Review Article

Application of Laser in Oral Surgery

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Abstract:

In this review collected from the literature on usage of laser in oral minor surgery based on a Medline search in the time period between the years: 2008 and 2013, the most current evidence on laser-assisted oral minor surgery is going to be surveyed.

Keywords: laser; oral surgery; review

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Introduction

Laser is a monochromatic, collimated, coherent, and intense beam of light produced by stimulated emission of radiation of a light source. Lasers are classified according to different factors among which is the classification based on laser active medium such as gas, liquid, solid and semi-conductor, which identifies and distinguishes the type of emitted laser beam[1].

Visible beams (i.e. the Argon laser at 488 or 518 nm) and invisible beams in the infrared range (i.e. CO_2 (Carbon Dioxide 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), Diode (Gallium Arsenide) (GaAa)) are used in dentistry. The properties of a specific laser beam, particularly wavelength and the optical characteristics of the particular target tissue determine the type and the extent of interaction which may occur[1]. Low level laser therapy (LLLT) which has therapeutic effects without inducing a lot of heat is established in clinical dentistry because of its anti-inflammatory, bio stimulant and regenerative effects[2]. Its use has been widely reported with satisfactory results in the literature[3].

The recently rapid developments in laser technology and better understanding of bio-interactions of different laser systems have broaden the clinical use of laser in dentistry[2].

Common lasers used in oral surgeries are CO_2, Er. Family, Diode and Nd:YAG. Also low level lasers are used in assisting the procedures of disinfection and healing.

CO_2 was the first laser introduced to dental practitioners in the mid-1980s, because of its outstanding cutting abilities and surprisingly, after more than 25 years, it still remains as a desirable choice in facial cosmetic surgeries (10,600 nm)[4].

The Erbium family lasers (Er:YAG 2940 nm and Er,Cr:YSGG 2790 nm) are the lasers mainly used in dentistry for cavity preparation (Paghdiwala 1988, Keller 1989). Their emission wavelengths are perfectly matched to the absorption maximum of water which is a component of oral tissue[5].

Nd:YAG laser, is currently cleared by the U.S. food and drug administration for certain periodontal procedures and some vascular lesions. Its deep extinction length and penetration depth in soft tissue create significant lateral tissue damage, desirable for vascular lesions, but not for other pathology[4].

Diode laser (810-1064 nm) has become very popular in general dentistry because of their small size, low cost, fiber optic delivery and ease of use for minor surgery of oral soft tissue. The use of low level Diode laser for noninvasive athermal laser therapy is popular in European countries[4].

The application of these aforementioned lasers in

surgery in the literature will be surveyed in this review article

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[6].

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[7].

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[6].

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[8].

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[9].

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) in the management of oral lichen planus. Their results demonstrated that diode laser therapy seemed to be an effective alternative treatment for relieving the symptoms of OLP[10] (Misra, 2013 #491).

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[11].

A clinical report demonstrated the efficiency of Er:YAG laser in reducing symptoms and lymphoplasmocytic infiltrate in case of oral lichen planus (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/cm^2; and air/water spray (ratio: 6/5). The use of this wavelength offers several advantages including, a good and fast healing process, a very low level of discomfort during and after intervention, and a rapid disappearance of symptoms[12].

A case report presented a histologically diagnosed oral lichen planus excised by CO_2 laser. CO_2 laser was used to remove the lesion and the conclusive histopathological diagnosis was oral lichen planus. The patient was followed up over 1 year with no signs of lesion recurrence. The use of the CO_2 laser was found to be useful and effective to treat lichen planus[13].

Gingival melanin pigmentation

A clinical and histologic study compared surgical

stripping; erbium-doped:yttrium, aluminum, and garnet laser; and carbon dioxide laser techniques for gingival depigmentation. They 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 CO_2 lasers can be effectively used but with distinct differences 14.

Simsek et.al compared the use of diode and Er:YAG lasers in treating gingival melanin pigmentation (GMP) in terms of gingival depigmentation, local anesthesia requirements, postoperative pain/discomfort, depigmentation effectiveness, and total treatment duration. Their 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[15].

Fordyce granule excision

A surgical lip Fordyce granule excision using a high-power diode laser in a 19-year-old male was reported. The excellent esthetic result demonstrated the effectiveness of both high- and low-intensity laser therapies on the excision of Fordyce granules[16].

Oral dysplasia

A prospective study evaluated recurrence, residual disease malignant transformation, and overall outcome in patients undergoing such procedure. They demonstrated that recurrence and malignant transformation was mainly identified in erythroplakias and non-homogenous leukoplakias. 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[17].

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[18].

Oral melanoma

A retrospective study surveyed the convenience of laser surgery as optimal treatment for melanoma of the oral mucosa. In their experiment, conservative management with CO_2 laser was adequate for melanomas of the oral mucosa with extraction of the dental organs and curettage of the alveoli to achieve complete surgical resection microscopically without sacrifice of the quality of life. Management of the neck was controversial. 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[19]. (See Table 1 for an evidence summary).

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[22].

Boj et.al described the case of a 4-mm extravasation mucocele located on the lower lip with an erbium laser. They showed the wound healed excellently and rapidly without sutures. No relapse was observed a year after the surgery. Lasers apply modern technology and are useful for soft tissue surgery in pediatric dentistry, as operations are rapid and wounds heal well without sutures[22].

Oral mucocele resection with the scalpel versus the CO_2 laser was compared. Their results 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[23].

Ranula

Ranulas are mucus extravasation phenomenon formed after trauma to the sublingual gland or mucus retention from the obstruction of the sublingual ducts[24].

Lai et.al presented a case series report on the use of carbon dioxide laser treatment for ranula and a literature review of cases treated using carbon dioxide laser. The authors' experience and reports in the literature indicated that carbon dioxide laser excision of ranula was safe with minimal or no recurrence[24].

Table 1. Evidence table summary of different laser used in Removal of oral mucosa lesions

Study type	Author	year	Sample size	Laser type	Laser parameters	Result
Randomized clinical trial	Lopez-jornet[20]	2013	48	CO_2 laser		The CO_2 laser causes only minimal pain and swelling
Randomized clinical trial	Simsek[15]	2012	20	-gallium aluminum arsenide diode laser -Er:YAG laser	- continuous wavelength of 808 nm, -continuous wavelength of 2,940 nm	Diode and Er:YAG lasers administered at 1 W both result in satisfactory depigmentation
Randomized clinical trial	Agha-Hosseini[11]	2012	57	low-level laser CO_2 laser		Both methods may be effective in the treatment of OLP
Clinical trial	Kawczyk[6]	2012	85	photodynamic therapy (δ-aminolevulinic acid (ALA)	630-635 nm wavelength	PDT is more convenient for patients, less painful, and more esthetic.
Prospective study	Montebugnoli[8]	2012	13	Nd:YAG laser		clinical healing of leukoplakia treated by laser surgery may be accompanied by altered cell turnover in 20% of the cases
Prospective study	Jerjes[17]	2012	123	CO_2 laser		Laser resection/ablation is recommended for oral dysplasia to prevent recurrence and malignant transformation
Prospective study	Deppe[18]	2012	148	CO_2 laser		CO_2 laser was used in treatment of premalignant lesions of the oral mucosa
Retrospective study	Luna-oritz[19]	2011	4	CO_2 laser		CO_2 laser is adequate for melanomas of the oral mucosa with extraction of the dental organs
Clinical study	Hegde[13]	2013	140	CO_2 laser Er:YAG laser	(CO_2 laser, 2 to 4 W, continuous wave),and "brushstroke" (Er:YAG laser, 180 mJ, 10 Hz, long pulse)	Surgical stripping for gingival depigmentation remains the gold standard; however, Er:YAG laser and CO_2 lasers can be effectively used but with distinct differences.
Clinical study	Fornaini[21]	2012	52	KTP laser	the KTP laser (532 nm), used with low power parameter (1 Watt - CW)	KTP laser with low parameters permits to perform oral surgery with good pain control and good wound healing
Clinical study	Yang[9]	2011	114	CO_2 laser		Continuous smoking after surgical treatment and widespread multiple-focus lesions are the prognostic indicators for recurrence after laser surgery.
Case report	Misra[10]	2013	1	Diode laser	diode laser (940 nm)	Diode laser therapy seems to be an effective alternative treatment for relieving the symptoms of OLP
Case report	Fornaini[12]	2012	2	Er: YAG laser	energy, 80-120 mJ; frequency, 6-15 Hz; non-contact hand piece; spot size diameter, 0.9 mm; pulse duration, 100 µsec (VSP) to 300 µsec (SP) ; fluences, 12.6-18.9 J/cm^2; and air/water spray (ratio: 6/5)	The use of this wavelength offers several advantages including, a good and fast healing process, a very low level of discomfort during and after intervention, and a rapid disappearance of symptoms.
Case report	de Magalhaes-Junior[13]	2011	1	CO_2 laser		The use of the CO_2 laser was found to be useful and effective to treat lichen planus.
Non-randomized single arm, single site	Shafirstein[7]	2011	23	Pulsed dye laser		It could be used to achieve regression of oral leukoplakia

Pyogenic granuloma

Pyogenic granuloma (PG) may develop in the oral cavity of pregnant women. Lindenmüller et al. described CO_2 laser-assisted treatment of a giant pyogenic granuloma of the gingiva. Their results showed the initial wound healing was uneventful. A 12-months follow-up revealed no recurrence of the mass and healthy periodontal tissues[25].

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[26].

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[27].

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[28].

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[29].

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[30]. (See Table 2 for an evidence summary).

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[31].

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[32].

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

Table 2. Evidence table summary of different laser used in oral benign lesions surgery

Study type	Author	year	Sample size	Laser type	Laser parameters	Result
Clinical study	Yagüe-García[23]	2009	68	carbon dioxide laser	CO_2 laser (5-7 W)	There were no complications or relapses after a minimum follow-up of 12 months
Case report	Monteiro[27]	2012	1	CO_2 laser		The use of CO_2 lasers is currently the gold standard in the excision of epulis fissuratum
Case report	Arslan[29]	2011	1	CO_2 laser	3 watt (W), continuous wave (CW) with 90 degree angle tip	CO_2 laser worked well while making the excision with its hemostatic effect. No recurrence was seen in the two years follow-up period.
Case report	Lindenmüller[25]	2010	1	CO_2 laser		A 12-month follow-up revealed no recurrence of the mass and healthy periodontal tissues.
Case report	Genovese[30]	2010	1	gallium arsenide (GaAs) diode laser	(GaAs) diode laser at 980 nm wavelength, with 4.0 W of power	It is safe for use on large lesions and easy to manage, and postoperative problems.
Case report	Iseri[28]	2009	1	CO_2 laser		There was no recurrent fibrous tissue formation at 1 year follow-up
Case report	Boj[22]	2009	1	Erbium laser		The wound healed excellently and rapidly without sutures.
Case report	Asnaashari[26]	2013	1	Diode lasaer	810nm	perfect shaping was obtained after removal of the whole lesion in one session.
Case series	Lai[24]	2009	3	carbon dioxide laser		carbon dioxide laser excision of ranula is safe with minimal or no recurrence.

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[33].

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[34].

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[35].

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[36].

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[37].

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[38].

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. No significant difference was found in the widths of thermal damage zones between the CW and CF groups. The visual analogue scale (VAS) values and analgesic intake were low in the 2 groups. 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[39].

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. EC has the advantage of shorter operative time and lower mucosal wound-healing scale scores by postoperative day 3; 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[40].

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. They reported that CO_2 laser is an effective instrument for soft tissue excisional biopsies with minimal intraoperative and postoperative complications and good pain control. CO_2 laser applications are suggested as an alternative method to conventional surgery on oral soft tissues[41].

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[42].

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[43].

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[44].

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[45].

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[46].

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[47].

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[47].

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[48].

Surgical treatment with Er,Cr:YSGG-laser was reported in 5 cases of Bisphosphonate-associated osteonecrosis of the 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[49].

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[50].

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[51].

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[52].

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[53].

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[54].

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[55].

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[56].

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[57].

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[58].

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[59].

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[60].

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[61].

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[62].

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[63].

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