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Dental Lasers – A Prosthodontic Perspective!!!

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Abstract: *Laser technology is a new breakthrough in prosthodontics, but a practitioner or a dental student has very little knowledge about the uses of lasers in prosthodontics .This article outlines the basics of lasers ,uses of lasers in dentistry in general , applications of lasers in various fields of prosthetic dentistry and also illustrates measures to control laser hazards .*
Keywords*:Lasers, Prosthetic Dentistry,LaserSafety,Laser Hazards.*

I. Introduction

The theoretical basis of laser light production was developed some 90 years ago; the first laser was used on an extracted tooth 47 years ago. It is perhaps somewhat surprising that commercially available lasers have only been used in dental practice during the past 18 years. Associated with the launch of the first 'dental' laser, there was a level of hype that quickly led to a combination of frustration for dentists and researchers that discredited or minimized many of the claims for clinical use.

Unlike many fields of medicine and surgery, where laser treatment represents a sole source of remedy, in dentistry the use of a laser is considered an adjunctive in delivering a stage of tissue management conducive to achieving a completed hard or soft tissue procedure [1].

II. History

In 1704, Newton characterized light as a stream of particles. The concept of electromagnetic radiation, of which 'light' is an example, had been described in mathematical form by Maxwell, in 1880.The search for an explanation led in 1905 to Albert Einstein's fundamental theory that light can be regarded alternatively as composed of discrete particles (photons), equivalent to energy quanta.

In 1953, Charles Townes, experimenting with microwaves, produced a device whereby this radiation could be amplified by passing it through ammonia gas. This was the first MASER (microwave amplification by the stimulated emission of radiation) and was developed as an aid to communication systems and time-keeping (the 'atomic clock').

Albert Einstein first postulated Stimulated Emission in 1917, it was not until 1960 that the first laser was invented by Theodore Maimam. He was a scientist with the Hughes Aircraft Corporation and developed the first working laser device, which emitted a deep red-colored beam from a ruby crystal.

Many other kinds of laser were invented soon after the solid ruby laser – the first uranium laser by IBM Laboratories (in November 1960), the first helium-neon laser by Bell Laboratories in 1961 and the first semiconductor laser by Robert Hall at General Electric Laboratories in 1962; the first working neodymium-doped yttrium aluminium garnet (Nd:YAG) laser and CO_2 laser by Bell Laboratories in 1964, argon ion laser in 1964, chemical laser in 1965 and metal vapour laser in 1966 [1,2].

III. Components Of A Typical Laser

1.)Active medium: The active medium is positioned within the laser cavity, an internally-polished tube, with mirrors co-axially positioned at each end and surrounded by the external energizing input, or pumping mechanism.

2.)Pumping mechanism: This represents a man-made source of primary energy that excites the active medium. This is usually a light source, either a flashlight or arc-light, but can be a diode laser unit or an electromagnetic coil.

3.)Optical resonator: Laser light produced by the stimulated active medium is bounced back and forth through the axis of the laser cavity, using two mirrors placed at either end, thus amplifying the power. The distal mirror is totally reflective and the proximal mirror is partly transmissive, so that at a given energy density, laser light will escape to be transmitted to the target tissue.

4.)Deliverysystem: Depending upon the emitted wavelength, the delivery system may be a quartz fiber-optic, a flexible hollow waveguide, an articulated arm (incorporating mirrors), or a hand-piece containing the laser unit (at present only for low powered lasers).

5.)Cooling system: Co-axial coolant systems may be air- or water-assisted.

6.)Control panel: This allows variation in power output with time [1,3].

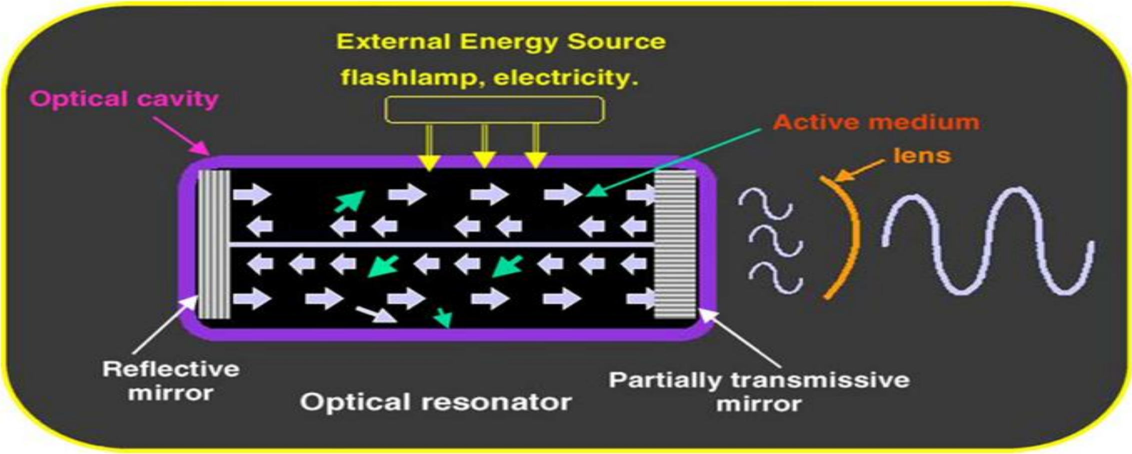

Fig.1. The basic component of a laser. The excitation source provides energy so that stimulated emission will occur within the active medium. The photons are then amplified by the mirrors and emerge as laser light.

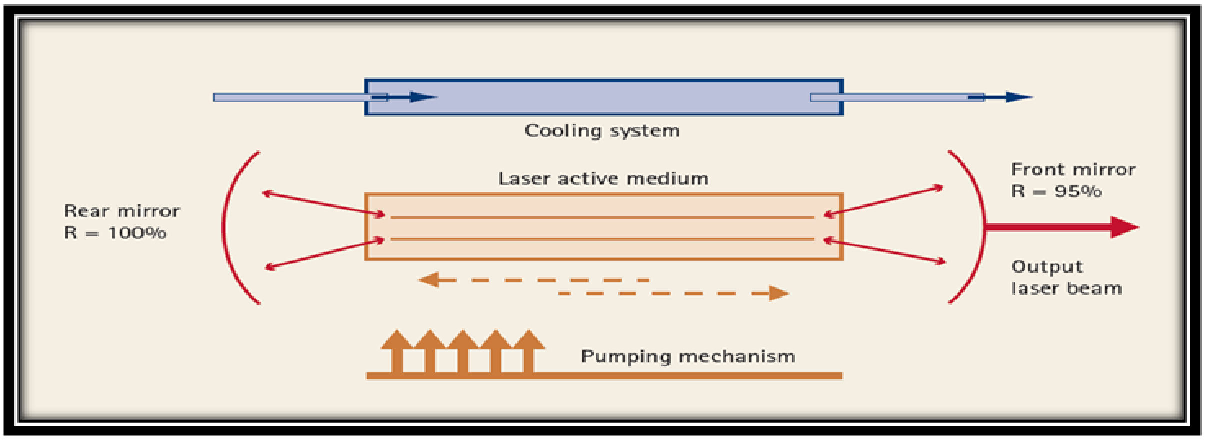

Fig.2. Schematic representation of typical laser cavity. Photons are reflected back and forth, raising the energy levels of active medium atoms.

IV. Laser Physics

Laser is the acronym for "Light Amplification by Stimulated Emission of Radiation" named by GORDON GOULD in 1957. A study of each of these words offers an understanding of the basic principles of how a laser operates.

4.1 Light

Light is a form of electromagnetic energy that behaves as a particle and a wave. The basic unit of this energy is called a photon. Laser light has one specific color, a property called monochromacity. Laser light possesses three additional characteristics: collimation, coherency, and efficiency.

4.2 Stimulated emission

A quantum, the smallest unit of energy, is absorbed by the electrons of an atom or molecule, causing a brief excitation; then a quantum is released, and the process is called as "spontaneous emission". Albert Einstein theorized that an additional quantum of energy traveling in the field of the excited atom that has the same excitation energy level would result in a release of two quanta, a phenomenon he termed stimulated emission. This process would occur just before the atom could undergo spontaneous emission.

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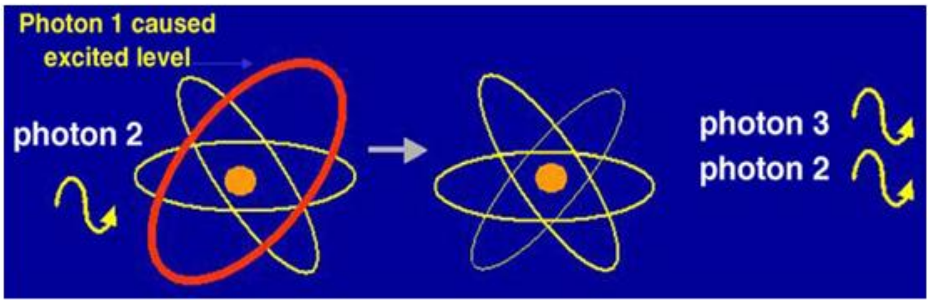

Fig.3. Stimulated emission. Photon 2 is an additional quantum of energy that enters the field of the already excited atom. There is emission of photon 3, and the atom returns to its resting state. Photons 2 and 3 are identical, and this is the beginning of laser light

4.3 Amplification

The photons are reflected back and forth within the active medium to further enhance stimulated emission, and successive passes through the active medium increase the power of and ultimately collimate the photo beam. This is the process of amplification.

4.4 Radiation

Radiation refers to the light waves produced by the laser as a specific form of electromagnetic energy. The electromagnetic spectrum is the entire collection of wave energy ranging from gamma rays, whose wavelength is about 10^{-12} m, to radio waves, whose wavelength can be thousands of meters. All available dental laser devices have emission wavelengths of approximately 0.5 µm (or 500 nm) to 10.6 µm (or 10,600 nm) [1, 4].

V. Commonly Used Lasers In Dentistry

The lasers used in dentistry are illustrated as follows:

Laser	Wavelength	Indications
Argon	488,515 nm	Pigmented lesions, Vascular anomalies, Plastic surgery
Diode	620-900 nm	Periodontal surgery, Bleaching, Photodynamic therapy, Soft laser therapy, Other soft tissue procedures
CO_2	10,600 nm	Soft tissue procedures
Nd:YAG	1,064 nm	Soft tissue procedures, Periodontal surgery, Pigmented lesions
Ho:YAG	2,100 nm	Arthroscopic surgery, soft tissue surgery
Er,Cr:YSGG	27Ba nm	Bone surgery, Periodontal surgery, Cavity preparations
Er:YAG	2944 nm	Bone-surgery, Skin resurfacing, Cavity preparations

Table 1: Lasers and their indications [5]

VI. Uses Of Lasers In Prosthetic Dentistry

6.1 Use of Lasers in Complete Denture Prosthodontics:

1.) Prototyping and CAD/CAM technology
2.) Study of complete denture occlusion using by three-dimensional technique
3.) Analysis of accuracy of impression by laser scanner [6].

6.2 Use of Lasers in Removable Partial Denture Prosthodontics:

1.) Treatment of unsuitable alveolar ridges
2.) Treatment of irregular and undercut alveolar ridges
3.) Surgical treatment of unsupported soft tissues
4.) Treatment of enlarged tuberosity
5.) Surgical treatment of tori and exostoses
6.) Removal of frena
7.) Removal of fibromas and papillomas
8.) Treatment of hyperplastic oral mucosa
9.) Treatment of denture induced mucosal lesions
10.) Vestibuloplasty
11.) Laser welding

12.) Lasermet RPD(laser designed partial denture) [7,8,9,10]

6.3 Use of Lasers in Fixed Partial Denture Prosthodontics:
1.) Gingival troughing
2.) Laser Sulculargingivoplasty
3.) Crown Lengthening Procedure
4.) Crown and Veneer preparation
5.) Gingival retraction
6.) Removal of gingival overgrowth before recementation of bridge
7.) Soft tissue management adjunctive to crown placement
8.) Defining emergence profile of abutment
9.) Bleaching
10.) Veneer removal
11.) Formation of Pontic sites
12.) Laboratory use (MLS crowns, laser welding etc.) [7, 11, 12, 13, 14, 15]

6.4 Lasers Implantology:
1.) Second stage uncovering
2.) Implant site preparation
3.) Peri-implantitis
4.) Implant surface treatment
5.) Implant surface debridement [16, 17, 18, 19, 20, 21]

VII. Dental Laser Safety

Laser safety is an issue limited not only to the performance of treatment within the dental operatory, but one that also encompasses the inter- relationship among health care providers, educational institutions, government and commercial sector.Given proper training with appropriate precautions, lasers may be used safely for the mutual benefit of both the patient and the dentist.

According to the CDRH and ANSI system of classification, class 4 lasers are defined as those devices that pose a biologic hazard from either direct or diffuse reflection. Generally any laser capable of emitting power greater than500 mw continuous wave output belongs in this class(Table 2&3).

CLASS	DESCRIPTION
I	Very low risk "safe under reasonable foreseeable use"
IM	Wavelength between 302.5 nm and 4000nm and are safe except when used with optical aids (e.g. binoculars)
II	Do not permit human access to exposure levels beyond the Class 2 AEL (Accessible Emission Limit) for wavelength between 400nm and 700nm
IIM	Have wavelength between 400nm and 700nm and are potentially hazardous when viewed with an optical instrument
IIIR	Range from 302.5 nm and 106nm and is potentially hazardous but the risk is lower than that of Class IIIB lasers
IIIB	Normally hazardous under direct beam viewing conditions, but are normally safe when viewing diffuse reflections
IV	Hazardous under both intra beam and diffuse reflection viewing conditions. They may cause also skin injuries and are potential fire hazards.

Table 2. Classification of lasers (IEC standards) [22]

LASER HAZARDS ENCOUNTERED IN DENTISTRY
1. OCULAR HAZARDS
2. TISSUE DAMAGE
3. RESPIRATORY HAZARDS/ENVIRONMENT HAZARDS
4. COMBUSTION HAZARDS (FIRE AND EXPLOSION)
5. ELECTRICAL HAZARDS (SHOCK)

Table 3. Types of hazards [22]

7.1 Laser hazard control measures
1.) Engineering controls:Engineering controls such as enclosures, interlocks and beam stops are very effective at eliminating hazards.

2.) Personal protective equipment:All people within the dental treatment room must wear adequate eye protection, including the patient.
3.) Administrative and procedural controls:If general anesthesia is administered during any dental procedure, in place of the standard P.V.C intubation tube, a red rubber or silastic tube should be used. For further protection, the tube can be wrapped with 1/3-1/2 inch aluminium tape. Highly reflective instruments and those with mirrored surfaces should be avoided since they cause damage to the non-target tissues .A wax spatula or periosteal elevator can be inserted into the gingival sulcus to serve as an effective shield when lasing soft tissue near teeth. For most applications it may be advisable to use low power time settings initially before progressing to higher and faster times. When lasers are not actually been used for treatment or if long pauses occur between use, the unit should be placed in a standby mode to prevent inadvertent firing of the laser beam. Most manufacturers provide a cover or metal hood to prevent accidental activation of the laser beam. The foot switch should be cleaned and inspected prior to use to avoid getting stuck in a position while operating. Most laser accidents and injuries can be prevented if appropriate control measures are recognized and implemented.
4.) Environmental controls: Laser use should be confined to controlled areas with restricted access. Use of protective laser curtains should be considered to prevent accidental exposures to passers-by. To avoid an electrical hazard during the operation of the laser unit, the floor of the operating room must be kept dry. Because laser energy generates heat, care must be taken to avoid the use of flammable and explosive liquid or gases in the operating room. Flammable materials such as surgical drapes and gauze sponges may be soaked in sterile saline to reduce the potential of burning by accidental exposure to the laser beam.All staff members should receive objective and recognized training in the safety aspects of laser use within dentistry [7, 22, 23]

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