentage.[1]

Materials and methods

The current systematic review aims to describe the effectiveness of laser therapy in patients with a diagnosis of oral diseases such as oral mucositis, oral leukoplakia, oral lichen planus, and recurrent aphthous stomatitis. The systematic review was designed based on the (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) PRISMA guideline. The articles were obtained from the PubMed database from 2016 to 2021 with no age and sex restrictions for the research respondents. The keywords used were “laser and oral lesion”, “laser and oral mucositis”, “laser and oral leukoplakia”, “laser and oral lichen planus”, and “laser and recurrent aphthous stomatitis”. The full articles of research that met the eligibility criteria were then considered for further screening. Afterward, some studies were excluded for several rationales. The inclusion criteria were: (1) the whole article was written in English; (2) the study was conducted on humans; (3) the study was designed with a Randomized Controlled Trial, Clinical Trial, or Cohort Study design; (4) the diagnosis found on the patients were oral mucositis, oral leukoplakia, oral lichen planus, or recurrent aphthous stomatitis. Comments, letters to editors, case reports, review articles, and conference papers were not eligible for inclusion, therefore, excluded.

Results

There were 316 articles concerning the utilization of the laser in dentistry. After eliminating 15 duplicates and filtering by the past 5-year-period, 301 titles, and abstracts were then analyzed. Seventy-two articles met the eligibility criteria and were included in the full-text review. After the reading and screening process, a further review of 13 articles consisting of 8 RCT studies, 4 Clinical Trials, and 1 Cohort was conducted. The research flow chart is presented in Figure 1. The results of this systematic review were analyzed from 13 articles that investigated oral lesions, including oral mucositis, oral leukoplakia, oral lichen planus, and recurrent aphthous stomatitis, using the LLL type (Table 1).

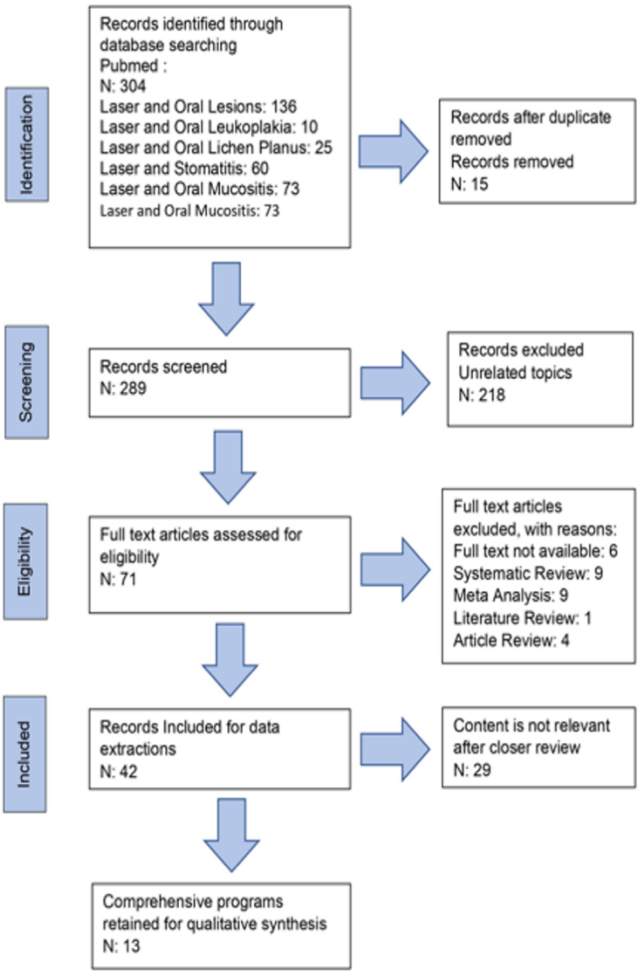

Figure 1. Research Flowchart with PRISMA Method.

Researcher/Year	Institution, Country	Article Title	Oral Lesion	Result Assessment	Outcome Assessment
Legouté et al./2019	University of Brescia, Italy	Low-level laser therapy (LLLT) in treating chemoradiotherapy-induced mucositis in head and neck cancer (HNC): results of a randomised, triple-blind, multicentre phase III trial.	Oral mucositis	LLLT/PBMT (photobiomodulation therapy) is recommended to prevent oral mucositis in HNC patients undergoing radiotherapy at a curative dose of 4 J/cm^2, although it potentially increases the malignancy of the primary tumour.	LLLT/PBMT is well tolerated, with a good safety profile for inpatients.
Medeiros Filho et al./2017	University CEUMA, Brazil	Laser and photochemotherapy (PCT) for treating oral mucositis (OM) in young patients: a randomised clinical trial.	Oral mucositis	The combination of PCT and LLLT can reduce the duration of OM lesions and pain and speed up the healing process.	PCT should be administered initially to reduce the number of microorganisms that can affect the general health of cancer patients while increasing the effectiveness of LLLT.

Amadori et al./2016	Institut de Cancérologie de l'Ouest, French	LLLT for the treatment of chemotherapy-induced OM in childhood: a randomised double-blind controlled study.	Oral mucositis	This study has demonstrated the efficacy of LLLT in reducing pain in chemotherapy-induced OM patients at a dose of 4 J/cm^2.	LLLT therapy: OM healing occurs spontaneously in most cases with no complications.
Marın Conde et al./2019	University of Seville, Spain	Photobiomodulation with LLLT reduces HNC radiochemotherapy-induced OM: a prospective randomised controlled trial	Oral mucositis	Photobiomodulation with LLLT reduces the incidence and severity of mucositis and does not affect the recurrence or emergence of new primary tumours.	There were no complications in the therapy with LLLT.

Gobbo et al./2018	University of Trieste, Italy	A multicentre randomised, double-blind controlled trial to evaluate the efficacy of laser therapy for the treatment of severe chemotherapy-induced in children: laMPO RCT	Oral mucositis	Photobiomodulation (PBM) has high tolerability and compliance.	None of the participants reported clinically proven side effects.
Antunes et al./2017	Instituto Nacional de Câncer, Brazil	Long-term survival of a randomised phase III trial of HNC patients receiving concurrent chemoradiation therapy with or without LLLT to prevent OM.	Oral mucositis	LLLT treatment had a significant positive impact on response to cancer complication treatment.	Placebo group (PG) patients had more morbidity, including dysphagia, gastrostomy, and a higher incidence of renal failure.
Soares et al./2018	Universidade Estadual de Montes Claros, Brazil	Treatment of mucositis with combined 660- and 808-nm-wavelength LLLT reduced mucositis grade, pain, and use of analgesics: a parallel, single-blind, two-arm controlled study.	Oral mucositis	hours. On the other hand, fibroblast proliferation decreased critically in an energy-dependent manner after 48 h and 72 h after LLLT application.	LLLT in the presence of infrared (808 nm) can reduce inflammatory mediators associated with pain sensation.
dos Santos Soares et al./2021	Federal University of Para, Brazil	Therapeutic effects of andiroba (*Carapa guianensis* Aubl) oil, compared to low level laser, on oral mucositis in children undergoing chemotherapy: A clinical study.	Oral mucositis	The andiroba group showed significantly better results compared to the laser group.	Andiroba gel showed higher analgesic potency than LLLT.
Suter et al./2020	University of Bern, Switzerland	A randomised controlled trial comparing surgical excisional biopsies using CO_2 laser, Er:YAG laser and scalpel.	Oral leukoplakia	Studies have shown no difference in pain using Er:YAG and scalpel in the first and second 3 days.	Complications, bleeding, and pain are lower with a laser compared to a scalpel.

Vu et al./2019	University of Sydney, Australia	Diagnostic utility of microsurgical carbon dioxide laser excision of oral potential malignant lesions (OPML) vs incisional biopsy: A retrospective histopathological review.	Oral leukoplakia	Laser excision biopsy (LEB) increases substantially with diagnostic accuracy in large OPML and can replace conventional incisional biopsy (CIB) diagnostics.	The disadvantages of laser ablation are the lack of tissue for histopathological analysis and the potential failure to diagnose cancer.
Matsumoto et al./2019	Kobe University Graduate School of Medicine, Japan	Clinical evaluation of CO_2 laser vaporization therapy for oral Lichen Planus (OLP): A single-arm intervention study.	Oral lichen planus	All patients received some benefits, less pain, and a lower recurrence rate.	Analgesic administration is considered necessary after seven days of irradiation
Mirza et al./2018	Ziauddin University, Pakistan	Efficacy of photodynamic therapy (PDT) and LLLT against steroid therapy in treating erosive-atrophic OLP.	Erosive-atrophic oral lichen planus	PDT and LLLT effectively treat the erosive-atrophic form of OLP in adult patients.	There were statistically significant differences between the PDT and corticosteroid groups.
Yilmaz et al./2017	Near East University, Turkey	Treatment of recurrent aphthous stomatitis (RAS) with Er,Cr:YSGG laser irradiation: A randomised controlled split-mouth clinical study.	Recurrent aphthous stomatitis	Er,Cr:YSGG could significantly reduce pain after treatment compared to the control group and significantly accelerate the healing of RAS lesions one day after treatment.	Er:YSGG laser with 0% water at 0.25 W is suitable for reducing pain and accelerating the healing process of RAS.

Table 1. Results and conclusions of articles investigating the effectiveness of laser therapy in patients with oral mucosal diseases.

Discussion

Mechanism of laser

Cold laser, also known as the soft laser, is based on a compact and low-cost diode device, often referred to as low-level laser therapy (LLLT).1 LLLT is a newly developed medicine, dentistry, and physiotherapy technique. The main benefit is a non-surgical approach, which will reduce the incidence of oedema and inflammation.[1,6]

The advantages associated with the use of soft lasers are better healing of the wound, better bone remodelling and repair, post-injury restoration of nerve function, and promotion of the modulation of the immune system and nociceptive signaling.[1,6] LLLT also stimulates various lymphocytes and mast cells, producing an anti-inflammatory action that causes changes in hydrostatic capillary pressure resulting in the absorption of oedema and elimination of metabolic intermediates. It can even enhance collagen production, epithelial cell's mitotic activity, fibroblast's mitotic activity, and also inhibit the nociceptive signals causing an analgesic effect.[1,6]

However, LLLT is found to directly affect blood flow so it is strictly contraindicated in coagulation disorder patients and can stimulate cell growth in malignancy. Due to their low side effects (therapeutic lasers less than 500 Mw), the low-level laser was classified by the United States Food and Drug Administration as a device that has a low-risk of side effects. Currently,

many wavelengths of the laser that are widely used in Dentistry, especially surgery of the oral cavity, including Nd YAG, Argon, KTP, and CO_2, which are used in diverse dental specialties, including the diagnosis and removal of caries, light composite healing, and vascular bleeding control. Additionally, LLLT has been applied in teeth whitening solutions activation, surgery of temporomandibular joint, and procedures of the soft tissue, such as gingivoplasty, gingivectomy, excisional biopsy, tumor excision, and second-stage implant restoration.[1,6]

Diode lasers have wavelengths ranging from 635 nm to 950 nm, use flexible types of quartz sera, are absorbed by the pigmentation of soft tissue, and have excellent agents of haemostatic. The output of power is 2 W to 10 W.[1,6] Different types of wavelengths can be categorized as follows:[1]

- UV Range (ultra-spectrum 400-700 nm)
- IR range (700 nm infrared spectrum to microwave spectrum)
- VIS range (visible spectrum 400-700 nm)

Dose calculation

Dose calculation is done by measuring the energy supplied to be used as mW x seconds (e.g., 100 mW x 10 seconds = 1000 mJ = 1 J). The dose is done by splitting the energy by the irradiation area. Optimal density of power is essential for triggering biological effects to ensure that prolonged exposure will not fully compensates for the low output. The target depth of treatment must be considered. Even when selecting the probe of the laser, the location of the targeted tissue and the tissue type also needed to be considered. For instance, the rays of the laser are transmitted more easily through mucosa and fat than the laser rays that through the muscle. Additionally, the presence of pigment and haemoglobin can also strongly affect the damper; thus, it is necessary to raise the dose. The penetration power can be increased by applying pressure to move the laser to become closer in terms of distance to the target.[1]

In the conditions of acute phase with the presence of oedema and inflammation, laser energy in higher doses can be administered with more frequent applications to promote healing. Laser therapy can be carried out conservatively with weekly or twice weekly in patients with chronic conditions such as pain and paresthesia. The first day of given the LLLT treatment, the effect will still be last on the day two of the treatment and this can be used as long-term prevention. In chronic conditions, the patient's body will respond as a flare-up in the acute phase, allowing the process of healing to start. The times of treatment program required according to the indications for LLLT may vary, in some instances, one therapy visit may be sufficient, but in many cases, multiple therapy sessions may be required.[1]

Laser effect

The earliest clinical study concerning lasers in Dentistry was carried out in 1964. Ear-nose-throat (ENT) physicians (otolaryngologists), oral surgeons, and periodontists were among the initial specialists to use lasers intraorally to do surgical application procedures in soft tissues. The use of laser on surgery in certain areas can pose a risk of bleeding, such as the cheek area, tongue, and base of the mouth; therefore, to give good control over the procedure access to the area must be eased.[1]

There are many indications for LLLT therapy utilisation in intra-oral diseases. In some cases, the administration of anaesthesia shows a positive effect and can reduce blood vessel or nerve trauma that needle sticks may cause LLLT is capable to be used on the mucosa's superficial part directly prior to the injection, therefore can produce a better effect of aestetic but it cannot be used to the area of the hard palate. Oedema caused by an increase in the inflammatory response will depend on the human body's lymph vessels system. Oedema will be reduced by direct application of LLLT to the lymph nodes. Oedema that was widespread will require multiple therapy sessions and higher doses for optimal recovery The pain threshold is felt to be lower with the administration of therapeutic lasers because of how the laser works, which can decrease the nerve conduction speed and potential of action and suppress noxious stimuli. In the beginning, in an acute type of pain, there will be a reduced level of PGE_2 and other markers of inflammation by inhibiting the terminals of peripheral afferent directly that suppress sensitization of peripheral and limiting the neurokinin release. The inflammatory cells and processes will be reduced by high-dose lasers, thus the pain sensation will be reduced in the condition that was already chronic, the conditions differ because they depend on sensitisation better than the inflammation Intra-

oral lasers are more helpful because of the interaction of specific areas of the tissue that got the disease and a considerable decline of pathogens and bacteria count by the use of lasers in surgery In the case of procedures on soft tissue, the laser achieves adequate healing, sometimes eliminating the need for stitches. Many researchers observed that the effect of the laser can decrease the effect of oedema as the result of the lymphatic channels and the blood vessels closed well.[1]

The laser machine produces light energy which interacts with the tissue that got the disease. The light reflection from the surface does not affect the tissue that was targeted and the light becomes more diffuse if the light pass-through narrow beams area and maintains its collimation, but if the reflection is reflected onto the tissue that was not targeted it can be harmful such as the eye; for instance, when a laser of CO2 is used, exposure to titanium implants causes more diffuse reflection. In laser therapy with transmission through the tissue directly, the targeted tissue will not be affected, but it depends on the laser beam wavelength. The desired energy can be weakened by the scattering of light. The photons will change their direction in the aftermath and it is important the use infrared lasers on the healthy soft tissue. The desired effect of the laser energy absorption and the total absorption will rely on the moisture and pigmentation content.[1]

Therapeutic laser light is a type of light that affects the reaction of oxidation-reduction in most cells and stimulates the biological processes of the cells. In this phase, the cells will be more acidic, but once the laser has been completed, they will become less acidic and more alkaline, thus they will be capable to do their function normally. The increase in ATP is the most important part, which is primarily produced by the Krebs cycle at the end of its cycle when the nitric oxide inhibits the photons of the cytochrome acceptor enzymes. The beam of the laser will begin the binding between cytochrome-c and nitric oxidase, allowing the production of the enzyme ATP to continue to directly supply the bio-stimulating energy to the body of the cells and the low-level laser light to be absorbed by the cellular photoreceptors to generate adenosine triphosphate is the principle of this laser beam. The most accepted theory is the photochemical theory which explains the laser effect and mechanism, whereby some biological events in the size of molecular will occur after some specific molecules absorb the light. Photoreceptors are several types of endogenous molecules and proteins located in the chain of the respiratory tract, that will cause an increase in adenosine triphosphate, such as cytochrome c-oxidase. A Laser of this type has been used for approximately 30 years, and no particular hazards have been reported.[1]

The energy of electromagnetic is ready to use in waves from small rays of gamma, with about 10-12 nm in wavelengths and thousands of meters from wavelengths to radio waves. The intraoral laser instruments available have wavelengths emission of about 488 nm to 10,600 nm and the radiation are non-ionizing. This radiation differs from ionizing radiation, whose effects on DNA are mutagenic. Lasers of dental generate radiation, thermal, and heat. Several lasers of dental give off visible light. Such example, lasers of argon give off blue-colored light of 480 nm, and when their frequency is doubled, they will give off blue-colored light and green-colored light of 514 nm. One of the primary instrument that gives off visible light, the Nd:YAG give off primarily green-colored light at the 532 nm wavelength, and some laser at the low level gives off light at the 635 nm wavelength for biomodulation and a 655 nm wavelength; a laser at the low-level can be applicated for detecting caries. The other types of laser device that are applied for surgery of the hard and soft tissue produce lasers in the center, near the infrared portion of the spectrum of electromagnetic, with low-level laser in the 810 nm range. Diode laser for surgery has a range of 800-830 nm and utilize an active diode medium consisting of arsenate, aluminium, and gallium; this medium is also utilized in 980 nm diode lasers likewise in1064 nm diode lasers. Lasers of Nd-YAG consist YAG, that is yttrium scandium, gallium, and garnet crystals smeared with chromium and erbium; nonetheless, Er;YAG at 2,940 nm wavelength utilizes erbium as an agent of doping and a 10,600 nm wavelength use CO_2.[1]

Based on previous studies, it is suggested that many research results support laser administration to several oral lesions analysed in this systematic review, such as oral mucositis, oral leukoplakia, oral lichen planus (OLP), and recurrent aphthous stomatitis (RAS). According to Legouté et al.[7], Medeiros-Filho et al.[8], Amadori

et al.[9], Marin-Conde et al.[10], Gobbo et al.[11], Antunes et al.[12], and Soares et al.[13], the LLLT has a positive impact on the treatment of chemoradiotherapy-induced oral mucositis. LLLT can reduce pain and speed up the healing process.[7-13] However, dos Santos Soares et al.[14] reported that the andiroba oil intervention group showed significantly better results than the laser group, with the result that none of the patients in the andiroba oil group experienced any pain.

Legouté et al.[7] reported that LLLT could increase the potential for primary tumour malignancy; therefore, applying LLLT should avoid tissue in the tumour area. In addition, the application of time and energy at the time of administration of therapy should be strictly controlled (the MASCC curative dose in HNC patients is 4J/cm2). However, Marin-Conde et al.[10] reported that LLLT did not affect primary tumours.

Suter et al.[15] compared three intervention groups for oral leukoplakia: surgical intervention with CO2 Laser, Er:YAG and scalpel surgery. The results of this study indicate that therapy with CO2 Laser and Er:YAG surgical intervention has a less painful effect than scalpel surgery. The duration of the intervention required is also shorter. The safe surgical distance for surgery with the Er:YAG laser is 0.2 mm, while the CO_2 laser is 0.5-1 mm. Another disadvantage of scalpel surgical intervention is that the sutures can interfere with the patient, and the duration of the intervention required is also longer. Vu et al.[16] explained further the intervention of Laser Excision Biopsy (LEB) in other Oral Potential Malignant Lesions (leukoplakia, erythroplakia). LEB is known to replace Conventional Incisional Biopsy (CIB) in the excision process for diagnostics. Excision is performed with a 250 mm spot in super pulse mode and power settings between 3 and 5 watts. The patient was positioned in Trendelenburg at 30 degrees, and then CO_2 laser surgery was used to ensure total resection of clinically relevant lesions, particularly regarding excision area and depth, determined clinically and with the aid of a surgical microscope.[15,16]

Matsumoto et al.[17] investigated the results of CO_2 laser administration in OLP. The CO_2 laser has high energy efficiency for tissues with high moisture content and is mainly absorbed about 200 Im from the irradiated surface. CO_2 laser therapy facilitates and reduces the administration of medical therapy for patients with residual or relapsed OLP. The administration of CO_2 laser therapy with a vaporization process at a wavelength of 10.6 m on a mucosal surface layer of 2 mm from OLP lesions is more efficient. Researchers chose a continuous mode wave that emits a continuous laser beam to avoid remnants of the unirradiated region. To prevent residual lesions and achieve sufficient depth, the researchers performed irradiation using the integration technique of regular horizontal irradiation and overlapping irradiation. As an application to OLP, PDT is considered a complicated technique and requires several treatments; therefore, not popular in clinical practice.[17]

Mirza et al.[18] reported a significantly higher mean of pain relief in the corticosteroid group than in the PDT and LLLT groups. PDT and LLLT are effective in treating erosive-atrophic OLP in adult patients. PDT showed superior results than LLLT. In the corticosteroid intervention group, the pain was found to be higher than in the PDT and LLLT groups.[18] A case report has been reported showing the use of diode laser combined with topical corticosteroid therapy that has been successful in the treatment of symptomatic OLP without any complication.[19]

Yilmaz et al.[20] reported that laser application significantly reduced pain. Therefore, the laser has been considered an alternative medicine method due to several promising capabilities for treating various types of lasers such as neodymium-supported gallium-aluminium arsenide (GaAlAs), yttrium, aluminium and garnet (Nd:YAG) and CO_2 lasers. Using a CO_2 laser with a power of 1W in defocus mode continuously will reduce the pain level in RAS compared to the placebo group. Er,Cr:YSGG can significantly reduce pain after treatment compared to the control group and significantly accelerate the healing of RAS lesions one day after treatment.[20]

Conclusions

Laser therapy is an advanced modern technology that has been proven to be useful and very effective for treating oral mucosal diseases, including oral mucositis, oral leukoplakia, oral lichen planus, and recurrent aphthous stomatitis. It has many advantages such as non-invasive,

less pain and bleeding, less infection risk, exhibits anti-inflammatory and anti-bacterial activities, and faster healing process.

Declaration of Interest

The author reports no conflicts of interest in this work.

References

1. Luke AM, Mathew S, Altawash MM, Madan BM. Lasers: A review with their applications in oral medicine. *J Lasers Med Sci*. 2019;10(4):324-329. doi:10.15171/JLMS.2019.52.
2. Le LN, Do TT, Le KPV. Influence of Low-Level Laser Treatment on Tooth Movement in Orthodontic Treatment. *J Int Dent Med Res*. 2022;15(4):1614–9.
3. Mahmood JM, Adam H, Khursheed AM, Rozita H, Rumaizi S, Ahmad A, et al. Effect of 940nm Low Level Laser Therapy on Bone Remodelling During Orthodontic Tooth Movement in Rats. *J Int Dent Med Res*. 2019;12(3):886–93.
4. Bunjaku V, Popovska M, Grcev A, Mrasori S, Kameri A, Sllamniku Z, et al. Non-surgical Periodontal Treatment and Low Level Laser Therapy (LLLT) Outcomes for Patients Suffering from Type 2 Diabetes Mellitus, Obesity and Chronic Periodontitis. *J Int Dent Med Res*. 2017;10(2):214–21.
5. Kashmoola Muhannad Ali, Mustafa Nazih Shaaban, Kamal HAF, Idzhar Muhammad Ikramullah. A Pilot Study on The Use of Low Level Laser Therapy in Treatment of Temporomandibular Disorder Muhannad. *J Int Dent Med Res*. 2018;11(3):1636–9.
6. Slebioda Z, Dorocka-Bobkowska B. Low-level laser therapy in the treatment of recurrent aphthous stomatitis and oral lichen planus: A literature review. *Postep Dermatologii I Alergol*. 2020;37(4):475-481. doi:10.5114/ADA.2020.98258.
7. Legouté F, Bensadoun RJ, Seegers V, et al. Low-level laser therapy in treatment of chemoradiotherapy-induced mucositis in head and neck cancer: Results of a randomised, triple blind, multicentre phase III trial. *Radiat Oncol*. 2019;14(1):83. doi:10.1186/S13014-019-1292-2.
8. Medeiros-Filho JB, Maia Filho EM, Ferreira MC. Laser and photochemotherapy for the treatment of oral mucositis in young patients: Randomized clinical trial. *Photodiagnosis Photodyn Ther*. 2017;18:39-45. doi:10.1016/J.PDPDT.2017.01.004.
9. Amadori F, Bardellini E, Conti G, Pedrini N, Schumacher RF, Majorana A. Low-level laser therapy for treatment of chemotherapy-induced oral mucositis in childhood: A randomized double-blind controlled study. *Lasers Med Sci*. 2016;31(6):1231-1236. doi:10.1007/S10103-016-1975-Y.
10. Marín-Conde F, Castellanos-Cosano L, Pachón-Ibañez J, Serrera-Figallo MA, Gutiérrez-Pérez JL, Torres-Lagares D. Photobiomodulation with low-level laser therapy reduces oral mucositis caused by head and neck radio-chemotherapy: Prospective randomized controlled trial. *Int J Oral Maxillofac Surg*. 2019;48(7):917-923. doi:10.1016/J.IJOM.2018.12.006.
11. Gobbo M, Verzegnassi F, Ronfani L, et al. Multicenter randomized, double-blind controlled trial to evaluate the efficacy of laser therapy for the treatment of severe oral mucositis induced by chemotherapy in children: laMPO RCT. *Pediatr Blood Cancer*. 2018;65(8):e27098. doi:10.1002/PBC.27098.
12. Antunes HS, Herchenhorn D, Small IA, et al. Long-term survival of a randomized phase III trial of head and neck cancer patients receiving concurrent chemoradiation therapy with or without low-level laser therapy (LLLT) to prevent oral mucositis. *Oral Oncol*. 2017;71:11-15. doi:10.1016/J.ORALONCOLOGY.2017.05.018.
13. Soares RG, Farias LC, da Silva Menezes AS, et al. Treatment of mucositis with combined 660- and 808-nm-wavelength low-level laser therapy reduced mucositis grade, pain, and use of analgesics: A parallel, single-blind, two-arm controlled study. *Lasers Med Sci*. 2018;33(8):1813-1819. doi:10.1007/S10103-018-2549-Y.
14. Soares A dos S, Wanzeler AMV, Cavalcante GHS, Barros EM da S, Carneiro R de CM, Tuji FM. Therapeutic effects of andiroba (Carapa guianensis Aubl) oil, compared to low power laser, on oral mucositis in children underwent chemotherapy: A clinical study. *J Ethnopharmacol*. 2021;264:113365. doi:10.1016/J.JEP.2020.113365.
15. Suter VGA, Altermatt HJ, Bornstein MM. A randomized controlled trial comparing surgical excisional biopsies using CO2 laser, Er:YAG laser and scalpel. *Int J Oral Maxillofac Surg*. 2020;49(1):99-106. doi:10.1016/J.IJOM.2019.05.012.
16. Vu J, Coleman HG, Palme CE, Riffat F, Schifter M, Zoellner H. Diagnostic utility of microsurgical carbon dioxide laser excision of oral potentially malignant lesions vs incisional biopsy: A retrospective histopathological review. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2019;127(6):516-525. doi:10.1016/J.OOOO.2018.12.010.
17. Matsumoto K, Matsuo K, Yatagai N, et al. Clinical evaluation of CO2 laser vaporization therapy for Oral Lichen Planus: A single-arm intervention study. *Photobiomodulation, Photomedicine, Laser Surg*. 2019;37(3):175-181. doi:10.1089/PHOTOB.2018.4559.
18. Mirza S, Rehman N, Alrahlah A, Alamri WR, Vohra F. Efficacy of photodynamic therapy or low level laser therapy against steroid therapy in the treatment of erosive-atrophic oral lichen planus. *Photodiagnosis Photodyn Ther*. 2018;21:404-408. doi:10.1016/J.PDPDT.2018.02.001.
19. Sufiawati I, Christine H, Drakel FF. The effectiveness of corticosteroid and diode laser combination therapy in the treatment of severe Oral Lichen Planus: A case report. *J Int Dent Med Res*. 2022;15(1):312-314.
20. Yilmaz HG, Albaba MR, Caygur A, Cengiz E, Boke-Karacaoglu F, Tumer H. Treatment of recurrent aphthous stomatitis with Er,Cr:YSGG laser irradiation: A randomized controlled split mouth clinical study. *J Photochem Photobiol*. 2017;170:1-5. doi:10.1016/J.JPHOTOBIOL.2017.03.011.