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Review

Lasers in the management of oral complications in Diabetes Mellitus – A narrative review

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Abstract

Diabetes Mellitus (DM) is a major global health issue that affects millions of individuals worldwide. Diabetes is known to affect various body systems, including the oral cavity and exerts a negative influence on human health. The oral complications of diabetes are diverse and affect various parts of the oral cavity, such as the oral mucosa, tongue, and periodontium. The pathogenesis of the oral disease secondary to diabetes is complex and involves various mechanisms such as impairment of neutrophil function, increased collagenase activity related to the microangiopathy of the mucosal blood vessels and neuropathic effects. The management of the oral condition is often challenging because of the underlying metabolic disorder. However, the advent of newer tools in healthcare, such as lasers, has shown excellent results in managing oral complications secondary to diabetes. Apart from being an excellent surgical tool, lasers are known to induce photobiomodulatory effects, resulting in effective pain management, repair and regeneration of the oral tissues.

Keywords: diabetes mellitus, lasers, oral medicine, photobiomodulation therapy, periodontitis.

Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder that occurs due to the lack of insulin secretion by the pancreas or by the inefficiency of the insulin generated [1]. Although there are numerous studies evaluating the prevalence of DM, the quality means of data collection and the population studied differ greatly. Hence, it is difficult to determine the exact estimate of prevalence. According to reports from 2019, the prevalence of diabetes was estimated to be 9.3%, i.e., 463 million people, which is expected to increase to 10.2%, i.e., 578 million people by 2030, and this figure may reach 10.9%, i.e., 700 million people by 2045 worldwide [2]. DM impairs the ability of the body to control the amount of blood glucose, which can lead to a variety of serious major illnesses and less minor issues [3]. The American Association of Diabetes defined diabetes in 2004 as a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. It is categorized based on the etiopathogenic aspect into two types: diabetes due to absolute deficiency of insulin secretion and diabetes due to resistance to insulin action [4]. Diabetes is known to affect various body systems and exerts a negative influence on human health. The relationship between metabolic disorders and oral health is directly related [5]. The oral complications of diabetes are diverse, affecting various parts of the oral cavity, and their management is complex. However, the advent of newer technological tools, such as lasers, has shown excellent results in managing oral complications secondary to diabetes. The present paper aims to provide a comprehensive review of the applications of low-level lasers in the management of oral complications of diabetes.

Oral complications of diabetes mellitus

Diabetes, like many other systemic diseases, exhibits various manifestations in the oral cavity. The common oral complications include periodontitis, which is considered the sixth manifestation of DM, xerostomia, burning mouth syndrome (BMS), angular cheilitis, Oral lichen planus, and delayed wound healing [6]. Diabetes is known to alter the morphology of the oral epithelial cells and can predispose the oral cavity to infections such as candidiasis [7]. People with diabetes frequently suffer from burning mouth syndrome and altered taste perception. These clinical abnormalities of the oral cavity might arise throughout the progression of the disease and are correlated with high glycemic levels of blood [8]. Impairment of neutrophil function, increased collagenase activity, decreased collagen synthesis, microangiopathy of the mucosal blood vessels, and neuropathy are some potential mechanisms that may be attributed to the basic pathogenic process behind oral complications in diabetes [9].

Lasers as a tool in the management of diabetes-related complications

Lasers were first used in dentistry by Maiman in the 1960s, which sparked ongoing research into their many potential uses in the field of Medicine. Lasers that are widely used in medicine and dentistry include carbon dioxide (CO_2), neodymium yttrium aluminum garnet (Nd: YAG), and erbium yttrium aluminum garnet (Er: YAG) Lasers [10]. In 1968, low-level laser treatment (LLLT) was first made available as a therapeutic modality. The technical parameters of a low-level laser differ from those of a surgical laser, and they operate under a wavelength of 600–1000 nm. They can both stimulate and suppress biological processes, referred to as Photo biomodulation, contributing to analgesic, anti-inflammatory, and wound healing properties of low-level lasers. Photobiomodulation (PBM Therapy) was previously known as Low-Level Laser Therapy (LLLT) [11].

Endre Mester discovered LLLT in 1967 at Hungary's Semmelweis Medical University [12]. PBMT uses non-ionizing light sources, such as light-emitting diodes (LEDs), lasers and broad-spectrum light, to induce photochemical and photophysical reactions in different tissues. There are references in the scientific literature where PBM has employed monochromatic lasers, quasimonochromatic LED lights, non-coherent and polychromatic light sources for various therapeutic purposes.

LLLT, in contrast to other laser techniques, does not have an ablative or thermal mechanism; rather, it produces a photochemical effect, which implies that the light is absorbed and causes a chemical change in the target tissue. It is not comparable to other types of laser therapy used for ablation, cutting, and thermal tissue coagulation, which is why this method is referred to as a low-level technique. The low levels of optimum energy density delivered is the other reason this method is called low-level laser photo biomodulation [11, 13].

Lasers, especially low-level lasers, have shown promising results in the management of complications of diabetes, such as diabetic foot ulcers, to promote wound healing, and in the management of diabetic neuropathy [14, 15]. Low-level laser therapy is considered a non-invasive therapeutic modality in the management of diabetic complications, as it can aid in the elimination of systemic drug therapy and its associated side effects [16]. Similar to the general medical use of low-level lasers, they are also used in dentistry, especially in Oral Medicine, to manage the oral complications of diabetes.

General mechanism of action of low-level laser therapy

When a low-level therapeutic laser beam is incident on a tissue, the photobiomodulatory effects occur by collecting light photons in the Cytochrome c oxidase and antenna pigments of mitochondria. The energy of the laser beam will be used in mitochondria to create adenosine triphosphate (ATP), and as a result, stimulation of fibroblasts and collagen synthesis takes place at the site. Apart from this, the energy generated at the irradiation site also increases the local microcirculation, aiding in wound healing. Additionally, it triggers transcriptional factors and mediates various intracellular signaling pathways controlling apoptosis cell death and induces antioxidant response, further contributing to the pair activity. The capacity of a low-level laser to inhibit the release of pain mediators and hinder the conduction of nerve fibers such as A-delta and C fibers was considered the major reason behind the analgesic effect of low-level lasers [10, 11].

Periodontal problems

Periodontitis in people with diabetes affects the gingiva and periodontal tissue due to the chronic inflammation resulting from bacterial invasion and immune dysregulation. Patients with type 1 and type 2

diabetes have been shown to have a higher prevalence and severity of periodontal disease. Chronic hyperglycemia leads to the buildup of various end products secreted from the glycation process and an increase in the secretion of pro-inflammatory cytokines like tumor necrosis factor and prostaglandin-E2 in diabetics have been postulated as the pathogenic event related to alteration in the collagen structure and immune function. These pathogenic processes tend to make gingival and periodontal tissues a favorable site for bacterial persistence [17, 18].

Since the 1980s, when periodontal surgery first received reports of its utility, photonic therapy lasers have been employed in periodontics. Surgical lasers are utilized for scaling and root planing (SRP), sulcular debridement of periodontal pockets, and root cleansing during soft or bone periodontal surgery. The most effective lasers for non-surgical periodontal therapy are high-power semiconductor diode lasers operating in a wavelength of 808–904 nm [19]. Experimental studies with diode lasers of 980 nm diode laser with 2–4 W power settings proved effective in pocket reduction therapy [20]. Chandra *et al*. used a diode laser of 808 nm to improve periodontitis's clinical and microbiological parameters among people with diabetes [21]. However, Diode lasers of 980 nm are much safer in terms of lesser heat production at the gingival tissue when compared to diodes of lesser wavelengths in the management of periodontitis [22].

Salivary dysfunction

Saliva is an essential bio fluid for the healthy functioning of the oral cavity and aids in major functions such as speech and mastication. People with diabetes have been found to have salivary dysfunction [23]. It is well recognized that the long-term consequences of diabetes mellitus are linked with microvascular angiopathy and endothelial dysfunction, which is reported to exert a decrease in the quantity and quality of saliva [24]. Though salivary hypo-function may be treated with cytoprotective drugs, growth factors, and muscarinic cholinergic agonists, they may be accompanied by other related side effects.

Low-level laser therapy is a non-invasive and safe approach to increase the salivary flow. Low-level lasers of 850 nm have shown promising results because of their bio-modulatory effects, resulting in cytokine and growth factor production alteration and promoting cell division and proliferation [25].

Lončar *et al*. studied the effects of low-level laser therapy on xerostomia due to various systemic diseases, and it was found that laser therapy was not only stimulating but also produced regenerative glandular response over a period of time [26].

Wibawa *et al*. studied in 2018 the effects of laser in xerostomia due to diabetes. A 940-nm diode with an energy density of 4J was used to irradiate the major salivary glands for two weeks to improve salivary glandular function [27].

Taste disorders

Taste disorder is one of the most typical oral symptoms of diabetes mellitus in both type 1 (T1DM) and type 2 (T2DM). Dysgeusia is the most frequent taste alteration associated with diabetes, apart from hypogeusia. It was believed that hypogeusia could be a precursor to diabetic neuropathy [8].

Evidence from the literature indicates that the perception of sweet taste is particularly impaired in diabetes, which leads to increased consumption of sugar and is related to an increase in glycemic levels [28, 29]. Low-level laser therapy can enhance local neural complex regeneration, cause microcirculatory alterations and stimulate the regeneration of taste buds. Using low-level lasers operating under 630–680 nm and with an energy density of 3 J/cm^2 in contact mode to irradiate specific regions of the tongue has improved taste perception significantly [30].

Oral lichen planus

Oral lichen planus is a chronic inflammatory type of autoimmune disease that is mediated by T cells. Patients with type 1 diabetes are reported to develop lichen planus more frequently than those with type 2 diabetes. Diabetic patients experience a protracted condition of chronic immunological suppression, particularly those with type 1 diabetes, which could be related to oral lichen planus [31]. According to previous literature, 2–3 sessions per week using diode lasers operating at wavelengths between 630 and 970 nm may be necessary for the lesion to heal completely. Sessions can last from a few seconds to eight minutes. Diode lasers can help reduce the symptoms associated with lichen planus. Hence, it is an effective substitute for traditional corticosteroid therapy in the treatment of oral lichen planus [32].

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Burning mouth syndrome

Burning Mouth Syndrome (BMS) is a complex disorder and the exact pathogenesis of this condition has not been fully understood. Successful management of BMS is challenging. Low-level laser therapy has been considered as a therapeutic option employed in BMS. The symptoms have significantly improved with laser photobiomodulation over 4–10 weeks, targeting different areas such as the tongue, buccal mucosa, and labial mucosa [33]. There is adequate evidence in the literature that reported the association between BMS and diabetes. Poor glycemic control and diabetic neuropathy are among the causes of diabetes linked to BMS. Additionally, it was found that better glycemic management has led to an improvement in BMS in some cases [34].

Gallium-aluminum-arsenide (GaAlAs) and Indium-gallium-aluminum phosphide (InGaAlP) have been successfully used to reduce the symptoms of BMS [35]. Evidence has found a decrease in the Tumor necrosis factor-alpha and interleukin-6 levels in the saliva of patients with BMS post-laser therapy, which may directly contribute to the recovery. The inhibitory effect of laser on neural impulse conduction and suppression of pain mediators may also be responsible for the decrease in pain perception [36].

Poor wound healing

Delayed wound healing is a frequent problem, leading to significant morbidity. Poor wound healing occurs due to complications of peripheral artery disease, inflammation, neuropathy, and hypoxic consequences. The pathophysiology of diabetic wounds involves a variety of cellular mechanisms, and research on human tissue and animal models has helped to clarify the reasons. Decreased growth factor synthesis, delayed angiogenesis and fibroblast migration, along with deficient proliferation and protease remodeling, were hypothesized to be the reasons behind the delayed wound healing [37].

Osman *et al.* reported early post-surgical healing of oral wounds in people with diabetes using low-level lasers of 810 nm wavelength. Low-level laser therapy acts by promoting the release of growth factors and increasing new capillary formation. It was also reported that irradiation of the wound by lasers operating between 600–1000 nm helped form collagen, new fibroblasts, and epithelial cells following the release of the growth factors, including vascular endothelial growth factors [38, 39].

Oral candidiasis and angular cheilitis

Candida is a normal oral microbial flora, but numerous circumstances, including immunological dysfunction and prolonged hyperglycemia, might encourage the development of candidal infection in diabetes [40]. According to Willis *et al.*, smoking, denture usage, poor oral hygiene, consumption of corticosteroids and broad-spectrum antibiotics are considered as predisposing factors for candidial infection among people with diabetes [41]. An erythematous crusting lesion is the hallmark of angular chelitis in the commissures of the lips and is reported to occur in diabetes with poor glycemic control [42].

Maver-Biscanin M *et al.* showed low-level laser diodes of 685 and 830 nm to effectively reduce the candidial yeast counts and reduce the clinical severity of the palatal lesions [43]. Successful management of angular cheilitis with reduced pain scores and wound healing using low-level lasers for photodynamic therapy using agents such as toluidine blue and photo dithazine has been reported in the literature [44].

Oral hyperpigmentation

Increased melanin pigmentation is reported as a complication of diabetes mellitus [45]. Various lasers have been used successfully for depigmentation procedures. Carbon diode CO_2 lasers of 10,600 nm,Nd:YAG lasers of 1064 nm, Er:YAG lasers of 2094 nm and diode lasers of 980 nm are the routinely used lasers.

The basic mechanism of lasers in the treatment of pigmentations is due to their ability to ablate the supra basal and basal layers of melanocytes present in the epithelium. The melanocytes absorb the laser light energy and convert it to heat, resulting in a photothermal reaction [46].

Conclusion

Apart from being an excellent surgical tool, lasers are known to induce photobiomodulatory effects, resulting in effective pain management and accelerating healing by promoting tissue repair and regeneration. Lasers have a promising role to play in the management of diabetes-related oral complications, thereby improving the oral health-related quality of life among people with diabetes.

Conflicts of interest

The authors declare no conflict of interest.

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