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Laser Vaporization of Mouth Lesions, an Overview

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Abstract

Lasers are utilized in dentistry as a therapeutic tool or as an auxiliary tool. The major purpose of employing lasers in dentistry is to overcome the difficulties that are currently observed in traditional dental treatment treatments. The laser is used in hard tissue applications such as caries prevention, bleaching, restorative removal and curing, cavity preparation, dentinal hypersensitivity, growth modulation, and diagnostics, whereas soft tissue applications include wound healing, removal of hyperplastic tissue to uncover impacted or partially erupted teeth, photodynamic therapy for malignancies, and photo-stimulation of herpetic lesions. Lasers' capacity to perform minimally invasive operations with minimum patient discomfort has proven effective in the patient delivery system in dentistry practice. The availability of lasers with various wavelengths has produced a surgical panacea, and laser technology has replaced traditional surgical techniques in many oral surgical operations.

Keywords: *Dental, Application, Laser, Co2, Oral, Lesions.*

1. Introduction

The standard treatment for oral lesions is surgical removal (cold-knife, laser excision and vaporization, cryosurgery, photodynamic therapy), medicinal treatment (topical or systemic), reduction of risk behaviors (smoking and drinking), and surveillance. Laser is currently the backbone of therapy for oral lesions all over the world, and it has previously been shown to be a safe and effective technique [1].

LASER stands for light amplification by stimulated emission of radiation and is monochromatic, collimated, and coherent [2]. Albert's hypothesis of spontaneous and simulated emission of radiation specifies three distinct characteristics of lasers: Monochromatic means that all of the waves have the same energy and frequency; coherent means that all of the waves of light are in phases linked to each other in speed and time; and collimated means that the waves are parallel (low beam divergence) [3]. Lasers are categorised according to many variables, one of which is the laser active medium, such as gas, liquid, solid, or semi-conductor, which identifies and classifies the kind of output laser beam. Laser beams are created by stimulating the emission of radiation from a light source [4].

Einstein recognized that the emission of radiation by a laser is a natural phenomenon [4]. A laser beam is formed when a light beam travels through a certain medium, causing stimulation of the particles within the medium to radiate the light in a specified direction, that is, the same way as the medium by the same wavelength as the original beam. In dentistry, both visible beams (such as the Argon laser at 488 or 518 nm) and invisible infrared beams (such as the CO2 laser, Ho:YAG (Holmium Yttrium Aluminium Garnet), Er:YAG (Erbium substituted: Yttrium Aluminium Garnet), Er-Cr: YSGG (Erbium, Chromium Doped Yttrium Scandium Gallium Garnet), ND:YAG (Neodymium-Doped Yttrium Aluminium Garnet), and Diode (Gallium Arsenide) are used. The wavelength of monochromatic light that may be reflected, dispersed, or absorbed determines the impact of a laser beam on biological tissue [3]. A deposition of energy then occurs in the tissue as a result of various biological tissue components absorbing light from various wavelength ranges. Several types of lasers are utilized in oral and maxillofacial surgery, depending on their wavelength range and concurrent absorption by biological chromophores such as water and hemoglobin. The lasers are employed for various clinical features [4].

Studies comparing the healing time of laser wounds to scalpel wounds have been inconclusive: some predict a quicker healing rate, others a delayed healing rate, and still others claim no significant difference [5]. It has been proposed that enhanced platelet activity at the site of the cut causes blood vessels to seal. Suturing is no longer required since lasers give good hemostasis. Some lasers can also be used to fuse tissue edges together, reducing the necessity for suturing. The decrease in postoperative edema appears to be due to the closure of lymphatic capillaries. The interaction of laser radiation with the pigmented part of bacteria found in the mouth cavity helps to reduce bacterial count at the surgical site [5]. ***Wigdor et al.*** stated the following advantages of lasers over cold steel surgical procedures: little postoperative edema and scarring, reduced bacteremia, instant sterilization of the surgical site, reduced mechanical stress, and little postoperative discomfort [6]. Another advantage of using lasers in practice is the psychological influence it has on patients. It instills greater trust in the patient's thoughts in the doctor who is perceived as employing the most advanced and sophisticated therapeutic equipment [7].

Rapid advances in laser technology, as well as a greater knowledge of the bio-interactions of various laser systems, have expanded the clinical usage of laser in dentistry.

Laser's history

"Heliotherapy" was the practice of our forefathers, which led to the invention of action therapy and photo-medicine. The Nobel Prize awarded to Finsen in 1903 for the creation of the carbon arc lamp with lenses and filters for disease treatment was a significant milestone in the development of lasers for medical purposes. Since 1963, ***Leon Goldman***, a pioneer in laser medicine, has published on the biological aspects of lasers as well as studies in laser dentistry, primarily on the impact of lasers on dental caries, teeth, and other tissues [2].

Albert Einstein laid the groundwork for the discovery of the laser in 1917 by understanding photoelectric amplification, and it was first made public in 1959. ***Miaman*** was the first to utilize a laser on hard and soft tissue in 1960. Laser advancements in the last two decades have expanded their usage in caries prevention, whitening, cavity preparation, dentinal hyper-sensitivity, growth regulation, and diagnostic objectives. It has been utilized in wound healing, the removal of hyperplastic tissue to reveal impacted or partly erupted teeth, photodynamic treatment of malignancies, and photo-stimulation of herpetic lesions in soft tissue. Lasers have been found to improve the efficiency, specificity, convenience, affordability, and comfort of dental treatment [8].

It was discovered in the early 1960s that the use of medical lasers in dental applications had limited utility. In the early decades, physicians realized that light enabled them to see various things, such as skin color and wounds, and that it assisted them in selecting the most successful therapeutic course of action. This prompted scientists to investigate the specialized uses of lasers in the medical and dentistry disciplines [2].

In the mid-1960s, improved caries eradication procedures based on an effective interaction of laser radiation with tooth structure were described. Ruby lasers were particularly effective in vaporizing cavities, but their high energy density produced permanent necrotic alterations in the pulp tissue. Then, Erbium Laser wavelengths were identified, which performed better in terms of cavity preparation while causing no damage to the pulpal tissue. Nd:YAG (neodymium-doped yttrium aluminum garnet) lasers were shown to be effective in different endodontic treatments, prosthetic devices, gold alloys, and prosthetic devices [9].

The Food and Drug Administration (FDA) approved the use of laser treatment in intraoral gingival and mucosal tissue surgery in 1990 because it assured a wound free of suture, discomfort, and bleeding and enhanced the dentist's convenience. Myers presented the first laser built exclusively for dentistry in the United States on May 3, 1990. The erbium wavelength has been shown to be particularly safe and effective among the different specific lasers developed to be utilized for soft tissue operations as well as for teeth and bone. Lasers, whether therapeutic or photo-bimodulation, have demonstrated beneficial healing benefits. The initial clinical trials of photo-activated disinfection revealed promising uses for disease management [10].

Mechanism of Laser

An energy source, an active lasing medium, and two or more mirrors make up a laser. The light from the dental laser is delivered to the target tissue via the fiberoptic cable, hollow wave path, focusing lenses, and cooling system [8]. The action is based on the Amdt-Schutz concept. This indicates that increasing or decreasing the stimulus dosage beyond the optimum dose will result in a weakening or lack of the effect. The optimal effect is produced by using the optimal dose. As a result, the bio stimulating effect of Low-Level Laser Therapy may be achieved by appropriate dosage exposure to tissues in a non-contact manner. Furthermore, Low Level Laser Therapy deposits sub-thermal energy inside tissues, which operates on the sub-cellular component. Low Level Laser Therapy also activates lymphocytes and mast cells, which provide anti-inflammatory activities and cause changes in capillary hydrostatic pressure, resulting in edema absorption and removal of intermediate metabolites. It can also boost collagen formation and the mitotic activity of epithelial and fibroblast cells.

Furthermore, by suppressing nociceptive impulses, it can generate analgesic effects [2]. In dentistry, two types of beams are used: visible beams like the argon laser and invisible beams like the carbon dioxide laser, erbium substituted yttrium aluminum garnet, erbium chromium doped yttrium, scandium gallium garnet holmium, yttrium aluminum garnet, and gallium arsenide. Many aspects of the laser beam, particularly the wavelength and optical properties of the specific target tissue, indicate the type and amount of the interaction that may occur [11].

Lasers used in surgery generate light at certain wavelengths that have direct effects on tissue, not only on coagulation and vaporization but also on the natural healing process of the cells. different than surgical lasers, different types of lasers are employed as bio stimulators [2]. There are several wavelengths that may be classed as UV (ultra-spectrum 400-700 nm), IR (infrared spectrum 700 nm to microwaves spectrum), and VIS (visible spectrum 400-700 nm). The laser transforms electromagnetic energy to heat energy, and its wavelength is determined by both design and clinical use [3].

Vaporization Technique

Tissue ablation (also known as vaporization) is done when the surgeon just wants to remove the target's surface or execute a superficial excision of tissue. The lesion is generally restricted to the epithelium or the epithelium and the underlying superficial sub-mucosa in these cases. Standard excision often results in deeper tissue loss, greater scarring and bleeding, and probable injury to essential neighboring structures. ***Ishii et al.*** discovered that using this approach to treat oral leukoplakia reduces not only recurrence and malignant transformation, but also postoperative impairment [12]. The case report from ***Chaudhary et al***. in 2011 illustrates the potential for the first application of this icy laser for treating a moderate instance of bilateral OSMF. ***Chaudhary et al.*** described an example of oral submucous fibrosis (OSMF) that was treated with laser (ErCr: YSGG) [13].

During an apicoectomy, the apex is exposed with a conventional bur or an Er:YAG laser, and the periapical soft tissue is removed using a CO2 laser rather than curetted using hand tools. The usual defocused ablation method is utilized. If the CO2 laser interacts with bone, it may cause some necrosis, although this is insignificant in comparison to the great elimination of tissue remains feasible with this approach. It is recommended to use numerous biopsy samples or toluidine blue staining for histologic identification of bigger surface lesions, such as leukoplakias [14].

The following lesions are commonly treated by vaporization: nicotine stomatitis, dysplasia, papillary hyperplasia, tissue hyperplasia, oral melanosis, lichen planus, leukoplakia, papillomatosis, hyperkeratosis and actinic cheilitis. Laser vaporization is a safe, non-invasive, low-cost, fast, and somewhat painless way of treating premalignant lesions [12,15].

Classification of Laser

Lasers used in dentistry can be categorized in several ways: According to the lasing medium utilized, such as gas laser and solid laser; tissue adaptability, such as hard tissue and soft tissue lasers; wavelength range, and, of course, the danger associated with laser application.

Carbon dioxide laser: The CO2 laser is a gaseous medium laser that uses an electrical discharge current to push a gaseous mixture of CO2 molecules through a sealed tube. The light energy, with a wavelength of 10,600 nm, is provided through a hollow tube-like waveguide near the end of the mid-infrared invisible nonionizing section of the spectrum. The flexibility of the CO2 laser to supply the appropriate power in continuous and gated modes using focused or non-focused hand-pieces provides this device with the versatility and precision required for soft tissue surgical operations [16].

Water absorbs the wavelength well, second only to the erbium family. It has a short depth of penetration into soft tissue and can quickly cut and coagulate soft tissue, giving it an advantage in treating mucosal lesions [16].

This wavelength has the largest hydroxyapatite absorption of any dental laser, almost 1000 times that of erbium. As a result, the tooth structure close to the soft tissue surgery site must be protected from the incoming laser beam. Because of the extended pulse duration and low peak powers, carbonization and crazing of tooth structure can occur owing to continuous wave emission and delivery system technology [16].

Diode laser: The diode laser's active medium is a solid-state semiconductor consisting of aluminum, gallium, arsenide, and, on occasion, indium, which generates laser wavelengths ranging from 810 nm to 980 nm. Hemoglobin and tissue melanin absorb the majority of all diode wavelengths. On the other hand, the hydroxyapatite and water in the enamel have a difficult time absorbing them. Aesthetic gingival re-contouring, soft tissue crown lengthening, exposing soft tissue impacted teeth, removing inflammatory and hypertrophic tissue, frenectomies, and photo-stimulating apthous and herpetic lesions are some of the specific operations [17].

Erbium laser: The 'family' of erbium lasers consists of two different wavelengths: yttrium scandium gallium garnet (YSGG) and yttrium aluminum garnet (YAG). Erbium wavelengths have the strongest affinity for hydroxyapatite and the largest water absorption of any dental laser wavelength [18]. As a result, it is the preferred laser for treating dental hard tissues. Erbium lasers may be utilized for both soft tissue ablation and hard tissue operations since dental soft tissue includes a significant amount of water [19].

Neodymium Yttrium Aluminum Garnet Laser: Due to the pigmented tissue's strong absorption of the Neodymium Yttrium Aluminum Garnet (Nd: YAG) wavelength, dental soft tissues can be sliced and coagulated with excellent hemostasis with this surgical laser [20]. Research on the Nd: YAG laser's nonsurgical sulcular debridement for periodontal disease prevention [21] and the Laser Assisted New Attachment Procedure (LANAP) [22] has been conducted in addition to its surgical uses.

Applications of laser

Soft tissue application:

Healing the wounds: Laser treatment increases proliferation at low levels (e.g., 2 J/cm2) but suppresses it at high doses (16 J/cm2). It influences fibroblast growth and motility, which may contribute to the greater tensile strengths recorded for healed lesions. Low level laser therapy (LLLT) of gingival fibroblasts in culture has been demonstrated to promote transformation in myo-fibroblasts (which are important in wound contraction) as soon as 24 hours after laser treatment. LLLT has also been shown to improve the healing of recurring aphthous stomatitis lesions in people. Positive evidence suggests that LLLT helps patients receiving radiation for head and neck cancer heal from mucositis and oropharyngeal ulcerations as well as stimulates dentinogenesis after pulpotomy [8].

Apthous ulcer and post herpetic neuralgia: Aphthous ulcers and recurring herpetic lesions can be photo-stimulated with low amounts of laser energy (HeNe), which has been shown to reduce discomfort and hasten healing [23]. Photo-stimulation at the prodromal (tingling) stage of recurrent herpes simplex labialis lesions appears to stop the lesions before painful vesicles develop, expedite overall healing time, and reduce the frequency of recurrence [24].

Lasers used for Photo-activated dye disinfection: Low power laser radiation can be used to photo-chemically activate oxygen releasing dyes, causing membrane and DNA damage in bacteria. The photo-activated dye (PAD) approach can be used using a system that includes low power (100 milli-watts) visible red semiconductor diode lasers and toluidine blue dye. The PAD approach has been found to be efficient in killing bacteria in complex biofilms, such as sub-gingival plaque, which are normally resistant to antimicrobial treatments [25]. The dye may be made species specific by tagging it with monoclonal antibodies [26].

Gram positive bacteria (including Methicillin resistant Staphylococcus aureus (MRSA)), Gram negative bacteria, fungi, and viruses can all be successfully killed by photo-activated dye [27]. The main therapeutic uses of PAD include cleaning of root canals, periodontal pockets, deep carious lesions, and periimplantitis locations [28]. Tolonium chloride is used in high concentrations to test individuals for oral mucosal and oropharyngeal cancers [29].

Crown lengthening and Aesthetic gingival re-contouring: In contrast to conventional gingivectomy, which is accompanied by pain, discomfort, and bleeding, many physicians now decide to add gingival cosmetic optimization as part of complete orthodontic therapy as a result of the development of the diode laser [30].

Un erupted and partly erupted teeth: Conservative tissue removal can expose an impacted or partly erupted tooth for bonding, enabling for appropriate placing of a bracket or button. It has the benefit of causing no bleeding and allowing for quick connection placement, as well as being completely painless [8].

Inflammatory, hypertrophic, and other tissue removal: Isolated patches of temporary tissue hypertrophy can be readily removed using a diode laser without the need for a referral to a specialist. The diode laser is also highly helpful for a variety of isolated applications, including removing tissue that has grown over mini-screws, springs, and appliances, as well as for substituting a tissue punch when installing mini-screws in the detached gingiva, if necessary [31].

Frenectomy: The optimal time to do a laser assisted frenectomy on a labial frenum that is high or prominent is after the diastema has been closed as much as feasible. Deglutition, speech, malocclusion, and possible periodontal issues can all be impacted by ankylosglossia. When a frena is removed with a laser, there is no pain, no bleeding, no need for stitches or surgical packing, and no special postoperative care is required [32].

tumors treated with photodynamic therapy: Photodynamic therapy (PDT), which has been used to treat oral mucosal cancers, particularly multifocal squamous cell carcinoma, works on the same principle as PAD, generating reactive oxygen species that directly damage the cells and the associated blood vascular network, causing necrosis and apoptosis; this activates the host immune response and promotes antitumor immunity through the activation of macrophages and T lymphocytes. There is direct evidence of photodynamic stimulation of tumor necrosis factor alpha production, a crucial cytokine in host antitumor immune responses. PDT therapy of carcinoma in situ and squamous cell carcinoma in the oral cavity has had favorable results in clinical investigations, with response rates approaching 90% [8].

Hard tissue application

Fluorescence produced by a laser: A rather frequent side effect of orthodontic therapy with fixed equipment is enamel demineralization with the development of white spots on the buccal surfaces of the teeth [33]. However, there is evidence that even tiny patches of superficial enamel demineralization may remineralize [34].

Diagnostic application: The laser is utilized for both diagnostic and research reasons in clinical dentistry practice [8].

Dentinal hypersensitivity: One of the most prevalent symptoms in clinical dentistry practice is dentinal hypersensitivity. When the desensitizing effects of an Er: YAG laser were compared to those of a conventional desensitizing system on cervically exposed hypersensitive dentine, it was discovered that desensitizing hypersensitive dentine with an Er: YAG laser is effective, and the duration of a positive result is longer than with other agents [8].

The etching process: Laser etching of enamel and dentine has been studied as an alternative to acid etching. Micro-irregularities and a lack of a smear layer can be seen on enamel and dentine surfaces that have been etched using (Er, Cr: YSGG) lasers. Adhesion to dental hard tissues is poorer following Er: YAG laser etching compared to traditional acid etching [8].

Preparing e-models with a 3D laser: The development of precise, affordable, three-dimensional (3D) imaging systems which may be categorized as contact or non-contact, destructive or non-destructive, hard or soft tissue imaging systems is helping us better understand how craniofacial structures evolve. A useful tool for creating 3D pictures of oral dental structures, the laser scanner may be used to scan soft tissues and is simple to use. Because e-models are created from scanned impressions, no cast preparation is required [8]. Images were generated in order to construct databases for normative populations and cross-sectional growth changes, as well as to evaluate clinical results in surgical and nonsurgical treatments of the head and neck areas [35].

Laser safety

Although the majority of dental lasers are quite simple to operate, some safety measures should be followed to guarantee their reliable and efficient operation. The first and most important precaution is that everyone in the area of the laser while it is in use wear protective glasses. The doctor, chair-side helpers, the patient, and any onlookers, such as family or friends, are all included. It is vital to use wave length specific protective eyewear. Furthermore, accidental exposure to the non-target tissue can be avoided by using warning signs placed outside the nominal hazard zone, restricting access to the operating room, reducing the amount of reflective surfaces, and making sure the laser is in good working order with all manufacturer safeguards in place. To avoid potential pathogenic pathogen exposure, high volume suction should be employed to remove any vapor plume formed during tissue ablation, and standard infection procedures should be followed. A dedicated Laser Safety Officer should be assigned to each office to oversee the appropriate use of the laser, organize staff training, monitor the usage of safety goggles, and be knowledgeable about the relevant laws [8,36].

Dental Implants

Lasers have shown to be an invaluable tool in implant surgery, with several uses. Due to its special characteristics, managing the soft tissues around dental implants can be greatly benefited. For example, possible bleeding can be better controlled, there is less mechanical stress placed on the soft and hard tissues, local infections can be prevented, there is less postoperative pain and inflammation, and there is a lower chance of developing postoperative bacteremia [37].

Concerns about the risks of laser applications have developed along with the usage of lasers in implant dentistry [38]. Thermal damage has also been linked to implant failures following adjunctive laser surgery. In less time and with less heat production, the Er:YAG laser created preparations with straight and precise edges, free of bone pieces and other waste. The treated surface underwent barely detectable thermal changes [39].

Laser disadvantages

However, there are certain drawbacks to laser surgery. Delayed inflammatory responses are possible, resulting in minor post-operative pain lasting 1-2 weeks. Epithelial regeneration following standard surgery may differ/lag. Furthermore, the therapy is highly costly due to the usage of specialized technology. When utilizing lasers, you may experience a decrease of touch sensibility. Lasers are now being researched to make them more clinician-friendly [40].

4. Conclusion

Laser therapy in oral medicine has the potential to accelerate treatment and recovery. Additional applications for laser-based photochemical processes are quite promising, particularly for targeting specific cells, pathogens, or chemicals. After decades of development, laser technology for hard tissue application and soft tissue surgery is nearing completion, and more breakthroughs are likely. The soft tissue laser is a cutting-edge equipment in general dentistry that offers consistent aesthetic results. Specialized laser technologies have become critical components of modern dentistry practice throughout the years, proving to be an excellent instrument for increasing efficiency, specificity, convenience, affordability, and comfort of dental treatment.

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