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REVIEW ARTICLE

Prosthodontic perspective of laser application: A review

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Abstract

Background: A laser works primarily through stimulated emission which is responsible for the biological effects produced by the lasers. With the development of the ruby laser by Maiman in 1960, various studies on applications of lasers in dentistry have been conducted. Various wavelengths of dental lasers have been discovered so far but not all of them are used in prosthetic rehabilitation. Advent of different laser systems has a considerable spectrum of applications in removable prosthodontics and fixed prosthodontics. **Aim:** When compared to traditional methods, laser treatments are less invasive and painful. Various studies have documented the capacity of laser wavelength and laser parameters used in prosthetic dentistry. Moreover, it is important to study the different reactions; they can produce on the soft and hard tissues. Therefore, proper knowledge of properties of lasers and its mode of action are also important for its advantageous use. The aim of this article is to debrief the application of lasers in a prosthodontic perspective. **Conclusion:** The knowledge and ideas of pioneers in the field of laser are being developed and expanded into clinical practice that can enhance the quality of dental care and make the patient comfortable. The unique features and vast potential of dental lasers allow the overall success rate of any procedures. Thus, lasers have become an inexorable clinical tool in a dental armamentarium. Despite the benefits, laser energy also poses some risks. Hence, the clinician must understand the principles of lasers to take full advantage of its benefits and to provide safe and effective treatment. **Clinical Significance:** Recently, computer-aided design and rapid prototyping technology, surface treatment of base metal alloys, and study of occlusion in complete dentures using three-dimensional laser scanner have been developed. Thus, laser seems to be very helpful in reducing the complexity and thus provides a better platform and easier accomplishment of the task.

Keywords: Complete denture, Computer-aided design/computer-aided manufacturing, Dental implants, Fixed dental prostheses, Laser, Maxillofacial prosthesis, Removable prostheses

Introduction

Light is a fundamental part of our life. The revelation of the laser during the 20th century marked a change in the conventional treatment modalities in the field of health sciences.[1] A laser is an abbreviation of light amplification stimulated emissionradiation. This electromagnetic radiation is produced through a process called stimulated emission[2] [Figure 1].[3] Unlike the normal light sources such as tungsten lamps and mercury lamps, "Laser" has a unique property that it can travel long distances with less divergence. Albert Einstein is the one who credited for the event of the laser theory.[3]

Theodore H. Maiman of the Hughes Research Laboratory, California, was the first scientist who given credit for demonstrating and operating ruby laser for the 1st time in 1960.[1] MASER, a concept proposed by Charles H. Townes in 1951, became the basic principle for laser production. The use of laser in the dental field increased with the discovery of laser with different wavelengths and advancements in different delivery systems.[2]

At present, numerous laser systems are available for dental treatments. The US Food and Drug Administration approved neodymium-doped:yttrium-aluminum-garnet (Nd:YAG), CO_2, and diode lasers for soft-tissue management in the patient's mouth. The use of the erbium-doped:yttrium-aluminum-garnet (Er:YAG) laser for hard tissue management was approved in 1997 by the US Food and Drug Administration.[2]

The clinical applications of laser depends on its wavelength, as it determines how the laser will interact with the target tissue.[3-6] Dental lasers function by creating waves of photons specific to each laser wavelength.[7] Depending on the wavelength and photon energy, lasers can be either visible, infrared, or ultraviolet radiations [Figure 2].[2] When these rays are focused to a point, it transmits heat and power.[8] This photonic absorption leads to intracellular and/or intercellular changes within the target tissue. These changes within the tissue produce the desired result.[9]

The superiority of lasers to other modalities is that they provide a blood-free surgical field by sealing the blood vessels, thereby offering excellent visibility and reduced operative time and minimize post-operative swelling by sealing the lymphatic vessels.[10]

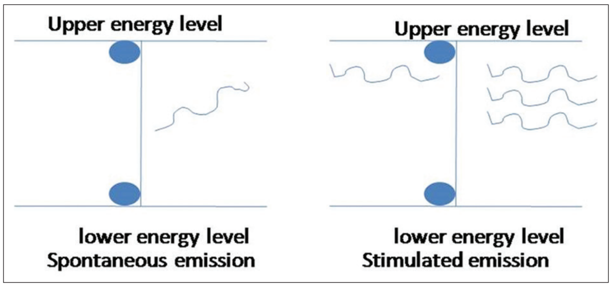

Figure 1: Spontaneous and stimulated emissions

Lasers offer the ability to negotiate curves and fold in the oral cavity and can vaporize, cut, and coagulate tissue. With the use of lasers, the bacterial count is reduced, chances of mechanical trauma are minimal, scarring is negligible, and pain is almost nil probably due to sealing of the nerve fiber.[10]

Basic components of laser and its production [Figure 3][2]

a) Active/laser medium can be solid, liquid, or gas. Moreover, this medium determines the wavelength as well as the nomenclature of the laser[1,2,10,11]
b) Laser cavity/optical cavity/housing tube – It is an internally polished tube, with coaxially arranged mirrors at both the ends. One mirror is fully reflective and the other mirror is partially reflective[1,2,10,11]
c) Pumping mechanism/external energizing unit is an artificial source of energy that pumps the atoms of the active medium to higher energy levels. The source of energy can be a flashlight, an arc light, or an electromagnetic coil.[1,2,10-11]

When atoms of the active medium are bombarded with photons from the external energy sources, the incident light energy is absorbed by the target atom resulting in the movement of an electron to the higher energy level and making it unstable. This transmission results in the emission of photonic energy (spontaneous emission). When this already unstable or energized

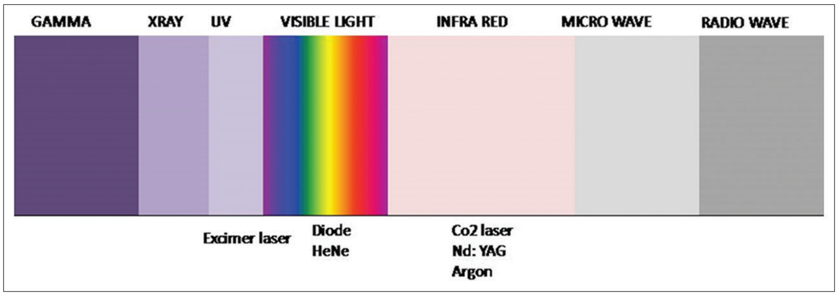

Figure 2: Electromagnetic spectrum showing the available dental laser wavelengths

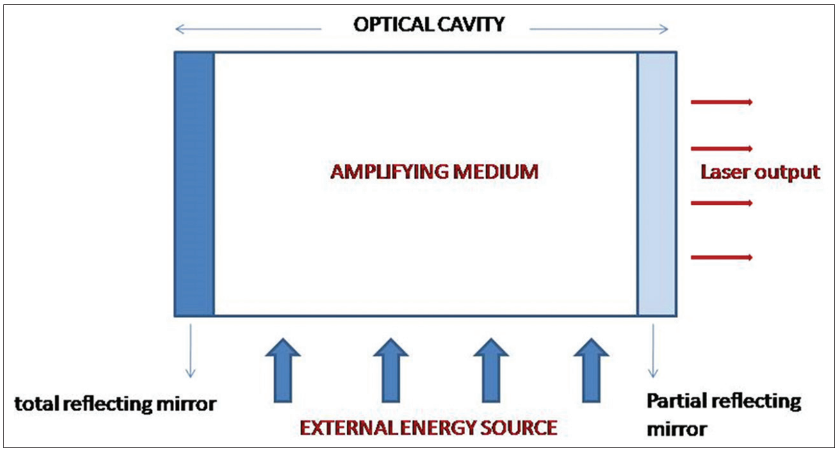

Figure 3: The basic components of a typical laser cavity

atom is bombarded with a second photon, two photons of identical wavelength are released. This phenomenon is termed as "stimulated emission." This process continues as the coherent photons energize more surrounding atoms. To maintain this excitation process, a constant supply of energy is required.[1,2,10-11]

Laser Application in Prosthodontics

Complete denture prosthodontics

Prototyping and computer-aided design and computer-aided manufacturing (CAD/CAM) technology

Rapid prototyping (RP) is a recent technology that allows designers to quickly create physical prototypes of their designs, rather than just two-dimensional (3D) pictures.[12,13] This system consists of software that slices the CAD model into various thin (e.g., 0.1 mm) sections. These slices are then integrated one over the other to construct a 3D solid model. RP is an additive technique, whereas computer-aided milling is a subtractive process that removes material from a solid block. RPs additive nature allows it to make objects with complicated internal features that cannot be manufactured by other means.[12,13]

Laser rapid forming (LRF) of a titanium denture base plate[12,14]

The traditional lost-wax technique is commonly used to fabricate titanium denture base plate in dentistry. However, this technique is time consuming and associated with defects and inaccuracies by the laboratory process. Advanced technologies integrate the use of laser scanner, CAD/CAM, and LRF for the construction of the titanium plate of a complete denture.

Laser scanners are used to scan the edentulous ridge and digital data are stored in the computer. Using this 3D computer-aided data, the digitized plate was finally designed and stored as STL format. Moreover, these images are sliced into the various thin sections. Then, the denture plate will be fabricated layer by layer, on the LRF system. After finishing and polishing, this denture plate can be used by patients.

Analysis of occlusion by CAD/CAM[12]

Occlusion of a new denture can be examined by laser scanner technique and 3D reconstruction technique. The relationship between the parameters of balanced occlusion can also be verified.

Analysis of the accuracy of impression by the laser scanner[12,15]

Several studies had been conducted to compare the accuracy of various elastomeric impression materials. However, these two-dimensional studies neglect the 3D changes that occur along a 3D surface.

The scanning laser 3D digitizer can determine x, y, and z coordinates, and thus, the dimensional change along theses axis can be accurately measured without any errors. The 3D laser captures complex 3D data and they are exported into 3D (Scan Surf) software and stored in the computer with a resolution of 130 mp. These data are processed to design the 3D meshwork image of the object. The images generated are superimposed to evaluate the differences between two similar images. Then, the shortest distance of each point from the surface of one object to another is calculated. This is considered as the difference between the two surfaces, within a range of 0.5 mm.

Frenectomy[16]

The argon laser is most commonly used laser for frenectomy procedures. While the argon laser is very effective in cutting fibrous tissue at higher energies, it is also beneficial for lingual frenectomy because its hemostatic properties. The use of argon laser helps to remove the tissues effectively and helps to maintain a bloodless working field. Continuous wave laser can excise the frenular tissue, when the laser is set at power of 1–2.25 W.

Tuberosity reduction[16,17]

Frequently, the maxillary tuberosity area approximates the retromolar pad and is composed primarily of fibrous connective tissue. This reduces the space for the prosthesis and needs to be altered to provide space for the prosthesis. The CO_2 laser is suggested for larger pre-prosthetic surgery due to its speed and effectiveness in vaporization. The use of new 600 μ and 1000 μ fibers and sculpted tips allows the operator to vaporize or cutaway tissue carefully as needed until the desired result is achieved.

Fixed partial denture[18]

Crown lengthening

This is a procedure done when the clinical crown appears to be too short or the patient has an unesthetic gingival contour producing an uneven smile. Corrections can be made by removing excess gingival tissues without raising a flap.

The thermal effect of the laser helps to seal the vascular and lymphatic vessels and vaporizes the excess gingival tissue. Therefore, no sutures are placed and the wound heal by secondary intention.

Advantages

- Helps to maintain a dry and clean surgical field
- Better visualization
- Tissue surface sterilization leads to reduction in bacteremia
- Decreased post-operative complication such as pain, swelling, and edema
- Less traumatic and sometimes no need for anesthetizing the work field
- Faster recovery and increased patient compliance
- Less chairside time.

Laser troughing[16,17]

Laser troughing can be done around a tooth before the final impression. This can be done using the laser, which replaces the use of retraction cord, electrocautery and eliminates the use of hemostatic agents. The results of using laser for troughing are predictable, efficient. Laser simplifies the procedure by minimizing epithelial trauma, reducing bleeding during impression making, and post-operative problems, and reduces chairside time.

Veneer removal[17-19]

Lasers such as Er:YAG and ErCr:YSGG can be used to remove unwanted or failed veneers. The use of laser reduces the difficulty in removing restoration. The laser energy absorbed in the water molecules present in the adhesive weakens the bond between the silane and the resin. The application of laser eliminates the need for cutting the crown while removing. This method enhances debonding without causing any trauma to the tooth.

Removable partial denture

Laser welding[20]

A pulsed laser with relatively low average out power can be used to repair the defects in removable partial dentures. Laser welding is an accurate method which rapidly joins the different components of RPD. However, the success of this method depends on different factors.

For example: For Co-Cr alloy frameworks:

The welding parameters were predetermined for each working step and for each defect (fixing, joining, filling, and planning). The outcome of this procedure depends on the perfect combination of pulse energy (6–14 J), pulse duration (10–20 ms), and peak power (600–900 W).

Treatment of unsuitable alveolar ridges[17-19]

Alveolar resorption is a continuous and constant process that occurs both in the vertical and lateral direction. Thus, if uneven resorption occurs, it will result in atrophic ridges. This will reduce the available saddle area, which leads to an ill-fitting prosthesis. To detach and to smooth the sharp bony projections on the residual ridge, soft-tissue lasers may be used. Commonly used soft-tissue lasers are CO_2, diode, and Nd:YAG. The erbium family of the laser can produce hard tissue surgery.

Treatment of undercut alveolar ridges[17-19]

The alveolar undercut can occur due to inadequate compaction of the alveolar ridges after extraction or failure to replace the fractured alveolar plate. Undercuts are more commonly found in the lower anterior region or with prominent pre-maxilla. This can cause soft-tissue trauma, ulceration, and pain when prosthesis removed from the undercut region. Soft-tissue laser can be used to remove the undercut present. Erbium lasers can also perform osseous surgery.

Implant dentistry

For sterilization of socket[21,22]

In immediate implant dentistry, the laser can be used to sterilize the socket immediately after extraction without any pain.

Peri-implantitis[21,22]

The major advantage of using laser is that they do not transmit damaging heat. Because of this property, lasers can be utilized to clean the implant surface by vaporizing the granulation tissue around the implant. This improves the prognosis of implants.

Removal of diseased tissue around the implant[16,17]

The diode lasers alone or with toluidine O dye can be used for implant maintenance, because of their bactericidal effect. Debridement of implant abutment surface can be done effectively with lasers. This reduces the bacterial count, decontaminates the implant surfaces, and thereby improves the success rate of implants.

Maxillofacial prosthodontics[23]

Newer technologies like RP simplify the process associated with the fabrication of facial prosthesis. This technique is more beneficial as it eliminates the laborious steps in conventional impression techniques and improves patient's acceptance. The selective laser sintering (SLS) technology made possible the fabrication of wax pattern in a simply and effectively. The wax patterns can be made directly in the patient's mouth and this eliminates tedious laboratory procedures.

SLS[23]

The SLS is a CAD method which mainly uses the laser. Lasers are used to design digital models and these data are stored in STL formats. Using specific software, the data are again sectioned to thin slices (typically about 0.1 mm/0.004 inches). On a removable platform, the laser sintering machine produces the models by applying incremental layers of materials. The machine lays down a layer of powdered material one over the other with an accurate thickness, and a solid model is created.

Conclusion

The knowledge and ideas of pioneers in the field of laser are being developed and expanded into clinical practice that can enhance the quality of dental care and make the patient comfortable. The unique features and vast potential of dental lasers allow the overall success rate of any procedures. Thus, lasers have become an inexorable clinical tool in a dental armamentarium. Despite the benefits, laser energy also poses some risks. Hence, the clinician must understand the principles of lasers to take full advantage of its benefits and to provide safe and effective treatment.

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