LASERS IN DENTISTRY

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Abstract

The term LASER is a cipher for Light Amplification by the Stimulated Emission of Radiation. They are used as a niche tool as a direct replacement for conventional approaches such as scalpels and blades. Irrespective of its types, lasers have shown tremendous results in dentistry. This article provides a comprehensive review of the wide applications of lasers in different fields of dentistry.

Keywords: Laser, direct replacement, applications, dentistry

Introduction

Albert Einstein is credited for postulating Laser theory. He was the first one to construct the term “Stimulated Emission” as published in 1917 in Physikalische Zeitschrift.1 Laser light is not only a monochromatic light but also possesses a few additional characteristics such as collimation, coherency and efficiency. Theodore Harold Maiman on May 16, 1960 at the Hughes Research Laboratory in California was credited for constructing the first prototype laser. He exposed extracted tooth to an exciting ruby rod with intense pulses of light by a flash lamp.2 Then it was introduced into dentistry by Goldman et al in 1965. The majority of dental lasers are available within the visible or invisible infrared non-ionizing portion of the electromagnetic spectrum; with wavelengths of approximately 500nm- 10,600nm. In 1989 Kuler and Hibst demonstrated the effectiveness of pulsed Er:YAG lasers. Consequently, various laser systems such as Neodymium-doped Yttrium-Aluminium-Garnet (Nd:YAG) and semiconductor diode lasers have been approved for soft tissue and Erbium doped: Yttrium-Aluminium-Garnet (Er:YAG) in 1997 for hard tissue treatment in the oral cavity by United States Food and Drug Administration.3 In 1997 laser armamentarium had been designed. Dental lasers can be employed in both contact as well as non-contact modes. In the former mode laser tip is in direct contact with the target tissues whereas in the latter case beams are projected from a distance towards the target tissue as used in operative dentistry.

Components of a LASER:

The basic equipment of a laser includes an active lasting medium along with an optical resonator and a pumping mechanism.

The principal mechanism is based on photothermal; the conversion of light energy into heat. The pumping mechanism generates energy by stimulating photons. The optical resonator or cavity consists of two mirrors placed parallel on either side of the active medium. This helps to maintain a continuous avalanche process; producing laser light. These mirrors help to absorb and emit energy that resonates within this cavity thus amplifying the power. The light energy is converted to thermal...
energy which is cooled by air or water that simultaneously irrigates the surrounding and irritated tissue. Depending upon the wavelength emitted the delivery system may be a flexible hollow waveguide, a handpiece containing the laser unit, an articulated arm, or a quartz fibre optic.

Laser tissue interaction includes basic four steps – absorption, transmission, and reflection followed by scattering. When the temperature rises at the surgical site, certain reversible and irreversible changes can occur. Hyperthermia - below 50 degrees C, Coagulation and Protein Denaturation- between (60-70) degrees C, Welded-between (70-90) degrees C, Photovaporolysis- between (100-150) degrees C and Carbonization at a temperature above 200 degrees C which is a significant tissue damage as it is dehydration and burning in the presence of air resulting in the generation of carbon as an end result.

Classification

- Types:6
  - Soft laser: Helium- Neon, Gallium-arsenide
  - Hard laser: carbon dioxide, Argon
- Based on gain medium7
  - Gas lasers- carbon dioxide, neon and Helium
  - Liquid lasers- Dye lasers
  - Solid lasers – diode, Nd:YAG, Er:YAG
  - Semi solid lasers- Silicone lasers
  - Excimers- Argon-F, Xenon-F
- Based on the wavelength:7
  - Ultraviolet range 300-400nm
  - Visible light range 400-700nm
  - Near infrared range 700-1200nm
  - Far infrared range of more than 1200nm

Role of lasers in different fields of dentistry

Prosthodontics: The role of lasers range from fixed prosthodontics to removable prosthesis, from implantology to maxillofacial prostheses.

- Removable Prosthodontics: lasers used to perform most pre-prosthetic surgeries. Hard and soft tissue modification include tori or exostoses reduction, enlarged tuberosity reduction, inappropriate residual ridges including undercuts especially in the premaxillary region, frenectomy, denture stomatitis, epulis fissuratum, hyperplastic tissue resulting from the ill-fitting previous denture. These modifications in mouth preparation boost stability, retention, and support of the final prosthesis.
  - Prototyping and CAD/CAM Technology are technologies that can automatically construct physical models from Computer-Aided Design. Rapid prototyping is an additive process in which layer-by-layer wax or plastic helps to create a solid object. Selective Laser sintering includes three components- A laser beam, a moving platform, and a roller. The roller helps to spread a layer of material on the platform formed by fusion with a laser beam. Although it is extremely time-consuming, is highly accurate.
  - Laser Welding: Pulsed laser with relative low average out power helps to repair removable partial dentures defect.
- Fixed Prosthodontics
  - Crown Lengthening: to have an adequate crown height by removing required gingival soft tissue.
  - Tooth Preparation:11 based on hydrokinetic technology in which laser-energized water is used to ablate tooth structure and its surrounding soft tissue. Finish lines are prepared without the use of local anesthesia. It saves time and prevents bleeding. The laser handpiece consists of fiber-optic tips that direct laser energy to a focal point.
  - Laser scanning: 3D laser captures complex 3D texture-mapped models and is exported into a scan surf software application which builds a three-dimensional meshwork image of the object.
  - Formation of ovate pontic site.
  - Veneer removal: Laser energy passes through the veneer unaffectedly and is absorbed by water molecules of adhesive, thereby, detaching the veneer without cutting it off.
  - Laser troughing: It is a method for gingival retraction with the help of a laser used in perfectly healthy gingiva.
- Maxillofacial Prosthesis:
Selective laser sintering or three-dimensional printing with the laser beam is an alternative approach to fabricate wax patterns for the maxillofacial prosthesis. It reduces both labour-intensive laboratory procedures and time. Moreover, it saves negative replica for the future which is lost in conventional fabrication technique.\textsuperscript{12}

**Endodontics:**

- **Treatment of Dentinal Hypersensitivity:**

The first Nd: YAG laser used in the treatment of dentine hypersensitivity was in 1985 by Matsumoto. One of the theories suggested that laser energy is absorbed by water and hydroxyapatite. The laser heats up the water causing it to become steam leading to expansion; causing cracking of the tissue that forces cracked material away from the ablation zone. Er, Cr: YSGG lasers at 0.5W potency for the 30s produce required closure of dentinal tubule to treat dentinal hypersensitivity. However, the use of lasers is very technique sensitive as it gives rise to severe thermal damage to pulpal tissue.\textsuperscript{13}

- **Bleaching:**

Diode lasers are used to bleach teeth in order to improve esthetics. This prevents tooth sensitivity and modifies the complexion of the tooth.

- **Oral Implantology:**
  - *For sterilization of socket:* it is recommended in case of immediate implant placement to remove an infection from the desired socket.
  - *Lasers in Ailing implant:* in case of inflammation around osseointegrated implants. Diode, and CO\textsubscript{2} lasers are mostly used. Deppe et al 2001 conducted that peri-implant defects are not only treated successfully by laser decontamination without affecting surrounding tissue but also help in bone regeneration.\textsuperscript{14} However, Kreisler et al in 2002 state that Nd:YAG and Ho:YAG is not recommended in the debridement of implant irrespective of power output.\textsuperscript{18}
  - *Second stage for implant:* exposure of the cover screw of an implant to rehabilitate it using laser helps to maintain haemostasis along with minimal retraction of peri-implant soft tissues. CO\textsubscript{2} laser is mostly used as it is not absorbed on metal surfaces.
  - *In the treatment of Peri-implantitis:* It is an inflammatory process that involves both hard and soft tissue around the implant along with bone loss. The development of biofilm around the implant leads to peri-implantitis. This biofilm can be reduced by lasers. It has been recommended that Er:YAG lasers are more effective than carbon dioxide lasers.
  - *In welding of titanium framework:* laser welding is recommended to fabricate titanium framework as it can be done directly on the working cast.

- **Oral Surgery:**\textsuperscript{16,17,18}
  - *Removal of mucosal lesion* such as Leukoplakia, Lichen Planus, Gingival margin Pigmentation, Oral Melanoma.
  - *Removal of benign lesion* such as pyogenic granuloma, ranula, haemangioma, gingival hyperplastic lesion.
  - *Frenectomy and ankyloglossia*
  - *To maintain haemostasis*

**LASER hazards:**

**According to ANSI and OSHA, categorized under four categories:**\textsuperscript{19}

**Class-I:** Low-powered lasers which are safe to use such as Laser beam pointers.

**Class-II:** Lasers that are hazardous only when viewed directly for longer than 1000 seconds. **For example:** He-Ne lasers.

**Class-II b:** low-powered visible lasers that are hazardous only when viewed directly for more than 0.25 seconds.

**Class-III a:** moderate-powered visible lasers that are hazardous only when viewed directly for less than 0.25 seconds without magnifying optics.
**Class-III b:** moderate powered visible lasers that are hazardous only when viewed directly.

**Class-IV:** High-powered lasers that are hazardous to ocular, skin and fire hazards.

**Conclusion**

Although the use of lasers has significantly increased over the last decades, it is highly technique sensitive. The literature analysis shows that laser treatment represents a promising alternative in Dentistry capable of replacing conventional treatment. The outcome of the treatment is purely based on the different techniques and wavelengths used during the procedure. The advantages of laser treatment are efficient and effectiveness with reduced use of local anaesthesia, greater hemostasis, and faster bone healing.

**References**