Review Article

DOI: 10.17354/ijss/2015/240

Laser Prescience in Pediatric Dentistry

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Abstract

Pediatric laser dentistry is a promising field in modern minimally invasive dentistry, and it can be "child friendly" approach. Laser is the common acronym used for laser. The use of lasers in dentistry has been evolved since 1960's by Maiman. Dental lasers offer many advantages like avoiding needles and high-speed hand pieces, which makes less traumatic experience and improves behavioral management of the child. Recent advances in laser technology and research have set the stage of revolution in pediatric dental practice to provide optimal, preventive, interceptive and restorative dental care in a stress free environment. The present article aims to revise some of the hard tissue and soft tissue laser applications in children.

Key words: Caries diagnosis, Caries prevention, Dental trauma, Frenectomy, Gingivectomy, Laser, Pediatric dentistry, Tooth eruption

INTRODUCTION

Pediatric dentistry is age defined specialty based not on a particular skill, but encompassing all aspects of child development in health and disease. Working with children is different from working with adults, it is essential to familiar with age-appropriate skills and functioning, and development. This century has seen advent of advancements even pediatric dentistry also influenced by all such advancements. Such changing trends help us to raise the standards by incorporating child-friendly approaches into dental care.

Laser is an acronym for light amplification by stimulated emission radiation and it is the greatest invention of this century. Laser treatment represents a main source of remedy in some fields like medicine and surgery, whereas in dentistry it is used as adjunctive during hard and soft tissue management. The use of lasers in dentistry has been evolved since 1960's by Maiman.[1] Initially lasers like ruby were used to carious enamel and dentine. Rapid development of laser technology has introduced various types like argon,[2] carbondioxide,[3] Neodymium-Aluminum-Garnet) (Nd:YAG)[4] or Erbium-Yatrium-Garnet (Er: YAG) and diode lasers[5] with wide applications in dentistry. These laser applications can be divided into hard and soft tissue applications.

The use of different types of new lasers enables pediatric dentist to provide minimally invasive dentistry for hard and soft tissue procedures with minimal discomfort, and no pain during and after treatment. It minimized the use of injections, eliminated the vibrations, smell of conventional dentistry and was appreciated by parents and children. This makes dental visit stress free and install positive dental attitude in a child. Recent advances in laser technology and research have set the stage of revolution in pediatric dental practice to provide optimal, preventive, interceptive and restorative dental care in a stress free environment. This paper reviews some of the laser applications in pediatric dentistry.

CLASSIFICATION OF LASERS

1. Based on active material[6] used
   - Gas lasers
   - Solid lasers
   - Liquid lasers
2. Based on the wavelength[7]
   - Invisible ionizing radiation
   - Visible
   - Invisible thermal radiation
3. Based on their operating mode[8]
   - Continuous

Access this article online

IJSS

www.ijss-sn.com

Month of Submission : 03-2015
Month of Peer Review : 04-2015
Month of Acceptance : 04-2015
Month of Publishing : 05-2015

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- Pulsed
4. Based on their power supply
   - Low power lasers
   - Mid power lasers
5. Based on delivery systems
   - Flexible hollow waveguide or tubes
   - Articulated arms
   - Fiber optic
6. Based on clinical use
   - For diagnosis Ex: Laser fluorescence, laser Doppler flowmetry
   - For non-surgical treatment
     - Laser activation of bleaching agent
     - Laser activation of light curing materials
- For surgical treatment
  - Soft tissue
  - Hard tissue
  - Combined

Laser Applications in Pediatric Dentistry

These are broadly divided into hard and soft tissue applications.

Hard tissue applications:
- Caries detection by laser induced fluorescence
- Prevention of enamel and dental caries
- Caries removal
- Cavity preparation
- Pit and fissure sealants
- Curing light activated resins
- Laser pediatric crowns
- Bleaching of vital and non-vital tooth
- Laser fusion of vertical root fracture
- Removal of old restorative materials
- Laser analgesia
- Orthodontic tooth movement
- Dental traumatology.

Soft tissue applications:
- Exposure of teeth to aid in tooth eruption
- Frenectomy
- Ankyloglossia
- Aphthous ulcers
- Herpes labialis lesions
- Dentigerous cyst
- Leukoplakia
- Treatment of mucocele
- Pediatric endodontics
- Gingival remodeling and Gingivectomy.

HARD TISSUE APPLICATIONS

Caries Detection by Laser Induced Fluorescence

Conventional methods of diagnosing dental caries such as manual probing and radiographic evaluation are often ineffective in detecting enamel defects, as they may be too small or inaccessible to the diagnostic tool. In addition, manual probing has the potential of stimulating caries due to the iatrogenic damage caused by the explorer. Radiographs (e.g., bitewing X-rays), although effective in revealing advanced stages of decay, are unsuccessful in detecting early caries, especially in the complex anatomy of fissure areas.

A new era has been began with laser in regard to early caries detection methods such as diagnodent,[9,10] quantitative laser fluorescence,[11] optical coherence tomography. These diagnostic techniques results in non-invasive or minimally invasive approach to clinical management of dental caries. This detection can be outperforming very accurately, the application is easy and very safe and also avoid ionizing radiation.[12]

Prevention of Enamel and Dentine Caries

The role of lasers in the prevention of caries has been explored since the 1960's by using ruby, Nd: YAG, CO_2 and argon lasers.

Various mechanisms which suggest caries prevention by lasers are:
- Increased acid resistance[13] in lased enamel by ultra-structural alterations of enamel, as a result of melting and resolidifying. Enamel micro hardness seems to be related to enamel mineral content, and plays a role in enamel demineralization, as well as in erosion inhibition.
- Organic blocking theory:[8] Partial denaturation of organic matrix may block the diffusion pathway in enamel, resulting in retardation of enamel demineralization.
- Combination of reduced enamel permeability and enamel solubility as suggested by Stern *et al*.[14] Diminution in the size of the apatite crystal, due to loss of water and CO_2, and that the hydroxyapatite crystal could be made more compact after laser irradiation, thus increasing to enamel resistance.
- Laser can alter the chemical composition and morphology of the highly mineralized (96%) dental enamel. Frequencies <450 mJ/cm^2, resulted in an increased Ca/P ratio, decreased amount of carbonate and protein and the formation of tri calcium phosphate and tetra calcium phosphate, suggesting the involvement of photo thermal mechanism.[15]

Combination of Laser and Fluoride in Caries Prevention[16]

Laser activated fluoride therapy

Laser irradiation reduces critical pH for enamel dissolution from 5.5 to 4.8. However, this critical pH is further reduced in the presence of fluoride in concentrations as low as 0.1 ppm. Reduction in critical pH may protect tooth structures from acid challenges. Lased enamel will not undergo dissolution until the critical pH of 4.3 is reached.[17]

Caries Removal

The first documented use of Er: YAG laser to remove carious tissue was at 1980's in a study by Hibst and Keller. Laser treatment possesses the requirements of minimal invasive dentistry. The possibility to ablate small area of infected layer guarantees maximum conservation of the tooth structure. Using the antibacterial property of the Er: YAG laser, decontaminate the affected layer that retains its remineralizing potential. The lack of smear layer after vaporization with laser assures a better retention of the composite resin to the dentine. Preparing the enamel surface with a laser before etching gives a better marginal seal of the composite restoration.[18]

Caries removal biophysics[19]

The biophysics of the hard tissue laser includes wavelength, energy density, and pulse duration of laser radiation and properties of the tissue, such as absorption, reflection, transmission and scattering. All dental hard tissues contain various amount of water. Water molecules in the target tooth are superheated, explode and in turn, ablate tooth structure and caries. A bactericidal effect, typical of laser-tissue interaction occurs as well. Water mediated explosive tissue removal has been shown to be the most efficient way of removing tissue while transferring minimal heat to the remaining tooth.

Instructions for handpiece application:

- Always gently touch target tissue with tip end
- Cutting radiation goes out only from the end of the fiber tip
- Direct water stream to the target tissue
- Always keep tip moving to provide effective ablation and better cooling
- For wide cut, constantly move tip over the surface
- For deep cut, constantly move tip up and down (pumping).

Structural morphology of the tooth after laser exposure shows no evidence of cracking, fissuring, or charring.

Cavity Preparation[20]

The use of lasers for cavity preparation and caries removal is based on then ablation mechanism in which dental hard tissue can be removed by thermal and or mechanical effect during laser irradiation (Table 1).[21]

Technique

A focused mode is used for fast cutting and defocused mode for slow cutting. For deep cutting, the tip is moved up and down as in pumping action. The operator can detect different tooth structures by hearing the sound of ablation (popping sound), which is differentiated by tissue type. Beginning of cavity preparation, focused beam of 6 W (67.9 J/cm^2) at maximum air pressure level and 32% water level. As enamel removal progressed to dentin, reduce the power to 3 W (33.9 J/cm^2) at 70% air level and 20% of water level. Line angles and point angles[22] are placed in preparation for greater mechanical retention of the restoration.

Advantages of laser cavity preparation

a. Laser is capable of preparing the cavity in an irregular fashion which is ideal for placement of composite or GIC (Minimally invasisssve procedure).
b. Strength of tooth is maintained, and bond strength of restoration is enhanced.
c. Acid etch step can be easily avoided, and micro-leakage of composite resin restoration can be minimized.

Pit and Fissure Sealants

A promising approach to non-operative dentistry is sealing of enamel lesions with low viscous light curing resins such as pit and fissure sealants. One of the important requirements of a pit and fissure sealant is that it should prevent micro leakage at its periphery failing which, the carious process continue underneath the sealants. John[23] (1997) found a delicate interlacing pattern of thin partitions and small knob like expansions in laser etched enamel and penetrations of micro fissures into the enamel estimated at 10 mm. These subsurface alterations may provide space for the infiltratiosssn and mechanical retention of dental resin. Brugnera[24] in a study with CO_2 laser improves the retention of sealant. Another in vitro study by Hicks *et al.*[25] showed benefit of argon laser polymerization, fluoride release and mechanical retention of sealant.

Curing Light Activated Resins

Schein *et al.*[26] (2003) on SEM evaluation of the interaction pattern between dentin and resin found morphological characteristics of the acid-etched irradiated dentin and

Table 1: Laser parameters for cavity preparation

Wet composition (Wt %)	Enamel	Dentin
Inorganic	96	70
Organic	1	20
Water	3	10
Recommended settings for the Er: YAG	**Energy (mJ)**	**Pulses per sec (Hz)**
Caries	100-200	10
Enamel	200-250	15
Dentin	150-200	10
Etching	30-50	15

found favorable diffusion of monomers through the collagen network. After cavity preparation using ER:YAG laser at 250 mJ/pulse, 4 Hz, noncontact mode, focused beam and a fine water mist was used.

Advantages

1. Laser required less time to achieve polymerization
2. Exposure time is less
3. Reduce chair time and achieving patient satisfaction especially with restless children
4. Helpful in situations where dry field for long length is difficult to maintain
5. In inaccessible areas, laser beam offers the advantage of no loss of power over distance
6. Increased penetration depth makes it possible to cure thicker increments
7. Improved adhesion
8. Reduce micro leakage.

Laser Pediatric Crowns[27]

Jacboson (2003) revealed the contemporary technique of performing laser pediatric crowns.

Tooth preparation

Biolase is set to begin cutting the surface layer of enamel. Initial cuts are made at a setting of 5.5 watts, 65% air and 55% water. Crowns should be prepared with same specifications as in the conventional method. However, the tooth surface is left roughened not smooth. Buccal, lingual, mesial and distal walls do not require an occlusal taper. Undercuts are placed to improve the bond of the resin crown. This technique eliminates local anesthesia, thereby providing optimal patient comfort and compliance.

Laser Bleaching

The objective of laser bleaching is to achieve power bleaching process using the most efficient energy source, while avoiding adverse effects.[28]

General protocols for laser bleaching:[29]

- Review the patient's oral habit and health history, life style and expectations
- Take a photographic record
- Discuss possible treatment sensitivity
- Discuss the combination of office bleaching and home bleaching
- First aid kit must contain antioxidants
- Assemble protection gear and safety eye goggles
- Rubber dam application is must.

Safety issues in laser bleaching:

- Special training for operating the equipment and use of special eye protection with orange colored lenses is mandatory.
- Handle hydrogen peroxide with extreme caution with well-protected isolation technique.

Laser Fusion of Vertical Root Fracture

Dederich[30] (1999) using exposure parameters of 15 W, 0.2 s and spot diameter of 1.0 mm, in 15 single exposures with average of 5 s lapse time between exposures and radiographic analysis at 1-year, observed good bone fill of the defect and satisfactory healing at predetermined exposure parameters.

Removal of Old Restorations

Hibst and Keller[31] showed removal of various restorative materials (composite, GIC) with Er:YAG laser. For pulpal safety lower pulse rates are indicated. Laser ablation of amalgam fillings should be avoided because of release of mercury vapor.

Laser Analgesia[32]

Analgesic effect on nerves supplying oral cavity is by decreasing firing frequency of nociceptors with a threshold effect by maximal suppression. Duration of analgesic effect can persist for 15 min approving for usage on patients having phobia to needles.

Orthodontic Tooth Movement[33]

Low level laser therapy (LLLT) at 8J/cm^2 energy density and at 100 mW was applied for retraction of maxillary canines into the first premolar extraction spaces along with fixed edgewise appliance. LLLT enhances rate of tooth movement and hence used as an adjunct to reduce treatment duration.

Dental Traumatology

Most frequently used lasers in dental traumatic injuries are Er:YAG, Er, Cr:YAG, diode and CO_2 lasers in uncomplicated and complicated fractures.

SOFT TISSUE APPLICATIONS

There are numerous soft tissue procedures, which can be performed with lasers. Two main features of these are reduced bleeding intra-operatively and less pain post-operatively when compared to conventional techniques.

Exposure of Tooth to Aid in Tooth Eruption

Lasers are used to expose the teeth and allow the eruption of teeth without any damage to tooth enamel. Lasers that have no absorption into enamel are ideal for locating and exposing the teeth with a retarded eruption or in need of operculum resection. Boj *et al.*[34] (2006) treated eruption cyst with laser powered hydrokinetic system and suggested no suturing or antibiotic or medication is necessary. Suggested settings are Er: YAG 30 h, 45 mJ both in contact and non-contact mode are used. This makes behaviour management by the pediatric dentist easier.

Frenectomy[35]

In newborn tight maxillary frenum may interfere with proper latching to breastfeeding. In older children, high frenal attachment may lead to mid-line diastema. Laser settings are Er:YAG 30 Hz, 50 mJ and laser energy is directed at the insertion of frenum and area between two front teeth. Sutures are not required. Post-operative period is uneventful.

Ankyloglossia[36]

The abnormal attachment on the lingual frenum is one of the most misdiagnosed and overlooked congenital abnormalities observed in children. Treatment of tongue-tie, laser settings include Er:YAG 30 Hz, 50 mJ no water with the use of safety goggles. A suture is placed at the junction of the frenum and end of the cut to prevent reattachment.

Apthous Ulcers[32]

Are painful and cause problems during eating and speaking. Energy directed into the surface of these lesions with lasers in the focused mode remove exposed nerve endings. Lesions can be rendered insensitive at low wattages within 4 min with light contact mode.

Herpes Labialis Lesions[37]

Lesions have been successfully treated with Nd:YAG laser in the free running pulse at an area of defocused non-contact mode. The infusion of laser energy disrupts the progress of the viral activity, arresting lesions progression. In the early stages, lasers may able to reverse the viral action and also prevent the lesions from recurrence.

Dentigerous Cyst[38]

Benign odontogenic cysts are common in unerupted tooth in the mixed and permanent dentition. Lasers are used to vaporize bony cavity and curettage of the cystic cavity, deduction of the cystic lining.

Leukoplakia[39]

Laser-assisted removal of the precancerous lesion by ablative Er: YAG laser with non-contact digitally controlled hand piece X-Runner in QSP mode (Light Walker AT, Fotona, Slovenia, 2013) was used. The laser settings were as follows: pulse energy 120 mJ, pulse mode QSP, frequency 20 Hz. Circle, rectangle or hexagon shape was selected according to the lesion size and shape. The hand piece was held at the distance of 15 mm from the lesion surface and water spray level was set to 10 ml/min.

Advantages

1. The operational field is very clear, especially because there was no bleeding
2. Time saving as the interventions was performed very quickly because of the automatic coverage of the area with the X-runner handpiece
3. Very safe and pleasant for the patient
4. Effective and comfortable for the operator
5. No post-operative swelling and pain reduction and accelerates wound healing.

Treatment of Mucocele[40]

Laser excision (Picasso, AMD Laser Technologies, USA; wavelength of 810 nm) was used under local anesthesia (2% lignocaine with 1:80000 epinephrine), using 300 μm diameter tip at 1.3 W. Uneventful healing without recurrence was reported.

Lasers in Pediatric Endodontics

Diagnosis of dental pulp

The principle of vital and non-vital diagnosis of dental pulp by laser Doppler flowmetry is based on the changes in red blood cell flux in the pulp tissue.[16] When normal pulp is stimulated by the pulsed laser at 2 W and 20 pulses per second at a distance of approximately 10 mm from the tooth surface, pain is produced within 20-30 s and disappears a couple of seconds after the laser stimulation is stopped. In acute pulpitis, pain is induced immediately after laser application and continues for more than 30 s after stopping the laser stimulation.

Indirect pulp capping[32]

Pulp capping is superior with disinfection attained up to the depth of 300 μm. Local analgesia is not required with laser due to less heat generation in the pulp chamber.

Direct pulp capping

Laser tissues have advantages with respect to control of hemorrhage and sterilization and is thus beneficial for use in direct pulp capping. Er, Cr:YSGG laser at 1 W, 20 Hz with 20% air and 15% water is used.

Pulpotomy[41]

Vital pulp amputation by laser therapy was one of the most successful treatments in Pedodontics as the amputation of the pulp tissue at satisfactory level is obtained. To achieve coagulation following amputation of coronal pulp reduced power setting of 30-40 mJ, with tip of hand piece held 3-4 mm away in defocused mode, devoid of water spray and only 30% air is used.

Access cavity preparation and canal preparation

New type of Er, Cr:YSGG lasers has been developed for access cavity preparation and enlargement of root canal orifices. The pulsed Nd:YAG laser with 2 W at 20 pps for 1 s is recommended for removing pulp remnants. It is effective tool for killing microorganisms because of the laser energy and wavelength characteristics. Infected root canals are indicated for this laser treatment, but application to extremely curved and narrow infected root canals may be difficult. Rooney *et al.*[42] reported sterilization rates of 80-90% depending on the conditions of root canals, type of laser device, application parameters.

Laser treatment of periapical lesions with sinus tract[43]

Although sinus tracts close by standard endodontic treatment, a few cases require special treatment. Pulsed laser, 2 W and 20 pps are recommended parameters can accelerate wound healing.

Gingival Remodeling and Gingivectomy[44]

Erbium laser with the energy of 55-80 Mj and frequency of 20-30 Hz without water spray is used.

CONCLUSION

Lasers in pediatric dentistry have benefits as well as limitations. Though American Academy of Pediatric Dentistry recognizes the use of lasers as an alternative method of providing soft and hard tissue dental procedures for infants, children, adolescents, and persons with special health care needs, dental professional requires additional training to use and apply on pediatric dental patients. In the present scenario, lasers can be a useful adjunct to our regular pediatric dental practice.

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How to cite this article: Shanthi M. Laser Prescience in Pediatric Dentistry. Int J Sci Stud 2015;3(2):197-203.

Source of Support: Nil, **Conflict of Interest:** None declared.