

LASER-Light Amplification by Stimulated Emission of Radiation

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ABSTRACT

Laser, a device that stimulates atoms or molecules to emit light at particular wavelengths and amplifies that light, typically producing a very narrow beam of radiation. The emission generally covers an extremely limited range of visible, infrared, or ultraviolet wavelengths. Many different types of lasers have been developed, with highly varied characteristics. Laser is an acronym for "light amplification by the stimulated emission of radiation." In that manner, they can confidently make appropriate decisions as to the best device to use on a patient (or the best device to purchase for a practice).

Keywords: Laser, wavelength, Emission, Lasers Hazards

INTRODUCTION

With the advancements in modern technology, new equipment and materials have been developed that can improve the quality and longevity of dental treatment, resulting in better comfort, safety and excellent patient acceptance. "Laser" is an synonym for "light amplification by stimulated emission of radiation." First principle of the laser was known in 1917 when physicist Albert Einstein described the theory of stimulated emission.¹

The main aim of restorative dentistry is to find the best procedure for caries removal to provide conservative treatments. Presence of pain, vibration, and especially application of local anesthesia are some of disadvantages of conventional caries removal methods.² To avoid all this discomfort, relatively new technology such as LASER is being recommended.

FUNDAMENTALS OF LASERS

Lasers are unique and versatile instrument that are being supplied to various aspects of dentistry today.

LIGHT

A form of electromagnetic energy light, exists as a particle, travels in the form of waves at a constant velocity.⁵

Amplitude defined as the vertical height of the wave oscillation from the zero axis to its peak. This defines the amount of energy in the wave: the larger the amplitude, the greater the amount of energy that can do required work.³

Wavelength is defined as the horizontal distance between any two corresponding points on the wave. It is measured in meters; and dental lasers have wavelengths on the order of much smaller units using terminology of either nanometers (10⁻⁹ meters) or microns (10⁻⁶ meters).⁴

Laser Physics

Laser is a device that converts electrical or chemical energy into light energy.⁷

Common principle of laser

Monochromatic

- single wavelength
- Laser light will have one specific light

Coherence

- light waves produced by laser have specific form of energy
- light waves are in plane with one another

Collimated

- have specific spatial boundaries
- have very low divergence with a constant size and shape of beam

Electromagnetic radiation emitted by lasers includes both visible and invisible light. Albert Einstein proposed the concept of stimulated emission of light (1917).⁶

Three processes were described:

1. Absorption
2. Spontaneous emission
3. Stimulated emission

An atom consists of nucleus which contains positively charged particles known as protons, around which electrons are revolving which is negatively charged.⁸

When an atom is struck by a photon, transfer of energy occurs which causes increase in energy of the atom. This process is termed as absorption. When photon ceases to exist an electron within the atom pumps to a higher energy level. This atom is then pumped up to an excited state from the ground state.⁹

In the excited state, the atom is unstable and convert back to the ground state, releasing the stored energy in the form of an emitted photon. This process is called spontaneous emission.¹⁰

When the atom in the excited state is struck by a photon of same energy as the photon to be emitted, the emission could be stimulated to occur earlier than would occur spontaneously. The stimulated emission interaction causes two photons that

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are identical in frequency and wavelength to leave the atom. This process is defined as stimulated emission.¹¹

Laser Types¹²

Based on wavelength.

1. Near infrared eg: diode laser, Nd:YAG
2. Mid infrared eg: Er:YAG
3. Far infrared eg: CO₂

Based on the target tissue

1. Hard tissue lasers eg: diode laser, Nd:YAG, CO₂
2. Soft tissue lasers eg: Er:YAG

Based on pulsing

1. Pulsed
2. Non pulsed

Laser Device¹³

It consists of:

1. Optical cavity
2. Laser medium
3. Power source

A. Laser Medium

Which may be solid, a liquid / gas

As a rule, the lasing medium gives its name to the laser e.g.

Ruby laser (solid)

Nd :YAG (solid)

Dye laser (liquid)

CO₂ (gas) and Argon (gas)

Semi-conductor lasers

B. Power Source

Excites or pumps atoms of laser medium to their higher energy levels.

C. Optical cavity

Consists of 2 mirrors which are reflective and partially transmissive located at either ends of cavity.

LASERS IN PEDIATRIC DENTISTRY

In pediatric dentistry the main aim in delivering care to our young patients is to provide optimal preventive, interceptive, and restorative dental care in stress-free environment. Lasers such as argon, diode, Nd:YAG, CO₂, and now the Erbium family enable minimally invasive dentistry for hard and soft tissue procedures.¹⁴

LASERS USED FOR SOFT TISSUE PROCEDURES¹⁵

Most soft tissue laser procedures can be categorized into one of three simple processes: incision, excision, or ablation.

Incision - performing a small biopsy of a large lesion on the palate.

Excision - Whether the dentist is performing a soft tissue tuberosity reduction to enhance the results of a removable prosthetic treatment plan.

Ablation - removing an area of lichen planus from the buccal mucosa.

Indications

Laser-supported treatments should be favored when treating patients that show one or several of the following symptoms:

- Teeth with a purulent pulpitis or pulp necrosis
- Teeth, of which the crown and root pulp show gangrenous changes
- Teeth with peri-apical lesions
- Teeth with a peri-apical abscess

Application	Possible laser types
Basic research Laser tissue interaction	All types
Oral medicine Laser doppler flowmetry Laser induced fluorescence (caries diagnosis)	He, Ne, diodes He, Ne, diodes Diode
Photodynamic therapy (for treatment of oral cancer) To release fibrotic bands in OSMF Oral soft tissue lesions frictional keratosis, leukoplakia, verrucous carcinoma	ErCr:YSGG Diode
Oral and maxillofacial surgery To achieve hemostasis Tuberosity reduction, alveoloplasty, bone and flap removal	Co2 Erbium
Conservative dentistry DH Cavity preparation Composite resin light curing Tooth surface conditioning, removal of defective composite restoration	CO2, Nd:YAG, Er:YAG Diode CO2, Nd:YAG, Er:YAG Argon, Er:YAG
Endodontics Root canal treatment, apicoectomy	Nd:YAG, CO2 CO2, Nd:YAG
Periodontics Laser-assisted curettage Gingivectomy and gingivoplasty	Nd:YAG, diode CO2
Analgesic effect and bio-stimulation Stimulation of wound healing	He, Ne, diodes, Nd:YAG
DH: Dentinal hypersensitivity, Nd:YAG: Neodymium-doped:yttrium aluminum garnet, Er:YAG: Erbium:yttrium aluminum garnet, Cr:YSGG: Chromium:yttrium-scandium-gallium-garnet	

Table-1: Laser applications in dentistry

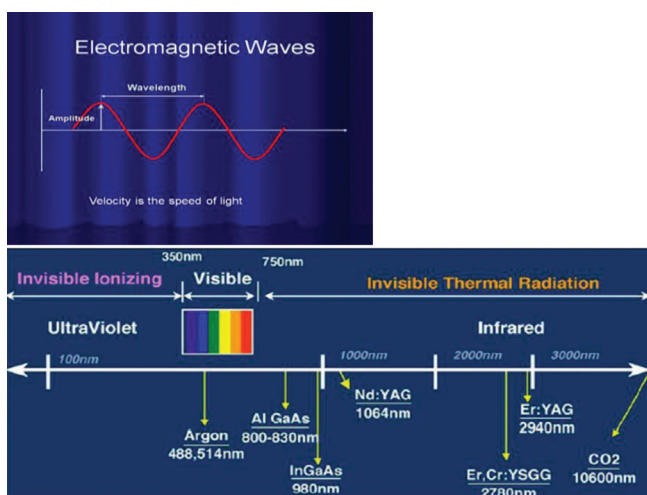


Figure-1: A portion of the electromagnetic spectrum showing dental laser wavelengths being used for treatment

- Teeth with lateral canals that lead to periodontal involvement
- Absorption of the apex caused by trauma
- Teeth that have been treated for at least three months without success

Contraindications

- Advanced periodontitis (degree 3 looseness)
- A deep crown
- Root fracture on the to-be-treated tooth
- Obliterated root canals diagnosed on endodontically affected tooth

Advantages

- During cavity treatment, lasers help in retaining more of the tooth that is intact.
- Osseous tissue removal
- Less painful so reduces the need for administering anaesthesia.
- Lasers lessen the swelling and/ bleeding

Disadvantages

- Delivery systems are bulky.
- No single wavelength will treat all dental diseases.
- Difficult access
- Lasers are relatively high in cost
- Require training for safe and effective operation

Laser safety¹⁸

Surgical lasers are the most hazardous group of lasers. Prevention from them during dental treatment is an important task.

There are three facts to laser safety:

- 1 The manufacturing process of the instrument
- 2 Proper operation of the device, and
- 3 The personal protection of the surgical team and the patient.

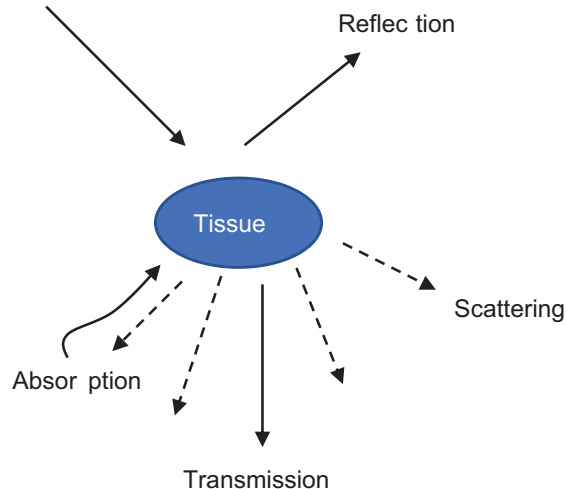
STERILIZATION AND INFECTION CONTROL

Steam sterilization is known to be the standard method of care. After each procedure each and every instrument (small flexible optic fibers, handpieces, or tips) must be steam

sterilized in separate sterilization pouches. They should be kept in the sterilization pouch until required for procedure. The port (connecting) end should be clean and oil free while using fiber-optically delivered lasers.¹⁶

Laser – tissue interaction

Laser irradiation



- When laser is emitted on tissue surface reflection, scattering, absorption or transmission can occur.¹⁷

Hazards

1. Ocular injury
2. Tissue damage
3. Respiratory hazards
4. Fire and explosion
5. Electrical shock

Laser safely control measures recommended by ANSI²⁰

Engineering controls

- Protective housing
- Interlocks
- Beam enclosures
- Shutters
- Service panels
- Equipment tables
- Warning systems
- Key switch

Administrative controls:

- Laser safety officer
- Standard operating procedures
- Output limitations
- Training and education
- Medical surveillance

Personal protective equipment:

- Eye wear
- Clothing
- Screens and curtains
- Special controls:
- Fire and explosion
- Repair and maintenance

CONCLUSION

Lasers represent advanced and effective technology for wide

range of restorative and endodontic applications with better range of outcomes. It is highly recommended that dentists should have proper knowledge and skill by which they can use lasers in various procedures effectively.

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