# LASER IN ORTHODONTICS- A REVIEW

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**ABSTRACT:**

The usage of lasers in dentistry has now become an integral part of everyday clinical practice. As we enter the next millennium we see that dentistry has advanced by leaps and bounds. Among the various advances, the one, which has a good scope of improvement, is the use of lasers in dentistry. Recent advances in laser technology and research has set the stage for revolution in dental practice. Thus, this article reviews the use of laser in orthodontics and provides an overview of types of laser, application in orthodontics, and laser safety.

**Keywords**: Amplification, Lasers, Radiation.

## INTRODUCTION

In the past two decades, laser devices have been used in innumerable ways to benefit humankind. LASER, which stands for Light Amplification by Stimulated Emission of Radiation, a process that can efficiently transmit energy through an electro-optical device in the form of a concentrated beam of light. The theoretical concept of the laser was proposed by Einstein in 1917. Lasers were developed in early 1960's and increasingly found a number of uses in medicine and surgery. Laser were introduced into general dentistry in the year 1994 and their use in orthodontics was established in no time since their introduction.[1] LASER is the acronym of the words 'Light Amplification by Stimulated Emission of Radiation'. A laser is a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation.[2]

When an atom of a substance in an excited state undergoes a spontaneous decay it emits a photon. In laser that photon communicates with another energized atom and stimulates the emission of another photon with accurately the same wave characteristics, further stimulates atoms and produce additional identical photons. The light waves created in the way are reflected back and forth repeatedly between mirrors set on either end of the laser chamber. Through a hole at the center of the partially reflective mirror, the laser beam leaves the chamber.[3]

Laser light has 3 basic properties:

•It consists almost entirely of one wave length advancing in the same direction (coherence)

•The light is traveling in a parallel plane with no divergence. (collimation)

•All laser energy intensifies at one wavelength and hardly deviates (Monochromaticity).

Commonly laser has low divergence Light from. It can go over incredible separations or can be engaged to a little spot with a splendor which surpasses that of the sun. On account of these properties, lasers are used different applications in all pursuits[4]

## COMMON LASER TYPES USED IN DENTISTRY

There are currently 24 indications for the use of dental lasers, mostly used are:

1. Argon laser – Argon laser
2. CO2 laser – Carbon dioxide laser
3. Diode laser – Diode laser (or Gallium Arsenide)
4. Er,Cr:YSGG laser – Erbium, Chromium: Yttrium-SeleniumGallium-Garnet laser
5. Er:YAG laser – Erbium: Yttrium-Aluminium-Garnet laser

6. H:YAG laser – Holmium: Yttrium-Aluminium-Garnet laser
7. Nd:YAG laser – Neodymiumdoped: Yttrium-AluminiumGarnet laser
8. KTP laser – Potassium Titanyl Phosphate (KTiOPO4) laser[5,6]

**Carbon dioxide laser**

The lasing medium in Carbon dioxide laser contains a mixture of carbon dioxide, nitrogen and helium gases. Nitrogen molecules are stimulated with energy from an electric discharge applied to the lower tube. The light energy, whose wavelength is 10,600 nm, is positioned at the end of the mid-infrared invisible nonionizing portion of the spectrum, and it is delivered through a hollow tube-like waveguide in continuous or gated pulsed mode. This wavelength has the highest absorption in hydroxyapatite of any dental laser, which is 1000 times greater than 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 or each.

**Diode Lasers**

Diode lasers are increasingly becoming popular owing to their compact size and relatively affordable pricing. A specialized semiconductor that yields monochromatic light when stimulated electrically is common to all diode lasers. An example is; a simple laser pointer. Diode lasers can be used in contact as well as non-contact mode and can function with continuous wave or gated pulse modes. Though they are not capable of free running pulsed mode. Diode lasers are invisible near infrared wavelengths and current machines ranging from 805 –1064 nm. One exception is the Diagnodent; a caries diagnostic laser which uses a visible red wavelength of 655 nm. Diode lasers are used for soft tissue only. The chromophores are pigments such as hemoglobin and melanin. Photothermal interactions predominate. They are quite effective for Gingivectomy, Biopsy, Frenectomy, and Photobiomodulation

Erbium Lasers

Erbium lasers comprises of two different crystals, the Er:YAG (Erbium yttrium aluminum garnet crystal) and Er,Cr:YSGG (Erbium chromium sensitized yttrium scandium gallium garnet crystal). They have different wavelengths, Er:YAG has 2940 nm and Er,Cr:YSGG has 2780 nm. There is a substantial water absorption difference between these two wavelengths. Er:YAG wavelength is at the peak of water absorption in the infrared spectrum whereas the Er,Cr:YSGG exhibits much lesser absorption. The Er,Cr:YSGG has also been shown to have considerably deeper thermal penetration in tooth structure. The erbium lasers are both, hard and soft tissue capable. Their primary chromophore is water, but hydroxyapatite absorption occurs to a lesser degree

**Nd:YAG (Neodymium: Yttrium – Aluminum – Garnet) laser**

It was developed by Ceusic in 1964. A wave length of 1.06 microns and can be transmitted via a fiber optic cable to hand pieces which resemble conventional dental instrument in size and shape. It is possible to cut soft tissues relatively painlessly. Unlike the Co2 laser, Nd:YAG laser beam because of its near infrared range can be delivered through a pure optical fiber. The laser beam is carried through a silica fiber 320 □m in diameter. Nd: YAG laser uses helium - neon (red) laser for aiming the beam; it can be delivered either contact or non contact system. The soft tissue surgery can be performed without needing the use of local anesthetic which may be useful for removing opercula from partly erupted teeth. This type of laser cannot be used on bone because it will damage bone cells at a considerable depth, causing necrosis.

**APPLICATION IN ORTHODONTICS**

Management of impacted teeth

•The diode laser can be used to remove tissue and provide access for attachment. These procedures provide earlier attachment to teeth and can significantly reduce treatment times.[7,8]
•Operculums on second molars often prevent banding of these teeth, resulting in increased treatment time to await further eruption.
•The diode laser can be used to help the clinician in evading these situations by going directly to attachment, bracket, or band placement[9,10,11]

**Laser Etching in Orthodontics**

Laser etching can be done using various types of lasers such as Argon laser, Krypton fluoride excimer laser and Arf-193nm, Krf-248nm, Xecl-308 nm
Principle: The high performance density leads to a locally with the irradiated material that splits restricted very strong and fast interaction the bond of organic and inorganic substances on the surface. This process of microexplosion is called photoablation.[12]
Due to the extremely short pulse length of some nanoseconds and sudden removal, there is no efficient heat conductance through the hard substance which shows that there is no harmful increase in the temperature of the pulp.[13]

**Bonding**

Argon laser for light curing adhesives the enamel surface was etched with 37% phosphoric acid for 15 seconds.14
•The surface was treated with Megabond.
•Adhesive precoated brackets were placed on enamel surface.
•Laser tip was held 0.5mm from the bracket and the light curing wand was kept touching the bracket.
•No enamel damage caused by argon lasers at energy levels of 1.6 to 6 watts.
It shows that 10 seconds of curing with argon laser yields bond strengths comparable to those achieved with 20 to 40 seconds of curing with a conventional high intensity light. The time saved in bonding a full arch is significant with the help of Laser.[15]

**Laser Debonding of Ceramic Orthodontic brackets**

Laser light has been shown to damage resins by thermal softening or photo ablation. Polycrystalline alumina and single crystal alumina (sapphire) ceramic orthodontic backets, both were bonded to the labial surface of lower deciduous teeth with regular acid etch technique
•The brackets were debonded by irradiating the labial surfaces of the brackets with laser light at wavelengths of 248nm, 308nm, 1060nm, under externally applied stress of 0.8Mpa,
•Debonding times were measured and the surfaces formed by debonding were detected with both light and scanning electron microscopy to conclude the extent of bracket and enamel damage.[16]
Laser energy can damage the adhesive resin by 3 methods
●Thermal softening – It occurs when the laser heats the bonding agents until it softens.
●Thermal ablation – It occurs when heating is fast enough to raise the temperature of the resin into its vaporization state before debonding by thermal softening occurs.
●Photo ablations – It occurs when high energy laser light interacts with the adhesive
material and the energy level of the bonds between the adhesive resin atom rapidly rises above their dissociation energy levels causing decomposition of material. {CO2 YAG lasers}
Time span for debonding in the laser is less than 4 seconds (2.9 □ 0.9 seconds) Debonding force is reduced in laser. Risk of enamel damage and bracket fracture is less. No pulpal injuring occurs when the max intra pulpal temp rise stayed below 2°C. The outcome of lasting time on intrapulpal temp increased and tensile debonding force with a 18 watt carbon dioxide laser. Ceramic bracket can also be debonded by laser debonding pliers.
The debonding of polycrystalline brackets is initiated by thermal softening of the bonding

resin due to heating of the bracket. The hot bracket then slides off the tooth. Ideal debonding time – 0.5 seconds shows no pulp reaction, Pulp irritation increases only with rise in lasing time. No enamel tear outs and catastrophic bracket failures were found. Nd:YAG laser and carbon dioxide laser are the lasers used. Porosity indicative of gas formation in a molten resin was found in a few locations.[17]

**Newer Bracket Systems**

Newer brackets with laser reinforced structured bases allow the force to be applied more closely to the crown. The patented laser structured base of brackets assures a tremendous bond during the complete treatment period.

Laser markings aid in easy identification of brackets. Also laser markings cannot be abraded and does not contain harmful coloring agents as opposed to conventional markings.[18]

Efficacy of low level laser therapy (LLLT) in reducing orthodontic post adjustment pain.

LLLT has displayed analgesic effects in many clinical applications. Terminology involved soft laser, mid laser, low energy laser, cold laser. Defined as laser treatment in which the energy output is small enough so as not to create an increase in the temperature of the treated tissue more than 36.5 degrees centigrade or normal body temperature.[19]

Biostimulatory effects of LLLT have been caused by its anti inflammatory and neuronal effects. It was proposed by Harris that LLLT has benign stimulatory influence on depressed neuronal and lymphocyte respiration. Stabilization of membrane potential and release of neurotransmitters.[20] Laser unit used was Class 3B Gallium diode laser probe with a wavelength of 830 nm. It was reported that LLLT stimulated the velocity of tooth movement via RANK and c-Fms gene expressions in vitro by Fujita et al. (2008) and Yamaguchi et al. (2007)[21]

**Laser Holography**

Hans Rydin and Bielkhagen (1982) developed a new method for comparing the tooth positions on the dental casts at different stages.[22]

Holograms of the casts were prepared using Helium Neon laser. Burstone C.J., T.W.Every and R.J.Pryputneiwiz (1982) based on pulsed laser hologram inferometry studied the dynamics of incisor extrusion

Technique is the output from the laser is split into two parts by beam splitter. One part was expanded by a beam expander and is used to illuminate the object. The scattered wave from the object is called object wave.[23]

**Laser spectroscopy**

Used in the field of dentistry for the purpose of analyzing the surface structures of dental materials. Used for gauging the surface roughness of orthodontic wires, brackets, assessment of materials, surface changes of orthodontic materials.[24]

**3D Laser Scanning**

Obtains 3D surfaces by recording measurements made by efficiently sweeping a handheld laser scanning pointer over an object, Similar to spray painting. The object's image immediately appears on computer screen. Completed scan is checked to combine any overlapping sweeps. Considerably decreasing the time to develop surface models. The mechanism of the scanner is to cast a fan of laser light over the object, while the camera on the pointer observes the laser to record a cross-sectional profile of the object. The software is used to conclude the position and orientation of the pointer facilitating the computer to reconstruct the full three-dimensional surface of the object.[25]

**Laser Micro Welding**

Laser welding results in deep penetration welds with least heat effective zones. Laser welding has the benefit of welding dissimilar metals while generating very low heat. The process is a non-contact one that aims laser

outputs of 2-10 kW into a very small area. The laser beam makes a 'keyhole and the liquid steel hardens behind the traversing beam, leaving a very narrow weld and heat affected zone. The weld is approximately 1 mm wide and the adjoining material is not distorted because the weld bead is small, there is generally no need for finishing or re-working and this minimizes costs.[24,26]

**Orthophaser**

Orthophaser Unit is comparatively larger than the conventional spot welder. It delivers highly superior result. Almost all metals can be welded by using it, including the most recent and popular titanium. The unit comprises of working microscope with integrated eye protections, flexible hand piece with a locking mechanism for the hand piece and a compact control with pre-programmed parameters. Argon is the gas used in this unit.

Effect of Lasers for Demineralisation Resistance

Under acid attack, exposure of enamel to laser irradiation imparts some degree of protection against demineralization. Using quantitative micro radiography, argon laser irradiation of enamel decreases the amount of demineralization by 30- 50%. Fox et al found that, in addition to reducing enamel demineralization and loss of tooth structure, laser treatment can cut the threshold pH at which dissolution occurs by about a factor of five. In sound enamel, calcium, phosphorus and fluoride ions diffuse into the acid solutions and are released into the oral environment with lased enamel, the microspaces formed by laser irradiation, trap the released ions and becomes the areas of mineral reprecipitation within the enamel structure. Thus, lased enamel has a greater affinity for calcium, phosphate and fluoride ions. This prevents demineralization.[27]

**Soft Tissue Lasers**

Soft tissue laser is an operative tool to aid in the management of treatment and improve our aesthetic results. The soft-tissue laser can considerably decrease treatment time by creating access for brackets/bands, refining bracket placement by improving tooth proportionality, and helping manage oral hygiene by eliminating the pseudo pockets. Gingival aesthetics can be improved through shaping and contouring the gingival tissue during treatment.

**Laser-Orthopaedics**

Lasers can be applied to manipulation facial growth. Study by Mostafa Abathi and Maryam in rabbits showed irradiation TMJ by LLL during mandibular advancement increases bone formation in condylar region. They irradiated TMJ by 630 nm KIO3 laser for 3 weeks Found that increase in bone formation in condylar region, while no increase in cartilage thickness and fibrous tissue.[28]

**LASER SAFETY**

According to the standards of American National Standards Institute and Occupational Safety and Health Administration, lasers are classified into four different classes based on potential danger, as follows:

Class I: These are low powered lasers that are safe to view

Class IIa: These are low powered visible lasers. They do not cause damage unless one looks directly along the beam for longer than 1,000s

Class II: These are low powered visible lasers. They are dangerous when viewed along the beam for longer than 0.25 s

Class IIIa: These are medium powered lasers that are not dangerous when viewed for less than 0.25 s

Class IIIb: These are medium powered lasers that are dangerous when viewed directly along the beam for any length of time

Class IV: These are dangerous high- powered lasers that can cause damage to the skin and eyes. Even the reflected or radiated beams are dangerous. It is necessary to take appropriate safety measures. Most of the lasers used for

medical and dental purposes are in this category.

In addition, the inhalation of laser deposits consisting of organic materials, water vapour, carbon monoxide, carbon dioxide and hydrocarbon gas can be dangerous. It is known that lasers operating at wavelengths below 400 nm (although not typically used in dentistry) have a detrimental effect to the skin. Lasers operating at non visible wavelengths (ultraviolet and infrared) and reflection of laser light from various surfaces can also increase potential danger. Because the biggest risk is for the eyes, protective glasses must be worn by the patient and the practitioner during laser therapy.

## CONCLUSION

As orthodontic clinicians have become increasingly focused on aesthetics, treatment quality, and increased productivity, new tools and technologies have become available that allow them to produce superior results in a minimal amount of time. One such tool is the dental laser.

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