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REVIEW ARTICLE

Laser for Soft Tissue Procedures in Oral and Maxillofacial Surgery

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ABSTRACT:

LASER is the acronym for Light Amplification by Stimulated Emission of Radiation. Lasers have been used for oral soft tissue dental procedures for more than 30 years, and have been researched since the mid 1960s. Improvements in technology have given the dentists many innovative treatment options. The present article reviewed the uses of lasers in oral and maxillofacial surgery.

Key words: Laser, Soft tissue, Technology.

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INTRODUCTION

Laser systems and their application in dentistry and especially oral surgery are rapidly improving today. The specific advantages of lasers are incision of tissues, coagulation during operation and postoperative benefits. The first laser was developed by Odore H. Maiman. Using a theory originally postulated by Einstein, Maiman created a device where a crystal medium was stimulated by energy, and radiant, laser light was emitted from the crystal. This first laser was a Ruby laser.[1] One year later, Snitzer released the neodymium laser (Nd:YAG). All of the early dental research focused on the Ruby laser, and the Nd:YAG laser was largely ignored during the early years. Experiments by Stern and Sognnaes found that the Ruby laser was not an effective wavelength for cutting enamel and dentin. Additional work by Stern suggested a possible role for lasers in caries prevention, but overall, hard tissue applications for the Ruby laser were not promising.[2]

Semiconductor diode lasers (Gallium arsenide (GaAs), gallium-aluminum-arsenide (GaAlAs) are portable compact surgical units with efficient and reliable benefits. They are assigned according to economic and ergonomic consideration and offer reduced costs in comparison to other modern hard laser devices.[1] This laser can be used in a continuous or pulsed mode of operation through contact or noncontact application on tissues according to the clinical approach and treatment method.[3]

Research then focused on soft tissue, where several of the early lasers proved to be successful. The argon, carbon dioxide, and Nd:YAG laser proved effective for cutting and coagulating soft tissue. The first reported oral surgical application using a CO_2 laser occurred in 1977. Because of the thermal nature of these soft-tissue lasers, injections were required in most cases. In January 1987, the first FDA clearance for a CO_2 laser used in oral surgery paved the way for the acceptance and viability of using lasers in the oral cavity in a clinical environment. The stage was set for a new round of research and investigations into lasers for broader applications such as cutting enamel, dentin, and bone.[4]

Simplified laser physics for dentists

LASER is the acronym for Light Amplification by Stimulated Emission of Radiation. Spontaneous emission occurs when atoms are excited to a higher energy state, their electrons occupy excited orbits, but spontaneously drop to a ground state orbit with the concomitant release of a packet of energy called a photon. Stimulated emission, however, occurs when atoms are energized by heat, light or electric discharge. In a laser, the pumping source supplies this energy to an optical cavity (resonator), which contains excitable atoms (the lasing medium). As these decay, they release photons of energy. The optical chamber is lined by a totally reflecting mirror on one end and a partially reflecting (partially transmissive) mirror at the other end, resulting in photons "resonating" from one end to the other, with some escaping through the transmissive mirror. As the "pumping‟ from the energy source continues, the number of excited atoms in the medium exceeds the number of ground state atoms. This is called a population inversion.[5]

Laser types

The main types of lasers used in dentistry are the diode laser (810nm–980nm), CO_2 (carbon dioxide, 10600nm) and the YAG family (2100 nm- 2940 nm) ie. ErYAG (erbium yttrium aluminium garnet), ErCr YSGG (erbium chromium yttrium selenium gallium garnet), and Hol YAG (holmium yttriumaluminium garnet). These feature predominantly as hard tissue lasers. NdYAG (neodynium, yttrium aluminium garnet) is an effective dental laser wavelength in soft tissue.[6]

Mechanism of laser interaction with soft tissue

The oral cavity contains a variety of soft tissue types including but not limited to dental pulp, mucosa, keratinized and non-keratinized gingiva. Furthermore, specific differences can exist for each tissue type, depending on location, tissue thickness, and degree of health. Depending on the wavelength of the laser device, the following interactions can be seen in varying degrees:[7]

- Reflection – no interaction occurs as the beam reflects off the surface.
- Transmission – no interaction occurs as the beam passes directly through the tissue.
- Scattering – an interaction as the beam disperses in a non-uniform manner throughout the tissue.
- Absorption – light radiation is absorbed by specific tissue elements. The predominant laser interactions within oral soft tissue are absorption and scattering.

Soft Tissue Laser Ablation

- Soft tissue laser ablation (incision and excision) is a process of vaporization of intra- and extracellular water heated by the laser light within the irradiated soft tissue. Water vapors, rapidly steaming out of the intensely laser-heated soft tissue, carry with them cellular ashes and other by-products of this fast water boiling and vaporization process.[8]

For a given laser beam diameter, the volume of irradiated tissue (if light scattering is negligible) is proportional to the absorption depth. The deeper the absorption depth (i.e., weaker absorption), the more energy is required to ablate the tissue. The shallower the absorption depth (i.e., stronger absorption), the less energy is required to ablate the tissue within exposed volume. Thus near-IR diode and Nd:YAG laser wavelengths are highly inefficient and spatially inaccurate laser ablation tools due to their weak absorption mid-IR erbium and IR CO_2 laser wavelengths are highly efficient and spatially accurate laser ablation tools due to their very strong absorption by the soft tissue. The depth of ablation is proportional to fluence, i.e. it is directly proportional to laser power and inversely proportional to spot size and hand speed.[9]

Soft tissue healing after laser

Surgical wounds are superficial or deep wounds on skin or mucous membranes due to a surgical intervention using a scalpel to cut through skin or mucosa and the underlying tissue. These wounds have neat edges and can be easily approximated spontaneously or with Mio sutures Simple surgical wounds heal through a series of morphological changes called "sanatio per primam intentionem". During this process the inflammatory phenomena are moderate. The first step consists in the accumulation of a serous exudates as a result of plasma leakage, exsudates that coagulates into a fibrin net, the template for granulation tissue.[10] The epidermis, through basal cell proliferation covers the superficial defect slowly and forms the epidermic scar. The dermic scar, formed by the granulation tissue is the result of a stimulation of fibrogenesis by adult connective cells which turn themselves into fibroblasts replacing the fibrocytes. The granulation tissue forms through multiple mechanisms: enhancement of fibroblast proliferation, of collagen and elastine synthesis which forms the extracellular network of connective tissue, new synthesis of chemotactic factors and beta interferon by the fibroblasts. The glycose-amino-glycans formed by fibroblasts also form the fundamental substance of the connective tissue in the dermal scar.[11]

Laser use in Oral surgery

Temporomandibular Joint Laser-Assisted Surgery

Arthroscopic surgery has become the treatment of choice for internal derangements of the temporomandibular joint using Er:YAG, CO_2 and Ho:YAG lasers. Using this technique, procedures such as discectomy, discoplasty, synovectomy, hemostasis, posterior attachment contraction, and eminectomy can be performed on an outpatient basis through two incisions less than 2mm each.[12]

Surgical Indications in Children

In cranio-maxillofacial surgery, laser therapy is indicated in the treatment of congenital vascular malformations, such as hemangiomas or naevi flammei which are treated by argon, Nd:YAG or dye lasers. Moreover, use of the CO_2 laser was shown to be effective in cleft surgery of infants.[13]

Laser Osteotomy

Experimental laser osteotomies were performed in vitro and in vivo with use of different wavelengths including excimer lasers, Er:YAG, CO2 and Ho:YAG lasers. The laser light may be used in cases of squamous cell carcinoma using a new photosensitizer meta-tetrahydroxyphenylchlorine (m-THPC). Intraoperative fluorescence-guided resections followed by PDT seem to be highly promising in improving the radicality of tumor resection combined with a conventional therapeutic approach.[14]

Dental Implantology

The most important indication of laser treatment in implantology is application in the peri-implant soft tissues, as well as decontamination of the implant surfaces in order to treat peri-implant bony defects and rehabilitate failing implants. The clinical use of lasers in modern oral implantology may be indicated in the different phases of the treatment. Lasers may be useful in pre-implant treatments when mucogingival surgery is required.[15]

Laser Hemostasis

In modern societies, there is an increasing number of older patients, especially who take anticoagulant drugs. Over the past years, haemostatic properties of lasers have been established. Due to deeper penetration in soft tissues, Nd:YAG and diode laser have been very effective. To reduce the thermal effect, pulsed lasers are used. Optical characteristics of blood result in scattering and dispersion of laser light, thereby reducing the adverse effects on bony tissue.[16]

Removal of Epulis Fissuratum

Monteiro et al[17] have demonstrated that Epulis fissuratum can be removed by CO_2 laser at wavelength of 10600 nm. The output power of 6.2 W with frequency of 50 Hz and pulse duration of 3 m is used for cutting this lesion. The laser is used in focused mode to generate a 0.7 mm spot size.

Excision of oral leukoplakia

Tambuwala et al[18] showed that a CO_2 laser with a laser spot of 200 mm and a wavelength of 10.6 mm can be used for excision of leukoplakia. The laser beam is set at 8e15W, and used in pulse mode with a 20 Hz frequency. The time of excision depended on the extent of the lesion, ranging from 10 to 15 min.[17]

Treatment of oral hyperpigmentation and gummy smile

Gingival hyperpigmentation and the condition known as gummy smile are very common dental cosmetic problems. Narayan et al[19] showed that gummy smile correction can be done using a laser with excellent results and emphasized the preservation of the biological width, especially when crowns/veneers are planned after gingival contouring. The diode laser (810-1064 nm) has been used for it. Nyansi Jha et al[20] demonstrated that the use of a laser as a treatment modality is considered to be a promising option for such cases.

Treatment of Osteoma

Han BL et al[21] reported that YAG laser can be used for osteoma treatment. The Ho:YAG laser energy is set at an intensity of 0.8 J at a rate of 5 Hz and with 60 watts of power. As the tip of the endoscopic fiber came into contact with the cranial surface with the frontal osteoma the energy is gradually increased, and the osteoma is excised under direct vision due to continuous saline irrigation. This method easily enables approaching the areas and contours of the osteoma, This method also has excellent cosmetic results.[18]

Treatment of Lichen planus

Derikvand et al[22] demonstrated that a diode laser can be used as the light source to irradiate the areas of the lichen planus lesions plus a 3-mm margin beyond the visible lesions, using an 830-nm 1.6-W continuous-wave (CW) mode. The healing process after each laser treatment is uneventful.

Laser-assisted uvulopalatoplasty

Abdullah B et al [23] reported that a surgical procedure that typically relies on the use of a carbon dioxide (CO2) laser to vaporize the uvula and a part of the free edge of the soft palate during one to several sessions.

Tumors and precancerous lesions

Thomson, P.J. et al[24] and Hamadah, O. et al[25] demonstrated that Nd:YAG lasers emit light at a wavelength range of 1064 nm, which is in-between the absorption maxima of water and blood. The penetration depth is therefore deeper than that of CO_2 or Er:YAG lasers and may reach 4mm, with the possibility of a larger zone of damage to the surrounding tissue. However, due to a higher potency of coagulation, Nd-YAG-lasers are recommended for tissue resection in cases of hemorrhage. Nd:YAG lasers are used for the excision of cancer in a focused mode as well as for the removal of precancerous lesions in a defocused mode.[19]

Other uses are-

- Frenectomy
- Incisional and excisional biopsies.
- Removal of benign lesions.
- Gingivoplasty.
- Soft tissue tuberosity reduction.
- Soft tissue distal wedge procedure.
- Gingivectomy.
- Removal of hyperplasias.
- Removal of hyperkeratotic lesions.
- Removal of pre-malignant lesions.

Advantages of Lasers

The hemostatic nature of the laser is of great value in Oral & Maxillofacial Surgery allowing the surgery to be performed more precisely and accurately because of increased visibility of the surgical site. Decreased postoperative swelling is characteristic of laser use. Decreased swelling allows for increased safety when performing surgery within the airway and increases the range of surgery that oral and maxillofacial surgeons can perform safely without fear of airway compromise.[20]

Tissue healing and scarring also are improved with the use of the laser. This improvement is due to a combination of decreased lateral tissue damage, less traumatic surgery, more precise control of the depth of tissue damage and fewer myofibroblasts in laser wounds compared with scalpel wounds. Hence, intraoral laser wounds can often be left unsutured unless cosmesis is considered.

Decreased postoperative pain often can be obtained with the use of lasers for surgery. The physiology of this effect is still unknown but probably relates to decreased tissue trauma and an alteration of neural transmission. This advantage becomes most evident in the management of extremely large lesions, in which conventional surgery requires parenteral drugs for pain control; mean while laser surgery requires nothing stronger than class III narcotics.[26-28]

Conclusion

Role of laser in soft tissue lesions has been associated with appropriate healing time and minimal bleeding. Also it is useful for lesions inaccessible with blade, lesions in aesthetic zone, lesions with probability of bleeding such as vascular lesions, and for patients with fear from blade surgery. We hope aggressive surgical modalities will be replaced by laser surgery in future.

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