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LASER APPLICATIONS IN ORAL SURGERY: REVIEW ARTICLE

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INTRODUCTION

The word laser comes from the first letters of Light Amplification by the Stimulated Emission of Radiation. This word mostly describes important physical reactions inside the cavity of laser processing machine.[1] Although knowledge of complex issues of laser physics is not necessary for a surgeon, however, having general information about stimulated emission is useful and the individual can evaluate more advanced laser technologies and gain insight into the effect of laser on biological tissue. Today, lasers are widely used in oral surgery including: control of leukoplakia, the removal of oral mucosal lesions, angiodysplasia, oral malignancies and in semi-selective and selective procedures such as periodontal surgery, pre-prosthetic surgery, TMJ arthroscopy and cosmetic surgery such as facial resurfacing.[2]

What is certain is the lasers are not definitive replacement of the traditional surgical instruments, but they can be used as a complement along with other conventional instruments. Laser application like other technologies has advantages and disadvantages.[3] Laser surgeries have several potential benefits which include laser real properties and its application. Laser disadvantages arise from the extraordinary power of the emitted beam and the complexity of beam production.[4]

Some considerable advantages of surgery with laser includes the ability of laser in coagulation, vaporization or cutting tissue based on the strength and duration of its application on the tissue.[5]

Some lasers effectively coagulate blood vessels and therefore provide a relatively dry surgical area. Thereby they decreases heat damage to the adjacent non-target tissue and they greatly reduce postoperative tissue edema caused by mechanical trauma to the tissue. In laser surgery damage is limited only to the injured tissue, especially when the laser is produced through a Coaxial systems in microscope.[5]

Additional advantages of laser application that have been reported by researchers are as follows: reduced post-operative pain probably due to the closure of the afferent nerve pathways by laser, reduced wound contraction caused by reduced stimulation of fibroblast cell elements and myoepithelial cells which leads to less scarring. Recently, lasers are used for welding the arteries and nerve repairing. They are also applied in new areas such as cosmetic surgery and resurfacing.[6]

Like any other technology, laser therapy also has disadvantages. First issue is the risk of inadvertent

exposure to the laser beam for the patient, surgeon and operating team. These rays cause skin burns, eye harassment and even cause blindness. Unfortunately, there have been several reports of patients injury due to fire of endotracheal tubes by laser energy. Other disadvantages include high cost of Laser equipment and its maintenance, the need for additional training of the surgeon and operating team, special plumbing and wiring, and continuous safety monitoring.[5]

This paper is a summary of different types of lasers that are used in oral surgery and general principles of their application. It is hoped that in the coming years broader applications of this miraculous beam to be known and applied.

The use of lasers in dental surgeries has begun in 1960.[1] The first documented application of laser in oral surgery has been registered in 1977.[2] Laser is rapidly becoming a standard treatment in many surgical procedures. The advantages of laser surgery include having sufficient visibility during surgery, homeostasis and reduced pain and discomfort in patients after the procedure. These features make the surgeon have better control within the oral cavity when working with laser.

A solid understanding of laser physics and biology of light interference with tissue is essential for selecting a suitable laser for each process. Depending on the type of tissue and required surgery method a variety of lasers

with specific wavelength and power can be used. Some of the common lasers include argon laser (Ar), carbon dioxide (Co2), Er: YAG, Er, Cr: YSGG, Ho: YAG, Nd: YAG, KTP, and diode lasers.[3]

Depending on the wavelength-related features, diode lasers, Nd: YAG, Erbium and Co2 lasers are the most common lasers used in oral cavity.

Diode laser (810-1064 nm)
Diode lasers with a wavelength between 805 to 1064 nm are produced by many manufacturers. These lasers are well designed and portable. Their prices are relatively affordable and can be effectively used in oral soft tissue surgery. Diode lasers can be used in continuous-wave (CW) or gated pulsed and in both contact with tissue or non-contact mode. Nm980 diode laser has significantly high absorption in water which results in more apical than thermal cuts. Optical penetration of this laser is less than 300 microns.

Romanos in his study came to the conclusion that cutting margins using diode laser 980 nm is much more accurate than cutting with other wavelengths of this laser.[4]

In addition to the use of 980 nm diode laser in surgical procedures of oral soft tissues, this type of laser, similar to Co2 laser, has become popular in the treatment of Peri implantitis because the bactericidal properties of theses lasers are applied without causing any change on the surface of implants.[5]

Nd: YAG Laser (1064 nm)
The laser with a wavelength of 1064 nanometers acts near infrared range. These lasers have poor absorption in surface tissues, but their deep penetration property causes clotting in deep tissues.[7] Since the laser has large penetration depth in soft tissue, it should be used in a pulsed mode.

Romanos believed that many processes can be performed without anesthesia because the pulse width is less than the time required to start a nerve action potentials.[8]

White et al concluded in their study that surgery with Nd: YAG laser generally does not require anesthesia compared to surgery with scalpel and the bleeding is minimal.[9]

When we need to harvest large amounts of tissue, anesthesia is required to be used for patient's comfort.[7]

Like diode laser, Nd: YAG laser can be utilized in both contact (for cutting) and non-contact (for coagulation) modes. This feature makes maxillofacial surgery be used in several cases such as coagulation of angiomatous lesions, homeostasis establishment in bleeding disorders, joint arthroscopic surgery, TMJ, vascular tissue cutting and palliative surgery (Palliative) in neoplasms.[10]

This laser can also be utilized in periodontal treatment such as debridement of gingival sulcus and removing bacteria from the sulcus. This treatment increases the chance of new attachment formation in gingival tissue, supportive bone regeneration and regrowth of periodontal ligaments.[11]

Erbium Lasers (2780 to 2940 nm)
The Erbium family lasers with two same wavelengths have gained great popularity in implant surgery. These groups of lasers are Free-running pulsed lasers with thermal effects which exclusively react with the surface layers of soft and hard tissues.[12] Laser beams are reflected by polished surfaces like titanium so they do not have any side effects on dental implants.[13] The applications of Erbium family lasers in dental implants surgery include: preparation of hard tissues of bone, implants second-stage surgery, soft tissue modification and treatment of Peri implantitis.[14-16]

Co2 Laser (10600 nm)
Co2 laser is the best laser for oral soft tissue surgery. As about 90% of the soft tissues consists of water and 10600 nm wavelength has the maximum absorption in the water, so this laser has an ideal absorption in soft tissues. When interstitial water absorbs the laser energy cell disruption will happen. The principles of Co2 laser as a surgical knife is based on the cell vaporization.[3] This wavelength makes the laser to be absorbed into the soft tissue. The produced heat quickly spreads to surrounding tissues and creates very narrow region of thermal necrosis with size of about 500 microns or less.[17] Creating very narrow region of thermal damage can cause clotting in regional blood vessels with approximately 500 microns diameter, which clinically manifested as homeostasis and sealing the regional lymph vessels which in turn will cause the lower risk of bacteremia after surgery compared to other surgical procedures.[18] Co2 laser energy can be transmitted in several ways including continuous, pulsed/chopped gated mode, Ultra speed, and Super Speed methods.[19]

Advantages and disadvantages of laser surgery
Advantages
The use of lasers in oral surgery has significant benefits for the surgeon and the patient. Since the laser has monochromatic, collimated and coherent light, therefore radiates an exact beam on the target area. Laser beam cut the target tissues more accurately than the surgical blade and creates a complete vaporization, as well as closes the blood vessels. In the reformative processes Laser possibly will be a choice of treatment because it can take a certain amount of tissue by selective ablation method.[20]

Hemostatic effect of laser reduces bleeding during surgery while creating a clean and free of blood surgical area that allows the surgeon to work with a better view and also with more speed and accuracy. This factor

makes laser to be a preferable instrument in all surgical procedures.[21]

Histological studies have shown that wounds caused by laser surgery contain low number of myofibroblasts.[20] This leads to the less contraction of wounds and scar formation that eventually result in a better healing.[12, 22] Due to better healing and homeostasis, oral ulcers caused by laser surgery do not need sutures and will improve by secondary repair unless the areas are important in terms of beauty.[21]

Using the laser, the patient will experience less pain and swelling after surgery.[23,24] In addition, laser surgery causes less airway obstruction in the patients due to less inflammation. Most post-operative pain in patients can be controlled with OTC painkillers such as ibuprofen. Because in most cases, post-operative pain will be moderate the physiological effect has not been known clearly, but is likely a result of reduced trauma to the tissues and changes in neurotransmission capabilities of neurons.[7]

Since patients experience almost a painless surgery and the complications after surgery is at minimum level, many surgical procedures can be performed in the office. The patient can return to work after 24 hours and even sometimes immediately.

Disadvantages

Despite the undeniable advantages of the laser, the surgeon should be familiar with the disadvantages of this method. Although the process of healing after laser surgery is accompanied by less scarring and better function, but some studies have shown that laser-related wounds take longer to heal compared to other wounds.[25] The damaged tissue requires neo-angiogenesis due to the sealing of regional blood vessels and lymphatic vessels. Laser-induced mouth wounds usually heal within 2 weeks, but other wounds generally heal within 7 to 10 days. Co2 laser-induced wounds form a fibrin membrane which acts as a biological dressing.[23] Because Co2 laser-induced wounds epithelialized slowly the fibrin membranes may remain even after 2 weeks. New clinicians should not confuse this case with infection as there is no need to antibiotics prescription or debridement of the region.

All wavelengths of the lasers utilized in surgery for vaporization, coagulation or cutting of tissue may produce a series of specific debris known as Laser Plume. Clinicians, their assistants and patients may be at risk of infection with debris. The Laser plume depending on the target tissue may contain carcinogens, irritants, viral or bacterial particles. Also debris may contain some chemicals such as polyaromatic hydrocarbons, carbon monoxide, multiple toxic gases, formaldehyde, hydrogen cyanide and benzene. Currently no proof and evidence exists regarding the side effects of exposure to Laser Plume particles. Studies carried out regarding the transmission of infection through Laser Plume are vague and have inconclusive results.

Several studies conducted on patients with type II human papillomavirus have shown that in the Laser Plume, live virus DNA have not been found.[26-31] A review of previous studies have shown that no one has yet become sick due to inhalation of Laser Plume debris after dental procedure. However, in every case the pollution generated by the laser need to be controlled using proper ventilation, adherence to the principles of infection control and the use of appropriate personal belongings.[32-35]

Laser Protection and Safety

When safety measures and principles of surgery are applied correctly, complications resulting from laser surgery will be very minor. The surgeon who has the knowledge of laser physics and the effects of lasers on soft and hard tissue can protect the patient and the surgical team against complications.

All efforts for providing security aim to prevent potential risks such as the use of non-flammable materials as much as possible. In operating environment laser radiation-resistant materials should be used to protect the anesthesia equipment. Moreover, using special anesthesia techniques can reduce potential risks of infection.

Personnel working in the laser area are also at risk. Compliance with some principles that protects them against possible risks are as follows[5]

1) Familiarity with the` symptoms caused by Laser
(A) Description of the type of laser
(B) Determine the degree of Laser risk
(C) Explain the equipment needed for personnel (especially eye protection)
(D) Identify the locations that laser should be turned off when personnel enter.
2) Protective eyewear should be used by all staff at all times.
3) Using appropriate protection
4) A container of sterile water available in the surgery room
5) Full time presence of Laser technician
6) Full attention to the laser by surgeon, anesthesia staff and attendees in the operating room
7) License to use laser apparatus

To avoid the risks and complications of laser in the operating room, the following points should be considered.

• To prevent the risk of fire due to the excess heat created by the laser, towels should be kept completely wet during surgery because they might ignite if they become dry.
• During maxillofacial surgery, many of the devices used in operation (e.g., tracheal tube) are placed near the area

of operation and should be covered with appropriate safeguards.

• When laser surgery is performed under general anesthesia, red-rubber endotracheal tube or other tubes that are secure against laser should be used. Using the endotracheal tube made of polyvinyl chloride (PVC) has contraindications.[24]

• When oral Intubation is used for intraoral surgeries, red-rubber endotracheal tube should be covered by a reflective foil or other resistant tubes against laser (such as metal oxide) or stainless steel should be utilized.[24]

• Before surgery, protective eyewear should be fully reviewed for each patient because in this type of surgery, eyes are in close proximity to the operating area and heat production is very dangerous. Also sometimes reflection of rays by equipment can damage the eyes. It is better to put a protective shield between the eyes and the operating area.

• Laser is created by a high-voltage electric current in a gas. If the laser generator is not used by expert technicians can cause electrical burns, cardiac arrhythmias or cardiac arrest.

• Laser is a powerful source of ignition. If combustible materials or gases accumulate in the atmosphere, laser beam can lead to explosions, so during anesthesia in laser surgery ether or cyclopropane should not be used. Alcohol is also explosive. During general anesthesia, the oxygen concentration must be reduced as much as possible.[24]

SUMMARY AND CONCLUSIONS

Albert Einstein at the beginning of this century stated basic principles of stimulated emission of radiation that formed the foundation of modern laser physics. By discovering the lasers, human achieved a new source of innovation which was different with visible light and the output rays were parallel and the intensity was high. Gradually, by developing laser science more public attention was drawn to the importance of scientific and practical lasers and finally caused lasers to be utilized in medical sciences, industry and even in military terms. Dentistry as the branch of medical science has not been separated from these efforts.

In 1990, FDA approved the use of laser therapy in oral soft tissue surgery. Annunciation such as "surgery without sutures, pain and bleeding" made dentists and patients happy. Different types of laser including Argon, Co2 and Nd: YAG and diode lasers were introduced to the market for dental applications.

The most common reasons expressed by dentists for using laser are less pain and concerns for the patient; easy application and being time-saving. Dental procedures such as gingivectomy, gingivoplasty, frenectomy, lesion excision and biopsy, homeostasis and creating space for molding are the most common types of laser therapy.

Patients prefer laser due to the less pain during cutting and during the healing period. Reduction of bleeding and patient satisfaction is also desirable for the dentist. Laser surgery in areas with excessive bleeding such as cheeks, tongue, floor of the mouth and also working on pathologic lesions provide appropriate access and control for surgery.

However, there are problems associated with a variety of medical lasers, such as: High cost, large unit with limited movement, difficult cutting compared to cutting with a scalpel, 220 volt (Ar) requirement.

In general it can be said that the use of a laser beam is very effective and efficient due to a decrease in surgical bleeding, dry operating environment, visibility and excellent access, reduced inflammation, the ability to remove residual neoplasia cells and reduced risk of recurrence, reduced pain and scarring, less or no need for sutures, lower possibility of bacteremia and lower or no risk of infection transfer from patients to dental staff.

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