Review Article

Laser and Its Use in Pediatric Dentistry: A Review of Literature and a Recent Update

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Abstract

Since last two decades, the use of laser in dentistry evolved in an immense way. Although soft-tissue laser was initially introduced, but with invention of new-generation laser, it is now widely used on dental hard tissue as well. Commonly used laser in dentistry includes neodymium-yttrium aluminum garnet laser, erbium: yttrium aluminum garnet, CO_2, erbium chromium:yttrium scandium gallium garnet, holmium:yttrium aluminum garnet, and diode laser. Treating a pediatric patient with laser for oral and dental procedure is beneficial as it is less fearful to the child and better accepted by parents. When a clinician uses the laser for surgical or pulpal procedure, children become more cooperative and thus enhances treatment outcome. It is used for caries prevention, early diagnosis, cavity restoration, management of traumatized teeth, and minor oral surgical procedure in child patients. Although the use of laser may produce certain hazards and need some precautions, its use in pediatric dental practice seems to soon become the gold standard.

Keywords: Different laser application in dental field, laser, laser in pediatric dentistry

Introduction

The word LASER is an acronym which stands for light amplification by stimulated emission of radiation, and it was first introduced in an article in 1959 by Gordon Gould, a Columbia University graduate student.[1] In 1917, when physicist Albert Einstein described the theory of stimulated emission, the principle of the laser was unfolded.[2] The first working laser was developed by Theodore Maiman at Hughes Research Laboratories in 1960.[3] CO_2 laser was invented in 1964 by Patel at Bell Laboratories;[1] however, it was introduced in oral surgery for removal of soft-tissue lesion in the 1980s.[4,5] In 1987, neodymium-yttrium aluminum garnet (Nd-YAG) laser was specifically developed for dental procedure, and later in 1990, it was approved by the Food and Drug Administration.[6,7] Although initially laser was used for soft-tissue procedure, but with the invent of new generation of laser, it is now widely used on dental hard tissue as well. Hard tissue laser provides an effective alternative to conventional drilling with a better working field for the clinician that enhances good result and better treatment outcome. Moreover, sharp dental instruments, drilling sounds, and vibration can be avoided in dental procedure and that may be helpful in pediatric dental practice.[8] With the recent advancement in laser application, it is now effectively used for diagnosis, prevention, and treatment of dental caries and also for minimally invasive procedure.[9] The rational use of soft- tissue and hard tissue laser for different oral procedure in infants, children, and adolescent is also recommended by the American Academy of Pediatric Dentistry.

Historical Background

- 1%–3% neodymium was used with yttrium-aluminum-garnet crystals for the production of Nd-YAG laser in 1961[1]
- One year after the development of Nd-YAG laser argon laser was developed, and in 1963, ruby laser was first used for the coagulation of retinal lesion[1]
- In 1964 at Bell Laboratories, CO_2 laser was built up by Patel
- In 1971, Weichman and Johnson reported the use of infrared CO_2 laser for apical foramen sealing in *in vitro* study.[10]

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After invent of diode laser, the laser application in the field of dentistry became widespread.

Classification of laser

Laser light is a single wavelength monochromatic light produced by the stimulation of a synthetic material.[11] For incising, cutting, and ablation, it uses light energy which has a continuous uniform emission from light chamber to target tissue.[8] There is an active medium (either gas or crystal or a solid state or a semiconductor) which on stimulation produces photons of energy and lasers are often named after their active medium. It is the wavelength which is unique for different lasers determines their clinical applications.[12] Chromophore or light-absorbing pigments are present in oral and dental hard tissue, and they are responsible for absorbing laser energy of a specific wavelength.[13-15]

Laser-tissue interaction

When laser light is applied on target tissue, it initiates photothermal reaction which causes heat generation and a rise in temperature within the tissue.[16] When this temperature is above 60°C, it causes protein coagulation within the tissue.[4] However, when the temperature rises above 100°C, it causes vaporization of water molecule and soft-tissue ablation.[4] However, above 200°C temperature is required for hard tissue procedure.[15]

When laser light hits target tissue, four types of interactions take place which depends on the optical properties of the target tissue and the wavelength of the laser light. These interactions are as follows:

- Absorption of laser light
- Transmission of laser light
- Reflection of laser light
- Scattering of laser light.

Absorption

The presence of chromophore within the target tissue is responsible for the absorption of laser light.[13-15] Different wavelengths of laser light have different coefficients of absorption with hard and soft-tissue components such as mineral, water, blood component, and pigment. The laser light having a shorter wavelength predominantly between 500 and 1000 nm is well absorbed by blood components and tissue pigments whereas those with longer wavelength have higher affinity with hydroxyapatite crystal and water molecule.[6]

Transmission

Transmission of laser light may occur through the target tissue without causing any effect, and this property largely depends on the wavelength of laser light.

Erbium family laser and CO_2 laser are well absorbed by tissue fluids whereas laser energy from argon and Nd-YAG is get transmitted to the adjacent tissue when it hits tissue fluids.[6]

Reflection

Laser light may be reflected from the target tissue without producing any effect on the tissue. This unintentional reflection could be dangerous for the eyes. However, this property is used by caries detecting laser to measure sound tooth structure.

Scattering of laser light

Scattering of laser light results in heat transfer and damage of tissue adjacent to the target area. It also decreases the favorable clinical outcome. However, this property is beneficial when the clinician is intended to treat an aphthous ulcer or cure a composite resin restoration.[6]

Different lasers and their applications in dental field

Commonly used laser in dentistry includes Nd-YAG laser, erbium: yttrium aluminum garnet (Er: YAG), CO_2, erbium chromium:yttrium scandium gallium garnet, holmium:yttrium aluminum garnet, and diode laser. These are used for soft-tissue and hard tissue procedure in the oral cavity and orofacial regions such as cavity preparation, caries detection, bonded restoration, root canal cleaning, periodontal surgery, treatment of peri-implantitis, and maxillofacial surgery.[9]

Nd:YAG laser has a wavelength of 1064 nm with a pulsed mode, and it is used for ablation or incision of soft-tissue lesion and removal of incipient caries.[16]

CO_2 laser has a wavelength of 10,600 nm with a gated or continuous mode. It has a limited penetration of 0.03–0.1 mm in the tissue and thus indicated for soft-tissue incision, ablation, deepithelialization, and periodontal surgery.[16] Er: YAG and Er-Cr: YSGG have wavelength 2940 and 2780 nm, respectively. They are mainly used in endodontic root canal preparation, caries removal, and cavity designing. Er-Cr: YSGG can ablate bone without causing bone charring or alteration of calcium-phosphorus ratio.[16] Nowadays, the diode laser is widely used. These are gallium-arsenide lasers with a wavelength of 904 nm and are mostly used for soft-tissue procedure.

Laser in pediatric dental practice

Treating a pediatric patient with laser for oral and dental procedure is beneficial as it is less fearful to the child and better accepted by parents.[17] When clinician uses the laser for surgical or pulpal procedure, children become more cooperative and it also enhances the treatment outcome.[16] It is used for caries prevention, early diagnosis, cavity restoration, management of traumatized teeth, and minor oral surgical procedure in child patients and seems to soon become the gold standard in pediatric dental practice.[18] Different laser application in pedodontic practice is described below:

Soft-Tissue Applications of Laser

Frenectomy and treatment of ankyloglossia

When hyperactive labial frenum is present, a laser-assisted frenectomy could be done with Er: YAG laser in an attempt for diastema closure.[19] Er: YAG laser is also used for surgical management of severe tongue tie or ankyloglossia in infants and children.[20]

Gingival recontouring and crown lengthening

CO_2 laser is used for gingivectomy procedure.[21] It is also used for surgical removal of soft-tissue tumor in the oral cavity.[22]

With the advent of diode laser, nowadays, clinicians prefer to reproduce gingival esthetics as a part of comprehensive orthodontic treatment.[23,24]

The advantage of using the laser in gingivectomy and gingival recontouring is that it provides a bloodless field and also sterilizes the wound by reducing the microbial load exposed to laser radiation.[16]

Exposure of unerupted tooth

To expose a unerupted or partially erupted tooth for orthodontic bracket or button placement laser is used. As the laser-assisted surgical field is relatively bloodless, immediate placement of bracket or button can be done. Er: YAG, Nd:YAG, and Er-Cr: YSGG are mainly used for this purpose.[25]

Pulpotomy of primary teeth using laser

For the preservation of pulp vitality lasers of different wavelength are used with a power of 0.5–1 W. They are used in pulse mode without water and at a low frequency for the duration of 10 s to avoid coagulation.[26] CO_2 laser can be used for pulpotomy in the primary tooth at a power of 1–4 W and they should be used in a noncontinuous manner to avoid excessive laser energy exposure to pulp tissue.[16] Formation of carbonized layer on the surface of the root canal is a disadvantage of using several laser exposure for complete pulp tissue removal, and this layer should be removed by irrigation using 3% H_2O_2 and 5.25% NaOCl.[16]

In 1989, Ehihara reported better wound healing in amputated pulp tissue after Nd:YAG pulpotomy.[16] Diode laser used for pulpotomy of primary teeth showed 100% success rate after a follow-up of 1 year and proved to be a better alternative to ferric sulfate and electrosurgery from clinical and radiographic point of view.[16] In 1999, Jeng-fen Liu *et al*. evaluated the effects of laser pulpotomy in primary teeth and found all the teeth which underwent laser irradiation were clinically successful in a 6 months follow-up visit except one.[16]

Direct and indirect pulp capping of young permanent teeth using laser

CO_2 laser is used for direct pulp capping as it controls hemorrhage and sterilizes the exposure site which facilitates better placement of calcium hydroxide paste at exposure site and induces favorable clinical outcome.[16] This laser irradiation is usually performed at a power of 1–2 W.[16]

The laser energy has a obtundant and sedative effect on inflamed pulpal tissue, and it can also close the dentinal tubule. The mechanism by which it helps in indirect pulp capping is thought to be similar to the sedative effect produced by laser in pulpitis.[19]

Laser in wound healing

Low-level laser treatment (LLLT) transforms gingival fibroblast into myofibroblast and thereby helps in wound contraction. This effect is seen as early as 1 day after laser treatment.[27] The proliferation of fibroblast is stimulated at a low dose of 2 J/cm^2, whereas it is suppressed at a higher dose (16 J/cm^2).[28,29] As LLLT promotes wound healing, it is used for the treatment of recurrent aphthous ulcer, mucositis, and radiation-induced oral ulcer.[30]

Laser in diagnosing pulp vitality

Laser Doppler flowmetry is a noninvasive method of diagnosing pulp vitality. It uses helium, neon, and gallium aluminum as a semiconductor diode laser at a power of 1–2 mW which measures the changes in red blood cell flux in the pulp tissue.[31]

Laser in disinfection of root canal

Laser used in root canal disinfection during root canal treatment is mostly pulsed Nd:YAG and Er: YAG laser, and irrigation of the canal with 5.25% sodium hypochlorite or 14% ethylenediaminetetraacetic acid is carried out during laser irradiation.[16]

Laser in tooth bleaching

Bleaching gel contains peroxide which upon oxidation produces bleaching action. When laser light hits this bleaching gel, it produces heat and oxidation process becomes accelerated.

Laser in pediatric crown preparation

Biolase is used for pediatric crown preparation. It is set at 5.5 W with 65% air and 55% water and crowns are prepared with the same specification as used in the conventional method.[32] This technique eliminates the need of local anesthesia and thus improves patient comfort.[32] It also increases the micromechanical bonding with resin cement as it produces more roughness on prepared tooth surfaces.[32]

Hard Tissue Application

Removal of caries, old restoration, and cavity preparation

Er: YAG laser is effectively used for caries removal from both enamel and dentin without causing thermal injury to underlying vital pulp tissue.[33] It also removes old glass ionomer and composite resin restoration by ablation.[34] Cavity prepared by LLLT is similar to that of the air-rotor except for the floor which is not smooth.[35]

Pit and fissure sealants

Laser can be used for fissurotomy, cleaning, and conditioning of pits and fissures before sealant application.[36] Erbium laser is mostly used for fissurotomy procedure. Application of laser does not eliminate the need of acid etching before sealant application.[37] The formation of enamel cracks and resulting microleakage at sealant enamel interface are the disadvantages of this technique which can be prevented by curing the sealant material using argon laser.[38] In primary teeth, surface conditioning with Er-Cr: YSGG laser does not have any effect in reducing microleakage at sealant enamel interface.[39]

Diagnodent and caries detection

Laser fluorescence is used for caries detection which reproduces a near accurate result and also speed of clinical diagnosis. Laser fluorescence at a wavelength of 655 nm is effectively used for the detection of occlusal caries, hidden

caries, and occult lesion in primary and permanent teeth.[26,40] Diagnodent is a commercially available device which uses laser fluorescence technology. Argon laser at a wavelength of 488 nm is used for quantitative detection of demineralization, particularly in interproximal surfaces. It is more effective in caries detection for primary teeth.[41]

Prevention of dental caries

Treatment of enamel surface of a newly erupted tooth with erbium or CO_2 laser increases caries resistance. CO_2 laser at 10,600, 9600, and 9300 nm is used for this purpose. Erbium laser at 2940 and 2780 nm wavelength produces the same result.[42] Argon laser is also used. Application of argon laser in conjunction with topical fluoride application reduces caries attack much more effectively than argon laser alone.[43]

Contraindications of Laser Use and its Limitations

- Laser should be used with caution in patient having cardiac pacemaker
- It is also not advised to use in cardiac patient with a history of anginal chest pain and arrhythmia
- Use of laser in dental practice requires intensive training and minute precision[5,19]
- The high cost of laser armamentarium is also a disadvantage in developing country like India
- The cost-effectiveness of treatment provided by laser is questionable; moreover, lasers of different wavelength are required for different oral and dental procedure[5,19]
- It should be used with precaution in patient with immunocompromised state as there is a potential chance of disease transmission through aerosol during the laser procedure.[44,45]

Clinical Recommendation in Pediatric Practice

- Laser can be used as an alternative to different hard tissue and soft-tissue oral procedure in pediatric patient
- Modifications in clinical procedure and additional use of high-speed handpiece may be needed in pediatric dental practice[5,41]
- Use of protective eyewear specific for specific laser wavelength is mandatory for dentist, dental team, and also for the patient
- The dental team should have received educational training program in laser before using it in the pediatric population.

Laser Safety

The use of protective eyewear is mandatory as it causes ocular hazards.[46] The operator must be cautious about accidental exposure to nontarget tissue and the operating area should have a limited accessibility for other persons to minimize its hazardous effects.[46] The presence of flammable materials in laser surgical room should be avoided as it can produce combustion hazards. The use of explosive anesthetic gases is contraindicated when laser surgery is planned under general anesthesia.[16] Moreover, it has to be ensured that the laser is in good working condition and all safeguard are in proper position.

Conclusion

Although it has some cost- and training-related disadvantages, its use in pediatric dental procedure is well accepted by the patient and their parents. Due to its minimal invasiveness patients of pediatric age group show cooperative behavior during dental procedure. Although its effectiveness in the diagnosis of dental caries, prevention of caries, endodontic management of deciduous and permanent teeth, and different soft-tissue procedure is well documented, further research regarding its efficacy in pediatric dental procedure is still needed.

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Conflicts of interest

There are no conflicts of interest.

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