Lasers In Orthodontics

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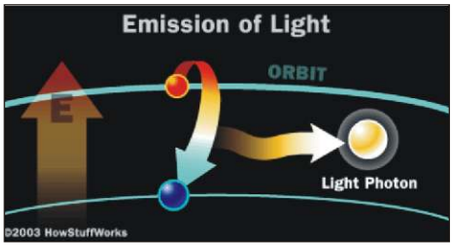
Laser is an acronym for "light amplification by stimulated emission of radiation." A laser is a single wavelength (or color) of light traveling through a collimated tube delivering a concentrated source of energy. Most elements in the periodic system (atoms, gases, organic molecules, diodes, chemicals, or electrons) can be used as media to develop a laser beam.

In a laser, the lasing medium is "pumped" to get the atoms into an excited state.

When a photon of exactly the right wavelength enters the electromagnetic field of an excited atom, the incident photon triggers the decay of the excited electron to lower energy state.

The stored energy is released in the

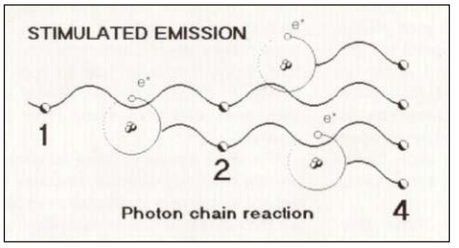


form of a second photon.

Stimulated emission occurs when the incident photon has same energy as released photon.

If a collection of atoms includes more atoms that are pumped into excited state than resting state, a population inversion occurs (it is the number of atoms in the excited state versus the number in ground state.)-ideal condition for lasing. The spontaneous emission of a photon by one atom will stimulate the release of a second photon in a second atom and these two photons will trigger the release of two more photons. These four then yield eight; eight yield sixteen and so on. A brief intense flash of monochromatic (same wavelength) and coherent (same phase) light is produced.

Principle of Laser



Laser works on the principle of generation of monochromatic,coherent and collimated radiation by a suitable medium in an optical oscillator.

Monochromatic

It contains one specific wavelength of light

Coherent

It is "organized" -- each photon moves in step with the others.All waves are in a certain phase relationship.

Collimated

All emitted waves are near by parallel and the beam divergence is very low.

Classification of Lasers

According to mode of emission

- Fractioned
- Continuous
- Pulsed

According to power

- High power laser
- Medium power laser
- Low power laser

According to emitting material

- Gas laser
- Solid state laser
- Dye laser
- Semi conductor diode laser
- Ring laser

The Carbon Dioxide Laser

The lasing medium contains a mixture of carbon dioxide, nitrogen and helium gases.Nitrogen molecules are pumped up with energy from an electric discharge applied to the lower tube.Because its wavelength of 10.6 m is well absorbed by enamel, it was thought that the carbon dioxide laser might be suitable for selected surface applications to teeth, such as the sealing of pits and fissures; the welding of ceramic materials to enamel; or the prevention of dental caries

Solid State Lasers

In solid state lasers,the lasing medium is suspended in a transparent crystal. A garnet crystal made from yttrium and aluminium is commonly used in a variety of surgical lasers call YAG lasers.YAG lasers can be used in combination with three rare earth elements, neodymium,holmium and erbium.

Argon Laser

It is one of the rare gas ion lasers capable of outputs of several watts continuous light in the visible green and blue portion of the spectrum.The active lasing medium is argon gas.

Laser Type	Wavelength (nm)
Argon fluoride (UV)	193
Krypton fluoride (UV)	248
Xenon chloride (UV)	308
Nitrogen (UV)	337
Argon (blue)	488
Argon (green)	514
Helium neon (green)	543
Helium neon (red)	633
Rhodamine 6G dye (tunable)	570-650
Ruby ($CrAlO_3$) (red)	694
Nd:Yag (NIR)	1064
Carbon dioxide (FIR)	10600

The Neodymium Laser

Nd:YAG laser is an effective tool for inhibiting the formation of incipient caries both in vitro and in vivo.

Laser Effects on Dental Hard Tissues

Thermal effects

The best known laser effect in dentistry is the thermal vaporization of tissue by absorbing infrared laser light. The laser energy is converted into thermal energy or heat that destroys the tissues. At 100 degrees centigrade the water inside the tissue vaporizes.

Mechanical effects

High energetic and short pulsed laser light can lead to a fast heating of the dental tissues in a very small area leading to mechanical damage of the irradiated tissue.

Chemical effects

The basis of the photochemical effect is the absorption of laser light without any thermal effect which leads to an alteration in the chemical properties of the irradiated tissues.

Enamel surface response to laser ablation

Carbon dioxide medium: Surface fusion, roughness, etching, partially fused crystallites, charred, cracking.

Nd:YAG: Terraced surface, rough fused crystallites, charred, cracking.

Argon: Reflection of beam produces minimal effect on enamel surface.

Ruby: Cratering, irregular cavitation surface, charred.

Uses Of Lasers in Dentistry

Argon laser: Are used for Root planing and curettage, Oral lesion therapy and Laser Tissue welding i.e. fusing vascular tissues by laser thermal welding and for coagulation and hemostasis of bleeding vessels.

Carbon dioxide Laser: Are used for Biopsies, Coagulation, Exposure of Implants, Distal wedge and tuberosity reduction, Hypersensitivity treatment , Pre prosthetic surgery, Gingival troughing etc.

Er:YAG Laser: Are used for Removal of dental filling materials and Bone ablation and oral soft tissue ablation.

Orthodontic Applications of Laser

- Gingivectomy/gingivoplasty
- Frenectomy
- Pain control with LLLT
- Demineralization resistance
- Bone growth
- Etching
- Bonding
- Debonding
- Newer brackets with laser cut bracket bases
- Holographic studies

Laser Etching

Laser irradiation at 1 W resulted in higher bond strengths of 5.64 ± 3.19 MPa, which is significantly different from that of acid etching. The time needed for laser systems is only 15 seconds, also shorter than that required for phosphoric acid. Thirty seconds of chair-time saving for each tooth equates to at least 5 minutes of chair-time saving for a full-mouth bonding.

From a clinical standpoint, saving chair time also improves adhesion because it reduces the risk of salivary contamination.

Laser Debonding

One of the major concerns when using ceramic brackets is the risk of enamel damage at debonding or that of bracket fracture.The occurrence of fractures can be explained by the high bond strength of ceramic brackets. Therefore, a debonding technique that reduces the required forces decreases the risk of enamel fracture .Laser energy can degrade the adhesive resin by 3 methods:

- Thermal softening,
- Thermal ablation
- Photoablation.

Thermal softening occurs when the laser heats the bonding agent until it softens. this results in the bracket's succumbing to gravity and sliding off the tooth surface.

Thermal ablation occurs when heating is fast enough to raise the temperature of the resin into its vaporization range before debonding by thermal softening occurs. This results in the bracket's being blown off the tooth surface.

Photoablation : It occurs when very high-energy laser light interacts with the adhesive material and the energy level of the bonds between the adhesive resin atoms rapidly rises above their dissociation energy levels, resulting in decomposition of the material.

The risk of enamel damage and bracket fracture is significantly reduced with lasers. The CO2 super-pulse laser is superior to normal-pulse CO2 and YAG lasers.

The risk of pulpal damage is significantly reduced if the following are used:

Super-pulse CO2 laser at 2 W for less than 4 seconds.

CO2 laser (10.6 m) for 3 seconds at 3 W.

CO2 laser (normal pulse) at 18 W for 2 seconds.

Pain Therapy

Low level laser has been shown by many investigators to produce analgesic effects in various therapeutic and clinical applications.Low level laser therapy (LLLT) is defined as laser treatment in which the energy output is low enough so as not to cause a rise in the temperature of the treated tissue above 36.5° C or normal body temperature. Because of its lower energy output and intensity, its effects are mainly nonthermal and biostimulatory.

The mechanisms of laser analgesia have not been established, but it has been attributed to its antiinflammatory and neuronal effects.Other neuronal effects include stabilization of membrane potential and release of neurotransmitters

Laser Welding

A common task for industrial lasers is the fusion of two metals without the aid of soldering agents. It is clearly documented that laser welding is stronger than solder joints of comparable size.This factor plus the low thermal distortion which accompanies the welding process makes the lab welding of prostheses very attractive.

The rapid and repeatable action of the pulsed neodymium laser micro welder used in simulating intra oral welding strongly suggests that safe intra oral welding can be done with proper controls on a routine basis with no damage to hard tissue.

White spot lesions

Enamel decalcification is a significant problem in orthodontic patients. The argon laser has been shown to reduce decalcification during an acidic challenge in vitro.

The use of the argon laser in dentistry has been proposed for polymerization of resin materials and bleaching of enamel. It has been shown to be safe for the intraoral polymerization of composite materials at low fluence levels. Recent studies suggest that the argon laser can be used to prevent enamel decalcification by altering the crystalline structure of enamel.

Soft tissue lasers

The uses of soft tissue lasers in orthodontic practice broadly fall into the following categories: (1) improving gingival shape and contour, (2) lengthening crowns, (3) idealizing tooth proportionality, and (4) resolving crown/height asymmetries.

Soft tissue reacts differently to a diode laser than to a scalpel. The laser can deliver energy in either a continuous or a pulsed mode. In the continuous mode, the tissues tend to absorb more energy, resulting in greater heat. The pulsed mode permits intermittent cooling between pulses of energy. Because the amount of heat generated during the procedure translates directly into the amount of collateral damageand thus postoperative discomfortit is generally recommended that the laser be used at a lower setting and in the pulse mode for soft tissue procedures.

Gingivectomy Performed With A Laser

Laser Tooth Whitening

The whitening effect with the use of argon laser is achieved by a chemical oxidation process. Once the laser energy is applied, the hydrogen peroxide (H_2O_2) breaks down to water (H_2O) and a free oxygen radical, which combines with and thus removes the stains molecule.

Holography

Holography is a photographic technique for recording and reconstructing images in such a way that the three-dimensional aspect of an object can be retained. The recorded image is called a hologram.Uses of holography include holographic study models, Holographic determination of centers of rotation produced by orthodontic forces and measurement of tooth movements achieved with orthodontics.

Laser hazards

Types of Laser Hazards

Eye : Acute exposure of the eye to lasers of certain wavelengths and power can cause corneal or retinal burns (or both). Chronic exposure to excessive levels may cause corneal or lenticular opacities (cataracts) or retinal injury.

Skin : Acute exposure to high levels of optical radiation may cause skin burns; while carcinogenesis may occur for ultraviolet wavelengths (290-320 nm)

Chemical : Some lasers require hazardous or toxic substances to operate (i.e., chemical dye, Excimer lasers).

Electrical : Most lasers utilize high voltages that can be lethal.

Fire : The solvents used in dye lasers are flammable. High voltage pulse or flash lamps may cause ignition. Flammable materials may be ignited by direct beams or specular reflections from high power continuous wave (CW) infrared lasers.

Environmental Hazards

Potential inhalation of airborne hazardous materials that may be released as a result of laser therapy.

Some lasers contain inert gases (argon, krypton or xenon) mixed with toxic gases such as fluorine or hydrogen chloride as the actie medium.

Inhalation of toxic material in the form of aerosols has been found potentially damaging to the respiratory system.

Standard surgical masks and surgical smoke evacuation equipment is used in the theatre.

Greatest producers of smoke carbon dioxide and Nd:YAG laser.

Conclusion

Understanding the various uses of lasers, is simply to accept, the cutting edge of present day orthodontics.With its numerous uses in dentistry and its ever growing uses in orthodontics,the safety precautions,and its disadvantages should also be kept in mind.To conclude, lasers are our tools of tomorrow, only if we are ready with the knowledge of it today !