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Use of lasers in oral and maxillofacial surgery: An overview

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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

INTRODUCTION

A laser is a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation.[1] Introduction of laser in dentistry, in the 1960s, by Miaman led to a continuous research in the various applications of lasers in dental practice.[2] The practice of oral and maxillofacial surgery has included the use of lasers since the mid- 1960s. Lasers are becoming increasingly popular due to the advent of office-based lasers, which are small, portable, and easy to manipulate within the oral cavity. Lasers enhance the current surgical options for treatment and have contributed

to the expanded scope of oral and maxillofacial surgery. Lasers traditionally have been used in oral and maxillofacial surgery for preprosthetic surgery, for the excision of benign and malignant lesions, for the excision of vascular lesions, and in the treatment of coagulopathic patients.

EVOLUTION OF LASERS

Albert Einstein in the year 1917 laid the foundation for the invention of the laser and its predecessor, 'the Maser,' by theorizing that photoelectric amplification could emit a single frequency, or stimulated emission.[1]

In 1957, Charles Hard Townes and Arthur Leonard Schawlow, then at Bell Labs, began a serious study of the infrared laser. As ideas developed, they abandoned infrared radiation to instead concentrate upon visible light. The concept originally was called an "optical maser". In 1958, Bell Labs filed a patent application for their proposed optical maser; and Schawlow and Townes submitted a manuscript of their theoretical calculations. [3]

The term LASER is an acronym for 'Light Amplification by the Stimulated Emission of Radiation' and was first introduced to the public in 1959, in an article by a Columbia University graduate student, Gordon Gould. Theodore Maiman, at the Hughes Research Laboratories in Malibu, CA, built the first functioning laser, by using a mixture of helium and neon. In 1961, a laser generated from crystals of yttrium-aluminum-garnet treated with 1-3% neodymium (Nd: YAG) was developed.[3] Maiman's functional laser used a solid-state flashlamp-pumped synthetic ruby crystal to produce red laser light, at 694 nanometers wavelength; however, the device only was capable of pulsed operation, because of its three-level pumping design scheme. Later that year, the Iranian physicist Ali Javan, and William R. Bennett, and Donald Herriott, constructed the first gas laser, using helium and neon that was capable of continuous operation in the infrared; later, Javan received the Albert Einstein Award in 1993. Basov and Javan proposed the semiconductor laser diode concept. [4]

LASERS IN ORAL AND MAXILLOFACIAL SURGERY

The efficacy of these lasers as soft tissue incising agents was first studied by Yamamoto et al. in 1972 using ruby lasers.[5] The development of the CO₂ laser and its tissue ablating properties led to an increased interest in the application of lasers to surgery. It was noted that the use of these lasers lead to reduced local hemorrhage and provided a clean surgical field to operate.[6] Designed specifically for use in dentistry, the dLase 300 Nd: YAG laser was introduced in the United States by Dr. Terry D. Myers and Dr. William D. Myers on May 3, 1990.[7] The introduction of the laser in dentistry must also be credited to Goldman L. who extensively studied the

effects of the lasers on soft and hard tissues and has been a staunch advocate of their use in routine dental practice.

CLASSIFICATION OF LASERS [8]

Lasers can best be described according to their gain medium and are broadly classified on this basis as:

Gas lasers

These include

- Helium-neon lasers: Nitrogen laser
- Argon laser: Carbon dioxide laser
- Krypton laser: Carbon monoxide laser
- Xenon ion laser: Excimer laser.

Solid-state lasers

These include

- Ruby laser: Nd: YAG laser
- Er: YAG laser: Ho: YAG laser.

Other types of lasers

- Diode lasers,
- dye lasers,
- semiconductor lasers, and
- Chemical lasers

Lasers can be also be classified as hard tissue and soft tissue lasers.

Hard Tissue Lasers

- Longer wavelength
- Cuts the tissue by ablation
- Used for tooth and bone applications

Soft Tissue Lasers

- Low energy wavelengths
- Cuts tissues by coagulation, vapourisation and carbonisation.

PRECAUTIONS BEFORE AND DURING IRRADIATION

- Use glasses for eye protection (patient, operator, and assistants).
- Prevent inadvertent irradiation (action in noncontact mode).
- Protect the patient's eyes, throat, and oral tissues outside the target site.

- Use wet gauze packs to avoid reflection from shiny metal surfaces.
- Ensure adequate high speed evacuation.

APPLICATIONS OF LASERS IN OMFS

Soft Tissue excision

Minimal bleeding occurs with use of a laser as compared to the scalpel. This provides a relatively bloodless field. The laser also coagulates the adjacent area due to its thermal effects. Postoperative swelling is also significantly reduced. [9]

Frictional keratosis

These lesions can be treated with laser therapy. Small questionable lesions can be excised by using carbon dioxide laser with a 0.2mm spot size. It is applied perpendicular to the elliptical outline around the lesion. After the outline is created, the edge of the tissue is lifted using tissue forceps and the underlying tissues are dissected with laser beam at a slight angle. [10]

Smokeless tobacco induced white lesions

These lesions are reversible after cessation of the habit. The lesions that persist even after cessation, especially those that exhibit ulceration should be sent for examination. They can be excised by using the laser in a focused mode. They are usually accessible to the laser occurring in the mucolabial or mucobuccal fold in the mandible.[11]

Leukoplakia

Lasers have found their application for the treatment of oral white patches. The conditions considered were benign lesions, leukoplakia and malignant lesions. No intra-operative complication was encountered and each patient made an uneventful recovery. When compared with other forms of surgery, CO₂ laser has certain advantages for both the surgeon and the patient in the treatment of oral soft tissue pathology. Healing following resection of benign lesions is excellent. However, with premalignant and malignant lesions, followup for many years is necessary to determine the rate of recurrence and the stability of the new epithelium after laser treatment, as well as to obtain a

comparison with conventional forms of surgery.[12]

Solar Cheilitis

It is a premalignant lesion involving the vermilion border of the lips and mostly the lower lips. If the lesion is not treated, it may transform into a squamous cell carcinoma. A carbon dioxide laser can be used at a focused spot to outline the lesion by passing between the vermilion and the hair bearing skin of the anterior lip surface and extending it towards the commissures and posteriorly to the labial vestibule.[13]

Laser vaporization

Used for the removal of large, epithelium-confined surface lesions. The use of a scalpel in these lesions would result in removal of tissue more than what is sufficient for the management of these lesions. e.g. oral papillomatosis, verrucous carcinoma etc.[14]

Laser ablation

Used for gingival contouring, management of hyperplastic lesions, hyperkeratosis, and stomatitis nicotina. Conservative treatment can be provided as it is possible to remove cell layers selectively from superficial surfaces.

Coagulation/hemostasis

Hemostasis while using lasers is achieved by contraction of the collagen of the vascular wall of vessels having diameter up to 500 μm . This leads to a reduction in the vessel diameter and bleeding is controlled. This property greatly facilitates the treatment of vascular defects and also for the control of hemorrhage. Once it is ensured that the surgical field is dry and saliva-free, the laser is directed over the tissues in defocused mode till the bleeding is arrested.

Recurrent Aphthous Ulcers

The ulcer is painful on palpation. Recently Low Level Laser Therapy (LLLT) has been used. It helps in immediate pain relief and accelerates wound healing. According to De Souza et al, 75% of the patients reported that there is a significant pain relief in the same session after laser treatment and the lesion is totally regressed in 4 days. When steroids are used, it takes 5-7 days for regression.[15] Bladowski et al. [16] also found that diode laser used at low levels reduces the

wound healing period to half compared to pharmaceutical method.

Apicoectomy

The effect of the laser not only enables removal of part of the root structure but also facilitates sterilization of the root in an infected area.

Frenectomy

Lasers provide a quick procedure for the excision of high frenal attachments. They also can be used in the lingual region where there is high vascularity due to the minimal bleeding caused by their use.

Sialolithotomy

The laser can be used to incise and expose the duct. A characteristic feature while using lasers is a flash of light that is observed when the light reaches the sialolith. This helps in localization of the sialolith in the duct.

Trigeminal Neuralgia

Neuralgic pain is the most difficult to treat but the introduction of laser therapy now permits patients to achieve life free from pain or with less pain. Authors have discussed whether low reactive level laser therapy (LLLT) is effective for the treatment of trigeminal neuralgia. They found that LLLT treatment is an effective method and an excellent supplement to conventional therapies used in the treatment of trigeminal neuralgia.[17]

Mucocoele

The treatment of numerous patients with mucocoeles of lower lip by means of Carbon dioxide laser vaporization have shown promising results. They found recurrence in 2 cases with rare complications, except for mild discomfort. One patient felt temporary numbness at the operative site. There was no bleeding and minimal scar formation.[18]

Temporomandibular joint arthroplasty

The use of Holmium Laser has been suggested for temporomandibular joint arthroscopic surgery. The surgery to ablate tissue, remove degenerated fibrocartilage and chondromalacia, and incise, cauterize, and scarify tissue was readily accomplished and took minimal amounts of energy and time. [19]

Prevention of surrounding anatomic structures

Osteotomies are being performed with drills, oscillating saws and chisels. However, these procedures, even if performed with great care, carry the risk of damaging the surrounding and enveloped tissues. Some authors evaluated a new laser bone cutting system enabling automatic detection of different tissue qualities by an integrated sensor to avoid damage to sensitive structures such as blood vessels or nerves. The specimens were evaluated histomorphometrically for the depth of cortical bone ablation when the closed-loop control system switched off the laser.[20]

Ankyloglossia

Kotlow L et al. (2011) reviewed the diagnosis and treatment of ankyloglossia and tied maxillary fraenum in infants using Er:YAG and 1064 diode lasers. He found that using lasers to correct these abnormalities may provide both the infant and mother relief and allow for improved, pain -free breast feeding without the need to place the infant into the operating room or under general anaesthesia.[22]

Excision of birthmarks

An estimated 10-20% of population is affected by Café-au-Lait spots. A study author conducted to follow a large series of patients with extensive Café-au-Lait birthmarks by the 510 nm pulsed dye laser treatment until total eradication of the lesions have been achieved in order to determine the actual number of laser sessions necessary to obtain lesional clearance and to determine the incidence of side-effects or recurrences. No recurrence of the lesion was observed 1 year following the termination of treatment.[23]

LASERS IN ORAL IMPLANTOLOGY

One advantage of use of is that impressions can be taken immediately after second stage surgery because there is little blood in the field due to the haemostatic effects of the lasers. There also is minimal tissue shrinkage after laser surgery, which assures that the tissue margins will remain at the same level after healing as they are immediately after surgery.[24]

Implant site preparation

Lasers can be used for the placement of mini implants especially in patients with potential bleeding problems, to provide essentially bloodless surgery in the bone. Removal of diseased tissue around the implant: Lasers can be used to repair ailing implants by decontaminating their surfaces with laser energy. Diode, CO₂ & Er:YAG lasers can be used for this purpose. Lasers can also be used to remove granulation tissue in case there is inflammation around an already osseointegrated implant.

Sterilization of socket

In immediate implant dentistry after extraction of tooth, without any infection, socket can be sterilized immediately without any pain.

PeriImplantitis

Since the laser does not transmit damaging heat, it can be utilized to vaporize any granulation tissue as well as clean the implant surface in peri-implantitis cases. This procedure eliminated the acute state of periimplantitis, resulting in positive GTR, and allowing the patient extended use of the implant.

Sinus lift procedure

Lasers can also be used in the sinus lift procedure. The procedure can be done by making the lateral osteotomy with a decreased incidence of sinus membrane perforation.

ADVANTAGES OF LASER SURGERY

Lasers have withstood the test of time and in spite of heretic criticism, they are widely used because of the following advantages that they offer:

- The use of a laser can decrease morbidity after surgery, and reduces the need for anesthetics.
- Lasers provide the added advantages of sterilization of the field of operation, decrease mechanical trauma by a contact-free incision and minimizes postoperative swelling, pain, and scarring.

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- Effectively coagulates blood vessels in the field of operation thereby maintaining a bloodless field
- Increased precision and accuracy in surgical procedures due to its ablative properties and effective control on the depth of penetration of the laser beam
- Histologically, the wound shows less wound contracture and scarring due to reduced myofibroblasts
- Better healing as compared to scalpel wounds
- Reduced need for sutures.

DRAWBACKS OF LASER SURGERY

Although the use of lasers has multiple advantages over the use of a scalpel, it still carries a few disadvantages:

- The speed of healing may be delayed
- Incidence of increased pain 4–7 days postoperatively
- Laser plume generated during the procedure may be harmful to the persons in the operating room
- Scattered and reflected laser beams pose a massive health hazard to the operator, assistants and patients
- High cost and operator training.

CONCLUSION

Looking to the future, it is expected that specific laser technologies will become essential components of contemporary oral and maxillofacial surgical practice over the next decade. An oral and maxillofacial surgeon should therefore strive to obtain sufficient knowledge on the application of lasers. A thorough understanding of the use of soft tissue as well as hard tissue lasers remains pivotal in order to carry out a systematic approach on the usage of the same without encountering any difficulty while performing laser assisted surgeries. Adequate safety measures and guidelines should be followed for the safe application of lasers. A further area of future growth is expected to be a combination of diagnostic and therapeutic laser techniques.

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