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Laser In Oral And Maxillofacial Surgery - Review of Literature

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ABSTRACT

Since the advent of lasers, they have found tremendous application in all fields of science. In recent times, lasers are viewed as an integral part of many of the surgical and medical practices currently employed. Hence, it becomes increasingly important to understand the rationale behind the use of lasers so as to use them efficiently and without undue inhibitions. The use of lasers in oral and maxillofacial surgery has seen a phenomenal increase in both, applications of lasers for different techniques, and also the number of surgeons opting to use them on a regular basis. This article serves to update practitioners on the development and current applications of these modern tools in regular practice so as to efficiently perform dental treatment and minimize complications associated with conventional techniques.

Keywords: Applications, lasers, Oral and Maxillofacial surgery

"The medical application of the laser is fascinating for two reasons. It is optimistic mission on the one hand while, on the other, it counteracts the original impression of the laser being a death ray" - **Theodore Maiman**

I. INTRODUCTION

The application of light for processing materials was first described by Arristophanes in his comedy ''The clouds“ 423 B.C. In the 2500 years that passed until the laser was invented, light had been used both for processing material and for medical purposes in various ways. But only the laser has paved the path for widespread therapeutic use of optical radiation [1].From 1917, Albert Einstein to 1960 putting forward the theory of stimulated emission[2] , Theodore Maiman presenting the first LASER model[3],since then, many more materials have been discovered that are capable of producing laser light.

Due to the physical particularities of the laser effect, it was not long until the wide array of possible applications were realized. It took several decades to develop reliable, appropriately designed lasers for routine use in medicine and as well as other applications [1, 4]. Lasers have become the standard of care for most of the procedures in the field of oral and maxillofacial surgery and they are considered to be efficient instruments for a various new applications within this speciality. Since mid -1960s, lasers have been included in the practice of oral and maxillofacial surgery. Lasers are commonly used in oral and maxillofacial surgery for the treatment of coagulopathic patients, preprosthetic surgeries, benign, malignant and vascular lesions excision.

The emergence of lasers in the field of medicine has led to the development of other techniques like skin resurfacing which would not have been possible with the use of electrocautery or scalpel. With the development of laser surgery, the management of patients with dental implants, derangements of temporomandibular joint, premalignant lesions, sleep apnea, and facial scarring after trauma has changed considerably. They can be used in addition to conventional surgical techniques and also as a sole modality for treatment of various pathologies of the oral cavity,face and as well as other regions of the body. [3,5]

To understand the applications of laser surgery, it is necessary to know the fundamental principles of laser light. Laser is a special light source because in general it has higher power and a better beam quality an coherency in comparison with the other light sources Unlike other light sources, lasers emit coheren monochromatic, and collimated electromagnetic radiation, with high intensity, displaying a high optical power per unit area for a given amount of energy as compared to broadband light sources. These characteristics endow the laser with unique applications. Of course, there are specific feature inherent to each type of a particular laser such as th spot size, wavelength, or radiance that is important to the specific kind of application intended [6, 7]. The most common surgical lasers emit wavelengths in the infrared (IR) part of the spectrum: the Nd:YAG (λ=1,064nm), the Er:YAG (λ=2.94μm), and the CO2 laser (λ=10.6 and 9.6μm). Within the visible portion of the electromagnetic spectrum, argon lasers emit light between 458 and 515nm, and excimer lasers are located in the ultraviolet part of the spectrum (100 to 400nm). Diode lasers emit wavelengths of 670 to 1551nm. For surgical indications, the later seem to be of increasing interest [7]. Up until now, most of the high-power lasers operated in the near IR or far IR range and there are excimer lasers that have considerable power in the UV range. Thus, there is still a gap in the middle range of the spectrum which motivated development of laser systems for the UV/VIS region of the electromagnetic spectrum [6].

Advancements in Laser Technology:

As laser technology evolved, new types of lasers were introduced, enabling precise cutting and ablation of both soft and hard tissues. Erbium-doped yttrium-aluminum-garnet (Er:YAG) and erbium, chromium: yttrium-scandium-gallium-garnet (Er,Cr:YSGG) lasers became popular in oral and maxillofacial surgery. They offered better absorption in water, making them suitable for hard tissue procedures, including bone ablation and dental preparation.[8-9]

Components of Laser

The basic laser components are active or gain medium, pumping device or source and resonant cavity is shown in figure below.

- The active Medium or laser gain medium.
- A pumping device.
- A resonant cavity.

The active Medium (or laser gain medium)

The primary element of a laser is an active medium, which can be solid, liquid, or gaseous. The following are the active medium's primary attributes:

- It must have a pair of energy levels separated by a certain amount of energy. The energy level having high energy is known as upper energy level or higher excited energy level and the energy level having low energy is known as **lower energy level** or ground state.

- A population inversion between two energy levels must be permitted.

A pumping device

It is an external source of energy which provides the necessary energy to the active medium to produce a state of **population inversion**, crucial for lasing action. The most commonly used methods of pumping are:

- Optical pumping,
- Electric discharge
- Inelastic atomic collisions,
- Chemical reaction energy called chemical pumping.
- A resonant cavity

Population inversion is achieved to amplify the signal via (or photon) stimulated emission. However, in practice, most of atoms in the excited state emit spontaneously and do not contribute to the overall output.

Only few atoms in the excited state emit via stimulated emission and hence overall gain of the output is small. Therefore, we require a positive feedback mechanism to make most of the atoms in the excited state to emit via stimulated emission for contributing to the coherent output.

A device used to have positive feedback mechanism for maximum coherent output is known as resonator or resonant cavity. Thus, resonant cavity or resonator is a **feed back device** that makes the photons to move back and forth through the active medium.

In this process, the number of photons emitted due to stimulated emission are multiplied. A resonant cavity consists of a pair of plane or spherical mirrors placed parallel to each other at the ends of the active medium.

One of the mirror is fully reflecting mirror and the other is partially transmitting mirror. The laser output is taken out through the partially transmitting mirror which is also called **output coupler mirror**. .[10]

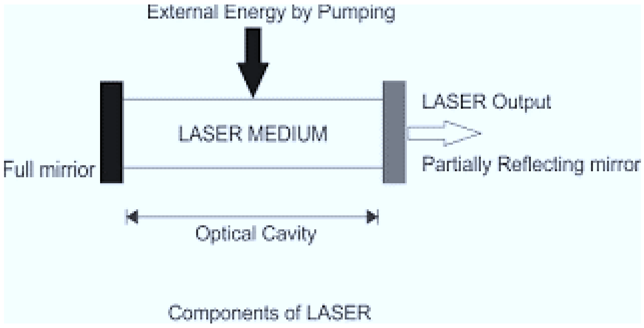

Fig 1: Components of Laser

Laser Physics

The root of the invention of laser lies in fundamental physics research, specifically, a 1917 paper by Albert Einstein on the quantum theory of radiation or stimulated emission, but it was a paper on laser theory published in 1958 by two physicists, Charles Townes and Arthur L. Schawlow, which spurred the race to make the first working laser. According to the Einstein principle, there is an equal probability that a photon will absorb or emit. Thereby, according to the Boltzmann distribution that when there are more atoms in the ground state than in the excited states and light is incident on the system of atoms, in thermal equilibrium, the probability of absorption of energy is much higher than emission. However, in the case that more atoms are in an excited state than in a ground state and strike with photons of energy similar to the excited atoms, many of atoms will induce the process of stimulated emission, whereby a single excited atom would emit a photon identical to the interacting photon. Under the proper conditions, a single input photon can result in a cascade of stimulated photons, and thereby amplification of photons will result. All of the photons generated in this way are in phase, traveling in the same direction, and have the same frequency as the input photon.

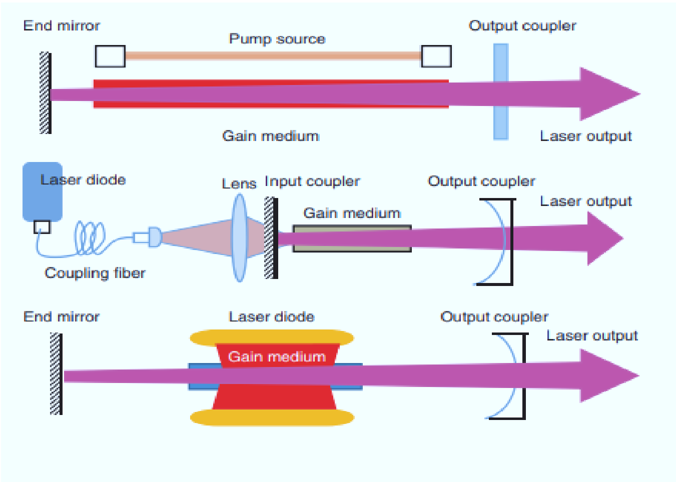

Figure 2: Schematic diagram of a typical laser (top) flashlamp pumped, (middle) laser-diode end-pumped, and (bottom) laser-diode side-pumped configurations, showing the three major parts: (1) laser gain medium, (2) pump source, and (3) optical resonator

A laser requires three major parts: (1) gain medium (e.g., gas, solid, liquid dye or semiconductor); (2) pump source (e.g., an electric discharge, flashlamp, or laser diode); and (3) the feedback system, e.g., optical resonator.[Figure 2] For instance, in the case of the first invented laser, the gain medium was ruby, and the population inversion was produced by intense broadband illumination from a xenon flashlamp. However, in the case of diode-pumped lasers, the population inversion is produced by laser diode that benefits from higher total conversion efficiency. Laser wavelength emission is determined by the gain medium and the characteristics of the optical resonator [11–16]. It is noticeable that some high-gain lasers do not use an optical oscillator and work based on amplified spontaneous emission (ASE) without needing feedback of the light back into the gain medium. Such lasers emit light with low coherence but high bandwidth.

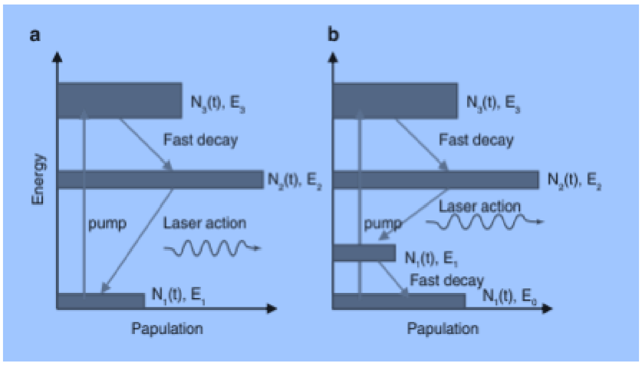

Figure 3: Schematic diagram of three-level laser (a) and four-level laser (b)

Mechanism of action of Laser

For optical frequencies, population inversion cannot be achieved in a two-level system. In 1956, Bloembergen proposed a mechanism in which atoms are pumped into an excited state by an external source of energy. A lasing medium consists of at least three energy levels: a ground state E1, an intermediate (metastable) state; E2, with a relatively long lifetime, ts, and a high energy pump state; and E3 [Figure 3]. To obtain population inversion, ts must be greater than t3, the lifetime of the pump state E3 that a characteristic of the three-level laser material is that the laser transition takes place between the excited laser level E2 and the final ground state E1, the lowest energy level of the system. The three-level system has low efficiency. The four-level system avoids this disadvantage.

The term laser is an abbreviation for —Light Amplification by Stimulated Emission of Radiation. Chain reaction of atoms produces laser light and a laser medium is used consisting of argon, ruby, CO2, and various other elements. Within the laser medium, there is a source of energy (electrical, another light source or chemical) which excites atoms. A laser tube or resonant cavity contains the energy source and medium. When the energy source excites or charges the medium, the atoms in their ground state are put into an excited state. Energized atoms return to the ground state after interacting with each other and photons are emitted which are of identical wavelength. Photon emission is stimulated when photons interact with other atoms in excited states. The laser light delivery to the tissues is by a contact or non-contact mechanism, after the laser light is delivered through fibre optic cable, waveguide and articulating arm system.[17]

Four reactions can happen when there is interaction of laser light with tissues: 1. Reflection off the tissue 2. Scattering to the surrounding tissues 3. Transmission through tissues 4. Absorption by the tissue chromophores. [**Figure 4**]

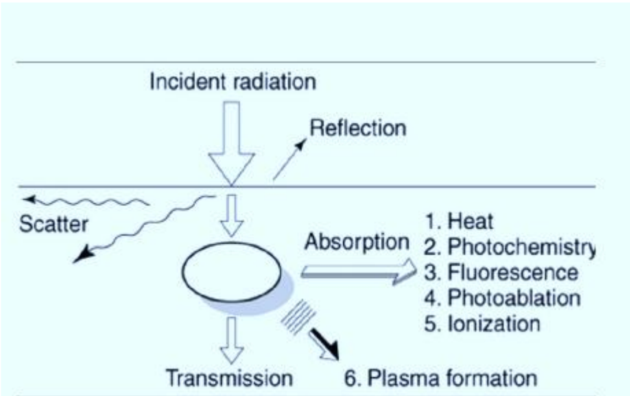

Figure 4 : Laser/Tissue Interactions

Laser-Tissue Interactions

1.. Photo-thermal interaction - This occurs with high powered lasers. The radiant energy absorbed by tissue substances are transformed into heat energy, which produce the tissue effect.[18] [Table1]

TEMPERATURE	**EFFECT ON TISSUE**
37°C - 50°C	hyperthermia
60°C	tissue whitens or blanches. Proteins begin to denature without vaporization of the underlying tissue. This phenomenon is useful in surgically removing diseased granulomatous tissue
70°C	Haemostasis by contraction of the walls of the vessel and is used for coagulation
70°C - 80°C	Soft tissue edges can be welded together with uniform heating.
100°C - 150°C	Vaporization , Ablation and spallation.
>200°C	Carbonization occurs with risk of soft tissue damage.

Table 1 : Photo-thermal interaction

2. Photo-chemical interaction - The basic principle of photochemical process is that specific wavelengths of laser light are absorbed by naturally occurring chromophores, which are able to induce certain biochemical reactions.

3. Photo-mechanical interaction - This includes photo-disruption or photo-dissociation and photo-acoustic interactions. In photo-acoustic effects, the pulse of laser energy on the dental tissues can produce a shock wave. When this shock wave explodes the tissue, it creates an abraded crater.

4. Photo-electrical interaction– This includes photo-plasmolysis, which describes how the tissue is removed through formation of electrically charged ion.[19] [**Figure 5**]

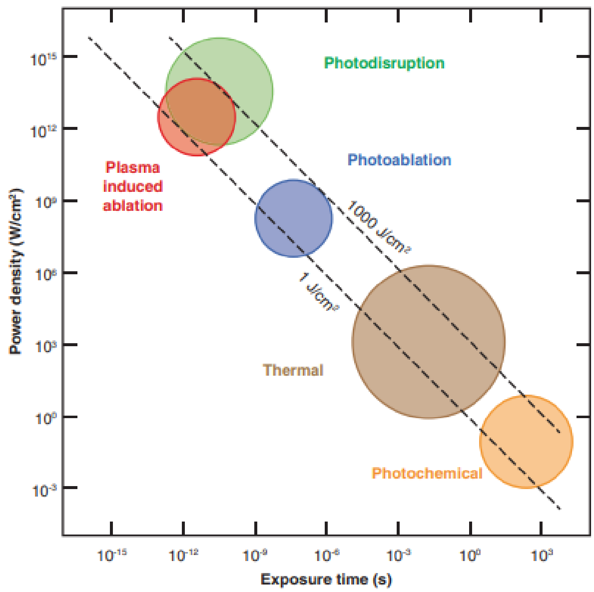

Figure 5 : Laser–tissue interaction map. Colored circles are rough estimation of the associated laser parameters

Classification Of LASER

BASED ON TYPE OF TISSUE

1) SOFT LASERS:

Helium-Neon

Gallium-arsenide

2) HARD LASERS:

Argon lasers

Carbon dioxide lasers

Nd: YAG lasers

HO: YAG lasers .[20]

BASED ON GAIN MEDIUM:

a) Gas Medium

o Helium Neon

o Argon

o Carbon dioxide

b) Solid Medium

o Neodymium YAG (Nd: YAG)

o Semiconductor

o Ruby

o Er: YAG

c) Liquid Medium

o Dye lasers

d) Molecular Medium

o Excimer (example: ArF, Krcl)

e) Free Electron Lasers [21]

II. BASIS OF OUTPUT ENERGY

a)Low output, soft or therapeutic eg. Low-output diodes

b)High output, hard, or surgical eg.CO2,Nd:YAG,Er:YAG

BASIS OF OSCILLATION MODE

a)Continous wave eg. CO2, Diodes

b)Pulsed wave eg.Nd: YAG, Er: YAG

Initial use of Lasers in Oral and Maxillofacial Surgeries

The development of CO2 laser and its properties of tissue ablation enhanced the interest in the laser application in the field of surgery. It was noticed that the use of lasers minimised the haemorrhage and provided a bloodless surgical field, the dLase 300 Nd: YAG laser which was designed for use in dentistry specifically, was introduced on May 3, 1990 in the United States by Dr. Terry D. Myers and Dr. William D. Myers. Strong et al. used CO2 lasers for excision of premalignant lesions and malignant lesions surgically and it was the first reported laser use specific to Oral and Maxillofacial surgery among other surgeries. For the treatment of various vascular lesions in the maxillofacial region, Apfelberg used Argon laser in 1987.Since then, the lasers were generally accepted for performing routine procedures in oral and maxillofacial surgery.[5]

Clinical and Technical applications

Incisional procedures require a precise thin cut with careful control of the depth of the cut. The thickness or thinness of the cut with a laser is controlled by the spot size (usually 0.1–0.4 mm). The laser beam's focal length is usually between 1 mm and 1 cm, depending on the delivery system, and is where the smallest spot size can be achieved with maximum power density. This is called "focused mode" (Fig. 6). The laser can be controlled by a foot pedal, but it is often useful to limit time on tissue to speeds faster than a foot control allows. Hence, a "gated/pulsed mode" can be used to generate 2–20 pulses per second to create or mark a dotted outline with lesser depth and allow careful delineation of the margins of the excision. This is then followed by a continuous mode (using the foot pedal) to "connect the dots" and complete the excision. The settings to obtain a desired depth of cut vary from one tissue to another due their different water content and absorption coupled with the surgeon-controlled factors as mentioned earlier. It is not possible to have standard laser parameters for all types of tissues or lesions. The smallest spot size possible with 4–10 W power can be a good initial setting. The initial cut then gives the surgeon ability to observe the clinical effect and depth of incision, which then can be used to lead to adjustments of the power and time on target to achieve the desired changes. Common soft-tissue lesions that can be incised or excised using lasers include fibromas, mucoceles, epulis fissuratum, mucosal or gingival lesions, papillomas, etc. Wound closure after a laser-assisted incisional biopsy or excisional procedure is often unnecessary due to the limited scarring and excellent hemostasis and is up to the surgeon's discretion, as healing is excellent regardless of closure. Closure does not usually effect hemostasis or pain relief.

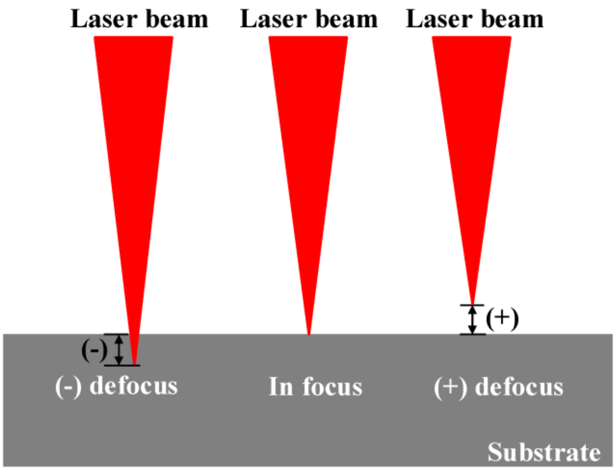

Figure 6 : Focused vs. defocused beam

Removal of oral mucosa lesions

A clinical study described the application of the potassium-titanyl-phosphate (KTP) laser (532 nm), used with low power parameter (1 Watt – CW) to evaluate the intra and postoperative pain. They proposed that KTP laser with low parameters permits to perform oral surgery with good pain control and good wound healing (Fornaini).

Oral leukoplakia

Oral leukoplakia is a pre-malignant lesion of the oral mucosa [22].

A randomized clinical trial compared the pain and swelling after removal of oral leukoplakia with CO_2 laser and cold knife. They concluded that CO_2 laser caused only minimal pain and swelling, thus suggesting that it may be an alternative method to conventional surgery in treating patients with oral leukoplakia.

A nonrandomized, single-arm, single-site phase 1/2 pilot study determined the safety and efficacy of photodynamic therapy in the treatment of oral leukoplakia with 5-aminolevulinic acid and pulsed dye laser. Photodynamic therapy with 5-aminolevulinic acid and pulsed dye laser could be used to achieve regression of oral leukoplakia. The treatment is safe and well tolerated. An application time of 1.5 hours and laser radiant exposure of 8 J/cm with 1.5-ms pulse time were found to be the optimal settings in this study. The high-power laser used in this study allows completion of laser therapy within 1 to 3 minutes. Further studies are necessary to determine the optimal laser radiant exposure and drug application to maximize the response rate [23].

The curative effects of photodynamic therapy (PDT) and cryotherapy in the treatment of oral leukoplakia were compared. They found that the advantages of PDT are connected to the minimally invasive and localized characters of the treatment with no damage to collagenous tissue structures; therefore normal cells will repopulate these arrangements. PDT is more convenient for patients, less painful, and more esthetic [22].

A prospective study evaluated clinical healing of a leukoplakia lesion after laser surgery, which was associated with a normal functional status of the new epithelium, also pathological alterations were related to the risk of local recurrence. They concluded that clinical healing of leukoplakia treated by laser surgery may be accompanied by altered cell turnover in 20% of the cases. Ki67, as a marker of proliferative status, may be a prognostic indicator in the mucosa replacing the lesion [24].

Yang et al. evaluated the associated factors of recurrence in patients who received laser surgery for dysplastic oral leukoplakia. This study suggested that continuous smoking after surgical treatment and widespread multiple-focus lesions are the prognostic indicators for recurrence after laser surgery. Changes in oral habits could be of great importance to the outcome of laser surgery of dysplastic oral leukoplakia [25].

Lichen planus

Oral lichen planus (OLP) is a common chronic disease of uncertain aetiology. Treatment of patients with symptomatic OLP represents a therapeutic challenge. One study evaluated the efficacy of diode laser (940 nm) and concluded its an effective alternative treatment for relieving the symptoms of OLP [26]

Low-level laser and CO_2 laser were compared in the treatment of patients with oral lichen planus. They showed that low-level laser displayed better results than CO_2 laser therapy as an alternative or additional therapy [21].

A clinical report demonstrated the efficiency of Er:YAG laser in reducing symptoms and lymphoplasmocytic infiltrate in case of OLP. The parameters used were: energy, 80-120 mJ; frequency, 6-15 Hz; non-contact hand piece; spot size diameter, 0.9 mm; pulse duration, 100 μsec (very short pulse) to 300 μsec (short pulse) ; fluences, 12.6-18.9 J/cm2; and air/water spray (ratio: 6/5). The significant advantages including, a good and fast healing process, a very low level of discomfort during and after intervention, and a rapid disappearance of symptoms [27].

A case report presented a histologically diagnosed oral lichen planus excised by CO_2 laser. The patient was followed up over 1 year with no signs of lesion recurrence. The use of the CO2 laser was found to be useful and effective to treat lichen planus [28].

Gingival melanin pigmentation(GMP)

A clinical and histologic study compared surgical stripping; erbium-doped:yttrium, aluminum, and garnet laser; and carbon dioxide laser techniques for gingival depigmentation which concluded that clinical repigmentation after gingival depigmentation is an outcome of histologic changes in the melanocyte activity and density of the melanin pigments. Surgical stripping for gingival depigmentation remains the gold standard; however, Er:YAG laser and CO2 lasers can be effectively used but with distinct differences [29].

Simsek et.al compared the use of diode and Er:YAG lasers in treating GMP in terms of gingival depigmentation, local anesthesia requirements, postoperative pain/discomfort, depigmentation effectiveness, and total treatment duration and the results demonstrated the total length of treatment was significantly shorter with the diode laser than with the Er:YAG laser. No melanin recurrence was detected during any follow-up session. They concluded Diode and Er:YAG lasers administered at 1 W both result in satisfactory depigmentation of GMP [30].

Fordyce granule excision

A case report on surgical lip Fordyce granule excision using a high-power diode laser in a 19-year-old male , and the excellent esthetic result demonstrated the effectiveness of both high- and low-intensity laser therapies on the excision of Fordyce granules [31].

Oral dysplasia

A prospective study evaluated recurrence, residual disease malignant transformation, and overall outcome in patients undergoing such procedure. Laser resection/ablation was recommended for oral dysplasia to prevent not only recurrence and malignant transformation but also postoperative oral dysfunction encountered by other conventional modalities [32].

Precancerous lesions

A prospective study evaluated the recurrence rates resulting from different methods of CO_2 laser vaporization. Their results indicated that for CO_2 laser treatment of premalignant lesions of the oral mucosa, the best results could be achieved with the defocused technique. It may be assumed that other methods with lesser penetration of thermal effects did not reach the deeper-lying cells and, consequently, render higher rates of recurrence [33].

Oral melanoma

A retrospective study surveyed the convenience of laser surgery as optimal treatment for melanoma of the oral mucosa. They recommend selective therapeutic resection of the neck only if it was found to be clinically positive. Elective dissection had not shown to have an impact in overall survival [34].

Oral benign lesions

Mucocele

Mucoceles are benign lesions of the minor salivary glands that are common in children. The most frequent localizations of these lesions include the lower lip and the cheek mucosa [33].

Boj et.al described the case of a 4-mm extravasation mucocele located on the lower lip with an erbium laser. Lasers apply modern technology and are useful for soft tissue surgery in pediatric dentistry, as operations are rapid and wounds heal well without sutures [34].

Oral mucocele resection with the scalpel versus the CO_2 laser was compared and it showed that oral mucocele ablation with the CO_2 laser offered more predictable results and fewer complications and recurrences than conventional resection with the scalpel [34].

Ranula

Ranulas are mucus extravasation phenomenon formed after trauma to the sublingual gland or mucus retention from the obstruction of the sublingual ducts [35].Lai et.al presented a case series report on the use of carbon dioxide laser treatment for ranula and indicated that carbon dioxide laser excision of ranula was safe with minimal or no recurrence [35].

Pyogenic granuloma

Pyogenic granuloma (PG) may develop in the oral cavity of pregnant women. Lindenmüller et al. described CO2 laser-assisted treatment of a giant pyogenic granuloma of the gingiva. Their results showed the initial wound healing was uneventful with no recurrence. [36].

Gingival hyperplastic lesions removal

Asnaashari et.al applied 810nm Diode laser to remove all of gingival hyperplastic lesions. Their results demonstrated that a perfect shaping was obtained after removal of the whole lesion in one session and no recurrence was observed in 6 months [37].

Epulis fissuratum

Epulis fissuratum is a pseudo tumor growth located over the soft tissues of the vestibular sulcus caused by chronic irritation from poorly adapted dentures. Treatment indication for these lesions is surgical excision with appropriate prosthetic reconstruction. One study proposed treatment of epulis fissuratum with carbon dioxide laser in a patient with antithrombotic medication. The lesions were excised with CO_2 laser, and no significant complications, such as hemorrhage, pain, swelling or infection, were recorded. They proposed that use of CO_2 lasers is currently the gold standard in the excision of this type of lesion, especially in patients with hemorrhagic diathesis or under antithrombotic therapy [38].

Treatment of epulis fissuratum with CO_2 laser and prosthetic rehabilitation of three patients with vesiculobullous diseases (VBDs) was presened with Işeri et al. The excision of fibrous tissue was performed with CO_2 laser, and the wounds formed by laser were left open to secondary epithelization. They demonstrated that the CO_2 laser might be a useful instrument in the treatment of soft tissue pathologies in VBDs patients due to minimal damage to surrounding tissue. Use of complete or partial dentures had been considered a practical, economic, and nonsurgical treatment option for patients who have been diagnosed with VBDs [39].

Lymphangioma

Lymphangiomas are hemorrhagic, rare, benign hamartomatous tumors of lymphatic system which have a marked predilection for the head, neck and oral cavity. Lymphangiomas are congenital lesions and an often present at or around the time of birth (60%).

In A case report, treatment of lymphangioma (a red-purple vesicular appearance, nonulcerated lesion, located on the gingiva of the mandibular alveolar bone) with CO_2 laser was described. CO_2 laser application (focused CO_2 laser beam, 10.600 nm) was performed in a separate operation room at 3 watt (W), continuous wave (CW) with 90 degree angle tip under local anesthesia. They concluded that CO_2 laser therapy can be used as a primary alternative method in the treatment of lymphangiomas. It can be safely used and recurrence may be less than conventional excision with scalpel. However, long-term clinical follow-up is necessary for the recurrence of the lesion [40].

Hemangioma

Genovese et al. reviewed the use of surgical lasers in hemangioma treatment. They described that the use of GaAs high-potency diode laser in the treatment of hemangioma reduced bleeding during surgery, with a consequent reduction in operating time, and promoted rapid postoperative hemostasis. It was safe for use on large lesions and easy to manage, and postoperative problems, including potential scarring, and discomfort are minimal [41].

Cancer of Oral cavity

A retrospective study assessed the efficacy of Nd:YAG laser for stage I squamous cell carcinoma of the lip. Their results reported the use of Nd:YAG laser for treatment of Stage I squamous cell carcinoma of lip in accordance with principles of minimal invasive and morbid surgery [42].

A retrospective study analyzed two hundred thirty-two patients with cancer of the oral cavity were treated by enoral laser microsurgery ± selective neck dissection ± postoperative (chemo) radiotherapy. They concluded that enoral laser microsurgery is an efficient therapeutic option in the treatment of oral cavity cancer. Oncological and functional results are comparable to any other treatment regimen, whereas morbidity and complications tend to be lower .[43]

A retrospective analysis evaluated 296 cases of early glottic squamous cancer with and without the involvement of anterior commissure (AC) treated by trans-oral CO_2 laser microsurgery. Trans-oral laser surgery is an excellent treatment option in patients with early glottic cancer irrespective of whether or not the AC is involved. Trans-oral laser microsurgery for early glottic cancer involving AC requires adequate exposure, proper assessment, good experience, and advanced surgical skills. [44]

An experimental analysis evaluated tungsten carbide-bur, piezoelectric and laser osteotomies. They concluded that currently, purchase and management elevated costs, minor versatility of use, and long training times for equipment such as Piezosurgery and laser limit their general use, but remain advantageous in case of risky interventions near noble structures. Choice of device depended on experience maturated by operator in time, characteristics of operation and patient's clinical conditions.[45]

An experimental study compared thermal changes of the bone surface, procedure time, and volume of the removed bone after drilling with an erbium: yttrium aluminum garnet (Er:YAG) laser (pulse energy, 1,000 mJ; pulse duration, 300 μs; frequency, 20 Hz) versus a low-speed surgical drill. They concluded that the Er:YAG laser produced preparations with regular and sharp edges, without bone fragments and debris, in a shorter time, and with less generated heat. Thermal alterations in the treated surface were minimal.[46]

Luna-Ortiz et al. reported that transoral laser microsurgery was recommended for treatment of soft palate tumors. This treatment could be considered a better option when compared with other modalities such as radio- or chemoradiotherapy which required a longer time of treatment, were more expensive and tend to produce significant toxicity.[47]

Photodynamic therapy (up to three rounds) is a comparable modality to other traditional interventions in the management of low-risk tumors of the oral cavity. Although, sometimes, multiple rounds of the treatment are required, morbidity following PDT is far less when compared to the three conventional modalities: surgery, radiotherapy, and chemotherapy.[48]

A clinical case evaluated the healing of the site after removal of the lesion with use of the laser diode. The laser diodes gave a significant contribution to improving the surgical treatment of tumors of the oral cavity, in fact during the surgery reduce bleeding and surgical time, and while in the process of healing by reduce swelling and post-operative pain and better results appearance without scarring.[49]

Excisional biopsy

A prospective randomized controlled clinical trial evaluated and compared clinical and histopathologic findings of excisional biopsies performed with CO_2 laser (10.6 μm) modes in 60 patients with similar fibrous hyperplasias of the buccal plane.The 2 CO_2 laser modes were appropriate for the excision of intraoral mucosal lesions. A safety border of at least 1 mm was recommended regardless of the laser mode used.[50]

A prospective animal study compared operative time and hemostasis of fiber-enabled CO_2 laser (FECL) energy to that of the electrocautery (EC) technique for oral tongue resection. They determined both EC and FECL are effective for resection of the tongue in rats. FECL has the advantages of less intraoperative bleeding, faster return to baseline body weight, and lower mucosal wound-healing scale score by postoperative day 7[51]

One study compared the conventional surgery with carbon dioxide (CO_2) laser applied on oral soft tissue pathologies and evaluated the effect of collateral thermal damage on histopathological diagnosis and reported that CO_2 laser is an effective instrument for soft tissue excisional biopsies with minimal intraoperative and postoperative complications and good pain control.[52]

Treatment of Oral Cavity Venous Malformations

Mucosal involvement of venous malformations can cause bleeding, pain, and functional impairment. Treatment options include surgery, sclerotherapy, or laser therapy. A retrospective study surveyed 4 patients (5 subsites) with oral cavity venous malformations treated with the Nd:YAG laser using an underwater technique. Their study demonstrated that the Nd:YAG laser can be a feasible option in the treatment of venous malformations of the oral cavity.[53]

One study reported two treatment strategies using intralesional laser photocoagulation (ILP) for large venous malformations (VMs) in the oral cavity. Treatments included a combination of ILP and transmucosal irradiation; compartmentalization and serial step irradiation. They demonstrated both treatment strategies improved the safety, reliability, and effectiveness of ILP and made the method less traumatic for patients. [54]

Miyazaki et al. described an ultrasound-guided intralesional photocoagulation (ILP) technique using a laser for treatment of deep venous malformations in the oral cavity. ILP is basically a blind operation and has a risk of unintended destruction of surrounding normal tissue; therefore the authors now routinely use guidance by ultrasonography using a mini-probe to improve the safety and reliability of ILP. The authors conclude that ultrasound-guided ILP with a laser is a promising technique for less-invasive treatment of a vascular malformation in the oral cavity. [55]

Álvarez-Camino determined the efficacy of the diode laser in the intralesional treatment of the orofacial venous malformations (OFVM). The advantages associated to the use of non-invasive techniques in the treatment of OFVM, along with the success rate and low number of relapses, showed the use of the diode laser as a therapy to be considered in the treatment of these lesions . [56]

A retrospective study evaluated the safety and efficacy of CO_2 laser resurfacing in the symptomatic treatment of intraoral lymphatic malformations (LM). They proposed CO_2 that laser resurfacing appeared to be both safe and efficacious in treatment of symptoms related to intraoral LM. Intermittent treatments for recurrent symptoms were expected . [57]

Bisphosphonate-associated osteonecrosis of the jaws

Bisphosphonates (BSPs) are used for the treatment of multiple myeloma, metastatic breast and lung cancer, Paget's disease, osteoporosis, hypercalcemia due to malignancy, and many other skeletal diseases. BSPs reduce osteoclastic functions, which result in bone resorption. Bisphosphonates-related osteonecrosis of jaws (BRONJ) is a newly developed term that is used to describe the significant complication in patients receiving bisphosphonates. BSPs are known to exhibit an anti-angiogenetic effect that initiates tissue necrosis of the hard tissue. There is currently no consensus on the correct approach to this issue[58].

A retrospective study compared the effects of laser surgery with biostimulation to conventional surgery in the treatment of BSP-induced avascular bone necrosis. They reported that there were no statistically significant differences between laser surgery and conventional surgery. Treatment outcomes were significantly better in patients with stage II osteonecrosis than in patients with stage I osteonecrosis. Their findings suggested that dental evaluation of the patients prior to medication was an important factor in the prevention of BRONJ. Laser surgery was a beneficial alternative in the treatment of patients with this situation. [59]

A clinical protocol supported by Nd:YAG low-level laser therapy proposed for extractions in patients under bisphosphonates therapy. Their experience supported the hypothesis that the association of antibiotic treatment and low level laser therapy (LLLT) through Nd:YAG laser (1064 nm--power 1.25 W; frequency 15 Hz; fibre diameter: 320 μm) could be effective in preventing BRONJ after tooth extractions in patients under bisphosphonates therapy [59].

Surgical treatment with Er,CrYSGG-laser was : reported in 5 cases of Bisphosphonate-associated osteonecrosis ofthe jaws. ErCrYSGG laser was successfully applied in surgical treatment of BRONJ. Stable mucosal coverage could be achieved in all of 5 cases. They proposed laser surgery could be considered as a promising technique for the effective treatment of BRONJ . [60]

Kan et.al presented the successful management of two dental patients who had high potentials for BRONJ development as a result of chemo and radiotherapy combined with IV zoledronic acid application. They proposed LLLT application combined with atraumatic surgical interventions under antibiotics prophylaxis is a preferable approach in patients with a risk of BRONJ development. Adjunctive effect of LLLT in addition to careful infection control on preventing BRONJ was reported and concluded. [61]

A prospective study investigated the clinical efficacy of low-level laser therapy (LLLT) for the management of bisphosphonate-induced osteonecrosis of the jaws

(ONJ-BP).This study suggested that LLLT would appear to be a promising modality of treatment for patients with ONJ-BP, providing that clinical efficacy is safe and well tolerated, especially by those patients who require conservative treatment. Of course, this needs to be addressed further in larger and randomly controlled studies in different clinical settings. [62]

Vescovi et al. proposed Surgical approach with Er:YAG laser on osteonecrosis of the jaws (ONJ) in patients under bisphosphonate therapy (BPT). They concluded that it was possible to observe that an early conservative surgical approach with Er:YAG laser associated with LLLT, for BP-induced ONJ could be considered as more efficient in comparison with medical therapy or other conventional techniques. [63]

Complications following the removal of mandibular third molars

A prospective, randomized, and double-blind study evaluated the analgesic and anti-inflammatory effects of a low-level laser therapy applied to the wound appeared after the surgical removal of impacted lower third molars. They determined that swelling and trismus at the 2nd and 7th postoperative days were slightly higher in the control side, although not statistically significant differences were detected. The application of a low-level laser with the parameters used in this study did not show beneficial effects in reducing pain, swelling, and trismus after removal of impacted lower third molars . [64]

Amarillas-Escobar evaluated the effectiveness of a therapeutic laser in the control of postoperative pain, swelling, and trismus associated with the surgical removal of impacted third molars. They concluded the use of therapeutic laser in the postoperative management of patients having surgical removal of impacted third molars, using the protocol of the study, decreases postoperative pain, swelling, and trismus, without statistically significant differences .[65]

Aras and Güngörmüş compared the effects of extraoral and intraoral low-level laser therapies (LLLT) on postoperative trismus and oedema following the removal of mandibular third molars. This study demonstrated that extraoral LLLT is more effective than intraoral LLLT for the reduction of postoperative trismus and swelling after extraction of the lower third molar. [66]

Endodontic surgery

An in vitro study evaluated the generated temperature of the Er:YAG laser, with three different pulse durations (pulse duration 50 μs, pulse duration 100 μs, and pulse duration 300 μs) for apicectomy, compared with tungsten bur and surgical saw. Their results showed that laser irradiation with pulse duration 50 μs appears to have the lowest temperature rise and the shortest time required for apicectomy of the three pulse durations. However, Er:YAG laser for apicectomy in all pulse durations could be used safely for resection in endodontics in the presence of sufficient water.[67]

Angiero et al. evaluated the efficacy of erbium lasers for retrograde endodontic treatment, in terms of clinical outcome and therapeutic success. The lasers used in the study were the erbium:yttrium-aluminum-garnet (Er:YAG) laser, wavelength 2940 nm, and the erbium,chromium-doped:yttrium-scandium-gallium-garnet (Er,Cr:YSGG) laser, wavelength 2780 nm. Laser-assisted surgery increases the range of therapeutic approaches in the sphere of retrograde endodontic treatment. The results of this study showed that the erbium laser, used for apicoectomy, results in a high success rate with considerable benefit in terms of clinical outcome and therapeutic success. [68]

Frenectomy

Labial frenulums are sagittal fibrous folds of oral mucosa with a periosteal insertion that extend from the lips to the alveolar or gingival mucosa. Occasionally, they assume inadequate size or location and may lead to functional and esthetic limitations. A comparative study evaluated labial frenectomy with Nd:YAG laser and conventional surgery. Their results showed that Nd:YAG laser frenectomies reduced transoperative bleeding, avoiding the need of suturing, and promoted a significant reduction of surgical time in comparison with conventional surgery. [69]

A case series reported the use of ND:YAG laser for a labial frenulectomy. Twenty-three patients were treated and afterward controlled. Laser treatment, above all ND:YAG, appeared to be the gold standard technique. [70]

The upper lip frenulum reinsertion, bleeding, surgical time and surgical wound healing in frenectomies performed with the CO_2 laser versus the Er, Cr:YSGG laser were compared. The upper lip laser frenectomy was a simple technique that resulted in minimum or no postoperative swelling or pain, and which involved upper lip frenulum reinsertion at the mucogingival junction. The CO_2 laser offered a bloodless field and shorter surgical times compared with the Er,Cr:YSGG laser. On the other hand, the Er,Cr:YSGG laser achieved faster wound healing. [71]

Fiberotomy

The effects of circumferential supracrestal fiberotomy in vivo (using diode, CO_2, and Er:YAG lasers) on the morphology and chemical composition of the root surface were evaluated. SEM analysis indicated that no thermal changes, including melting or carbonization, were observed following the lasing procedures. They concluded that laser-aided procedures, when used at appropriate laser settings, preserved the original morphology and chemical composition of cementum. [72]

Kim et al. investigated the effectiveness and periodontal side effects of laser circumferential supracrestal fiberotomy (CSF) and low-level laser therapy (LLLT) on orthodontically rotated teeth in beagles. They demonstrated that laser CSF was an effective procedure to decrease relapse after tooth rotation, causing no apparent damage to the supporting periodontal structures, whereas LLLT on orthodontically rotated teeth without retainers appeared to increase the relapse tendency. [73]

Ankyloglossia

One study compared the tolerance of lingual frenectomy with regard to a local anesthesia requirement and comparison of postsurgical discomfort experienced by patients operated on with both diode and erbium:yttrium-aluminium-garnet (Er:YAG) lasers. Their results indicated that the Er:YAG laser is more advantageous than the diode laser in minor soft-tissue surgery because it can be performed without local anesthesia and with only topical anesthesia. [74]

Photonic Therapies for Orofacial Rehabilitation and Harmonization

Considering the use of laser and LED light, it is possible to work from real-time optical diagnosis, with violet LEDs, performing dental lightening, with photodynamic therapy and photoactivation, laser surgery for ultra-conservative plastics and removal of carious tissue. But without doubt, the most frequently explored area that has a much broader field of action has been photobiomodulation and its combination with other therapies, such as chemical and mechanical treatments, bothfor the integumentary system and for the orofacial neuromuscular system. In this way, we will review the indications of the most commonly used spectral bands and their associations with kinesiotherapies (photokinesiotherapy) and with chemical–physical treatments (photopeelings). The intention of these therapies is to minimize the effects of aging using all the knowledge of anatomy, reconstituting the joviality without giving a plasticized, artificial aspect, with rhytidoplasty considered the gold standard. Face squaring most often starts from the age of 30, and, depending on genetic standards and the neutralizing ability of each person's free radicals, wrinkles may or may not arise early. Prophylaxis for patients with high muscular strength and very expressive people prevents the early appearance of static wrinkles. For this purpose, it is possible to use photobiomodulation with light-emitting red (600–700 nm) and low total energy per application point (1 J) or infrared laser with high total energy per application point (around 5 J), associating with the functional elastic bandages (Phototaping) or even using botulinum toxin. Orofacial rehabilitation/harmonization is, at the moment, a field of dentistry rather than a specialization. It brings together various very specific areas that intersect with each other and that seek the same goal of managing senescence and preventing the senility of the stomatognathic system.

A. Skin Rejuvenation

1. Ablative Laser Therapy

Aging skin is characterized by excess rhytides and laxity. Over the past 10 years, a mainstay of skin rejuvenation has been laser resurfacing. Laser skin resurfacing was first described in 1985, following carbon dioxide (CO2) laser treatment of actinic cheilitis that unintentionally resulted in dramatic cosmetic improvement of the treated lip [75] . Laser skin resurfacing is ablative and relies on the selective photothermal destruction of specific layers of the epidermis and dermis combined with a limited or controlled depth of residual thermal injury. The interaction achieves thermal confinement, resulting in laser pulse durations that are shorter than absorbed photothermal energy dissipation time, an effect that promotes highly localized heating[76]. Heat induces dermal remodeling with new collagen synthesis and collagen contraction[77]. Ablative laser therapy has largely replaced the widespread use of chemical peels, which depend heavily on individual skin diffusion properties that are widely divergent among different facial regions and different people. In contrast, laser resurfacing produces fairly homogeneous and repeatable results. Laser skin resurfacing works best for patients with fair skin, while the results for patients with darker skin are less predictable and prone to pigmentary changes.[78]

Presently, both CO2 and Erbium:YAG lasers are used for skin resurfacing. For most pulse durations, the CO2 laser creates a zone of thermal injury up to 200 μm in depth, leading to prolonged erythema and slower recovery times. In contrast, the use of an Erbium:YAG laser (pulse length, approximately 250 microseconds) has advantages such as relatively quick recovery times ,much less erythema, higher light absorbance and the production of less thermal injury with each pass (approximately 50 μm)[79]. However, slightly decreased clinical efficacy is also associated with the Erbium:YAG laser. Resurfacing has also been performed using combinations of laser devices (eg Erbium:YAG and CO2 lasers), laser and botulinum toxin injections, laser and traditional facial plastic surgery procedures and laser and metallic-based skin care products .[80]

2. Non-ablative Laser Therapy

While ablative laser skin resurfacing is in many ways safer and more predictable than the chemical peels that it has supplanted, its consequent epidermal and dermal destruction leads to prolonged recovery times and the potential for complications[81]. Non-ablative resurfacing aims to selectively heat dermal tissues, while sparing the epidermis from significant thermal injury thus reducing complications and recovery times.[82] This therapy relies on the selective heating of regions of tissue within the dermis, which is accomplished by using lower laser fluence rates or by protecting the epidermis using cryogen spray, contact, or air cooling. Diode lasers (532, 900 and 1450 nm), rare earth lasers such as Nd:YAG lasers and pulsed dye lasers (PDLs) have all been reported to improve skin appearance and textures[83].

Other Nonablative Technologies.

Radiofrequency (RF) devices are perhaps the most commonly used nonoptical nonablative technology for the treatment of rhytides and skin laxity. [83]Thermage (Thermage Inc, Hayward, California) is the archetype cosmetic RF procedure, achieving spatially selective heating through 2 simultaneous processes: the heating of tissue with RF energy and surface cooling with cryogen spray. The subdermal remodeling of collagen induced by the Thermage treatment contributes to improvements in skin laxity and texture[84], although complications have also been reported[85].

Radiofrequency has also been used in corrugator supercilii motor nerve ablation for the elimination of glabellar furrowing,a condition that is commonly treated by surgery or by botulinum toxin. Other nonablative resurfacing technologies that have been studied include high-frequency focused ultrasound, which has been used to specifically target and tighten the superficial musculoaponeurotic system in the faceor subcutaneous fat, and intense pulsed light, which will be discussed below. Recently, plasma skin regeneration devices have been introduced to achieve resurfacing by selectively heating the dermal layer with plasma energy.These devices, exemplified by the Portrait system (Rhytec Inc, Waltham, Massachusetts), represent the newest generation of nonoptical nonablative resurfacing technologies.[86]

Intense Pulsed Light.

Intense pulsed light therapies use full-spectrum, broadband light that is emitted from its flash lamp source, producing infrared wavelengths that can penetrate deeply within the skin and heat subsurface tissues. Its main advantage over lasers is its ultralow cost and short downtime, while having a moderate effect on improving the skin, possibly by the same dermal remodeling mechanism that attributes to the success of laser skin resurfacing.In contrast, other studies have negated the efficacy of intense pulsed light, observing minimal morphological changes in dermal collagen and no significant elimination of rhytides[86].

Epidermal Cooling.

Epidermal cooling was the most important advance in laser skin surgery during the past 10 years. Until cooling mechanisms were introduced, most optical devices generated heat at the surface unless specific chromophores such as tattoo ink or hemoglobin (eg, port-wine stain) were targeted. Surface cooling, in combination with laser heating, solved this problem by facilitating the creation of subsurface temperature elevations, while maintaining the surface at appropriate temperature levels (eg, near ambient). For rejuvenation, selective heating of the dermis and subdermal collagen was achieved.

The most effective cooling mechanism is cryogen spray cooling. Cryogen cooling is used both in nonablative resurfacing and in the treatment of pigmented lesions, where epidermal protection allows the use of greater laser fluences. In treating vascular lesions, Nelson et al[147-154] pioneered the successful use of cryogen cooling and PDL for treatment of port-wine stains and hemangiomas,and this technology has consequently been used in aesthetic applications.Cryogen spray cooling has also been used as an adjunct to laser hair removal to allow delivery of greater fluences to deeper depth. Other popular cooling mediums that have been used with varying efficacy in conjunction with nonablative laser therapy include the sapphire contact cooling device[87],based on direct conductive cooling, and cold-air cooling,which relies on convective cooling and could mitigate complications associated with ablative laser therapy.

Fractional Ablation

Fractional ablation, which is the most recent development in laser skin resurfacing, has existed conceptually for quite some time, though not implemented in practice. The term fractional photothermolysis was first coined by Manstein et al in 2004. In fractional ablation, laser spots are small (approximately 100 μm) and are separated from one another by a considerable distance. Small regions of tissue injury (and hence remodeling) exist as islands surrounded by normal skin where reepithelialization is rapid 23. The most popular fractional ablation devices operate at 1550 nm (Fraxel, Reliant Technologies, San Diego, California). Apart from being primarily used as a resurfacing tool, fractional photothermolysis has been used to treat pigmentation lesions, acne scars and surgical scars. Complications and adverse effects are short-term and usually limited to erythema, skin dryness, and facial edema. Fractional photothermolysis is generally associated with a relatively high patient satisfaction rate, as high as 75% according to Cohen et al [88]. The main challenge for skin resurfacing in the future will be to achieve a long-term natural looking substantial improvement in skin quality. Also, resurfacing and related technologies will strive toward achieving more dramatic results and postpone the need for traditional aging face procedures such as rhytidectomies and blepharoplasties.

Laser Safety

Safety in operation theatre is highly important during any procedure, special considerations have to be kept in mind while using lasers. Clear written descriptions of precautions of safety must be available in the working environment where a laser is used, as each laser has its own safety issues. This section discusses the necessity of executing safety precautions for surgical laser procedures.International standards are accessible by means of the International Electrotechnical Commission (IEC), documents 60601, 60825 and 60825-Part 8. These standards are the global criteria for safety of lasers and include informative and normative guidance for the manufacturers, professional clinicians and administrators of laser use facilities. For national standards of the country, they are used as the basis.[89]

Precautions and Risks Associated with Clinical use of Lasers[90,91]

Precautions before and during Irradiation

1. Use glasses for eye protection (patient, operator, and assistants). (FIG)
2. Prevent inadvertent irradiation (action in noncontact mode)
3. Protect the patient's eyes, throat, and oral tissues outside the target site.
4. Use wet gauze packs to avoid reflection from shiny metal surfaces.
5. Ensure adequate high speed evacuation to capture the laser plume
6. Speed of movement of the laser beam over the target tissue in order not to occur thermal damage - exposure of bone to heating at levels equal to or more than 47°C is reported to include cellular damage leading to osseous resorption. Temperature levels of equal to or more than 60°C result in tissue necrosis. Additionally,if soft tissue temperature increases above 200°C charring and carbonization occur.
7. The clinician's awareness of safety control measures and hazards and the recognition of existing standards of care are significant points for dental practitioners to avoid complications and failures.

Figure 7 :Precautions (**a**) Wavelength-specific eyewear for protection of operator, patient, and assistants. (**b**) "Danger" sign outside the operatory along with closure of any see-through glass panels on the door

Maximum permissible exposure[91]

Maximum permissible exposure (MPE) or exposure limit (EL) is the maximum threshold level at which one can avoid damage to the eye or skin. MPE depends on the target organ, type of laser, operation wavelength, source size, pulse duration, and repetition rate. MPE is not a constant value; it must be calculated by the laser safety officer for each laser, depending on its operational parameters.

Class 1: Lasers belonging to this class are safe both for direct exposure and for use with optical instruments. Output power of a Class 1 laser should be lower than 0.39 mW.

• Class 1M: Lasers operating in the wavelength range of 300–4000 nm are safe for direct exposure to the eye or skin. However, using optical components such as binoculars may be harmful to the eye.

• Class 1C: Lasers used for cosmetic applications related to the skin such as hair removal, acne treatment, and tattoo removal are recently established as a new class in IEC60825 version 07-2015. A clear objective is assigned for this class of lasers and they usually have a protection measure which ensures safety for the case of a user error.

• Class 2: Hazard depends on the exposure time of the eye to the particular lasers. For lasers operating in the visible range of light (400–700 nm), the aversion response (t = 0.25 s) guarantees the exposure time for bright light, meaning that visible.Class 2 lasers are safe for the naked for eye, even with the use of optical components. If staring into the laser beam intentionally, these lasers can be hazardous and cause flash blindness.Lasers in this class are not hazardous for the skin.

• Class 2M: This class is similar to Class 2 except that in the case of using eye loupes or binoculars, these lasers may harm the human eye.

• Class 3R: Lasers in the wavelength above 300 nm fall into this category. The risk level for accidental exposure of the eye is low with lasers belonging to this class. With exposure to the laser light, there is no risk for the skin. However, intentional staring at the light beam may cause eye injury. Trained personnel are required to operate this class of lasers.

• Class 3B: Even in the case of accidental exposure, the risk level for the eye and for the skin are medium and low, respectively. Direct viewing is hazardous, but viewing diffusive reflections is safe. For skin, if the beam is focused on a tiny spot, the feeling would be similar to a pinprick.

• Class 4: The most dangerous class of lasers poses a high risk of injury for both eye and skin. Even diffusive reflections can be hazardous. Interaction with the lasers causes temperature increases, which may result in a fire.

Advantages and drawbacks of Laser

Advantages [92]

• Hemostatic effect which provides a clear operating field.
• Reduces post-operative swelling and pain.
• Increased surgical procedure accuracy.
• Suture-less procedures.
• Enhance faster wound healing.

Drawbacks

• Scattered and reflected laser beams lead to a health hazard.
• Expensive procedure.
• Technique sensitive.

FUTURE OF LASER IN OMFS

The future of laser technology in craniofacial surgery is promising, as it continues to evolve and offer new possibilities for surgeons. Lasers have already made significant contributions to various aspects of craniofacial surgery, and ongoing advancements are likely to enhance their applications further. Here are some potential areas where lasers may play a role in the future of craniofacial surgery:

Soft tissue surgeries: Lasers have been widely used in soft tissue surgeries due to their precision and ability to selectively target specific tissues. In craniofacial surgery, lasers can be employed for procedures such as facial skin resurfacing, scar revision, and treatment of vascular malformations. Future developments may include more advanced laser systems that provide better tissue penetration, improved thermal control, and enhanced treatment outcomes.

Bone cutting and shaping: Lasers have shown promise in bone cutting and shaping procedures, offering advantages over traditional mechanical tools. Laser-assisted osteotomy can be used to precisely cut bone without damaging surrounding tissues, leading to reduced bleeding, faster healing, and improved surgical outcomes. As laser technology advances, more sophisticated systems may be developed for bone surgeries, enabling precise and controlled bone reshaping for craniofacial reconstruction.

Minimally invasive techniques: The trend in surgery is moving towards minimally invasive procedures that minimize trauma, scarring, and recovery time. Lasers can contribute to this by allowing surgeons to perform intricate procedures through small incisions or even endoscopically. For craniofacial surgery, lasers could be used in minimally invasive techniques for procedures like endoscopic brow lifts, endoscopic craniosynostosis surgeries, or laser-assisted orthognathic surgery.

Tissue regeneration and wound healing: Laser technology has shown potential in promoting tissue regeneration and wound healing. Low-level laser therapy (LLLT) can stimulate cellular activity, increase blood flow, and accelerate the healing process. In craniofacial surgery, lasers may be utilized for post-operative wound healing, bone graft integration, or promoting tissue regeneration in congenital craniofacial anomalies.

Imaging and diagnostics: Lasers can be used in various imaging and diagnostic techniques to enhance pre-operative planning and intraoperative guidance. Laser-based imaging systems, such as optical coherence tomography (OCT), can provide real-time high-resolution imaging of tissues, aiding in precise surgical navigation and ensuring optimal outcomes. Additionally, lasers can be used in spectroscopy or fluorescence-based techniques to identify and differentiate diseased or abnormal tissues from healthy ones.

It's important to note that the future of laser technology in craniofacial surgery will depend on continued research, development, and clinical trials. As the technology advances, it will be crucial to assess its safety, efficacy, and cost-effectiveness compared to existing techniques. Collaboration between surgeons, engineers, and researchers will play a vital role in shaping the future of lasers in craniofacial surgery.

III. CONCLUSION

The emergence of lasers with different wavelengths and their widespread application in oral lesion management may influence treatment outcomes in patients. In conclusion, the use of lasers in oral and maxillofacial surgery has revolutionized the field, offering numerous advantages over traditional surgical techniques. Throughout this dissertation, we have explored the various applications of lasers in different aspects of oral and maxillofacial surgery, including soft tissue procedures, hard tissue procedures, and adjunctive therapies.

One of the key benefits of lasers is their precision and ability to target specific tissues while minimizing damage to surrounding structures. This characteristic is particularly valuable in delicate oral and maxillofacial procedures, where preservation of healthy tissues is crucial. Laser technology allows for enhanced control during surgeries, resulting in reduced post-operative complications, faster healing times, and improved patient outcomes.

Furthermore, lasers offer significant advantages in terms of hemostasis and wound healing. By cauterizing blood vessels during surgery, lasers reduce bleeding and promote faster healing. This can lead to decreased post-operative pain and swelling, as well as reduced need for sutures or other traditional wound closure methods.

The versatility of lasers is also noteworthy. They can be used in a wide range of oral and maxillofacial procedures, including soft tissue surgeries such as gingivectomies, frenectomies, and mucocele removal, as well as hard tissue procedures such as osteotomies, implant placement, and bone regeneration. Additionally, lasers can be employed as adjunctive therapies, assisting in the treatment of conditions such as oral mucositis, temporomandibular joint disorders, and trigeminal neuralgia.

Although lasers offer numerous advantages, it is important to acknowledge certain limitations and considerations. These include the high cost of laser equipment, the need for proper training and expertise, and potential safety concerns associated with laser use. Additionally, not all oral and maxillofacial procedures can be effectively performed with lasers, and they should be used in conjunction with traditional techniques when appropriate.

In conclusion, lasers have emerged as powerful tools in the field of oral and maxillofacial surgery, providing enhanced precision, reduced post-operative complications, and improved patient outcomes. As technology continues to advance and research progresses, it is expected that the role of lasers in this field will continue to expand, offering even greater benefits and opportunities for innovation. However, ongoing research and education are necessary to ensure safe and effective integration of laser technology into oral and maxillofacial surgical practices.

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