EC DENTAL SCIENCE
Review Article

Lasers Use in Different Dental Pediatric Aspects

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Received: December 14, 2017; **Published:** February 10, 2018

Abstract

Children's oral health is of utmost importance for their well-being and their general medical state. Thus they must be encouraged to seek dental care regularly and not to fear dentists anymore. Therefore, pediatric dental practitioners need to learn new technologies such as lasers, in addition to the basic principles. As this technology is more entertaining to kids, as well as, less painful. The American Academy of Pediatric Dentistry (AAPD) recognizes the judicious use of lasers as a beneficial instrument in providing dental hard and soft tissue procedures for infants, children, and adolescents, including those with special health care needs.

The aim of this review is to inform and educate dental practitioners on the principles, types, diagnostic and clinical applications, benefits, and limitations of laser use in Pediatric Dentistry. Thirty citations were chosen through data base searches including the afore mentioned topic, concerned with lasers application in pediatric dentistry.

Keywords: *Lasers; Pediatric Dentistry; CO_2 Laser*

Introduction

The concept of light amplification by stimulated emission of radiation (LASER) was first introduced by Albert Einstein 1916 [1]. Laser acts by concentrating high energies into an intense narrow beam of electromagnetic radiation, thus giving an efficient, powerful ray that uses less energy than a conventional lamp. Laser light has unique properties, such as coherency and mono chromatism [1,2].

Physicians began integrating lasers in the mid 1970's for soft tissue procedures [3]. Oral and maxillofacial surgeons incorporated the carbon dioxide (CO_2) laser into practice for removal of oral lesions in the 1980s [2,3]. The first laser specifically for dental use was a neodymium-yttrium-aluminum-garnet (Nd:YAG) laser, developed in 1987 and approved by the Food and Drug Administration in 1990 [1,4,5].

Within a laser, an active medium is stimulated to produce photons of energy that are delivered in a beam with an exact wavelength unique to that medium [6]. Lasers typically are classified by the active medium that is used to create the energy. The energy radiated by the laser is basically a light of one color (monochromatic) and thus a single wavelength [6,7] Oral hard and soft tissues have a distinct affinity for absorbing laser energy of a specific wavelength. The wavelength of a dental laser is the determining factor of the level to which the laser energy is absorbed by the intended tissue. Target or identified tissues differ in their affinity for specific wavelengths of laser energy [1,6,8]. For this reason, selecting a specific laser depends on the target tissue the practitioner wishes to treat. The primary effect of a laser within target tissues is photo thermal [3,9]. When the target tissue containing water is raised above 100 degrees centigrade, vaporization of the water occurs, resulting in soft tissue ablation [1]. Since soft tissue is made up of a high percentage of water, excision of soft tissue initiates at this temperature. Hard tissue composed of hydroxyapatite crystals and minerals are not ablated at this temperature, but the water component is vaporized, the resulting steam expands and then disperses the encompassing material into small particles [1,8]. Modern pediatric dentistry must take advance from all new techniques and apply them once they are tested and proven to be effective [10]. The old concept of "Extension for Prevention" is nowadays changed for "Prevention of Extension" [11]. In order to fulfill this, new materials and new preparation designs have undergone continuous development. This means performing treatment with as little tissue loss as possible. With the new techniques available; digital radiology with low radiation emission, diagnostic laser and the dental operative microscope, we can aim for both an early diagnosis and a minimally invasive therapy such as: ozone therapy, air abrasion, rotary instruments for micro preparation [12]. Thus the concept of Micro Dentistry and tooth conservation, have changed the way of practicing dentistry too much. This psychological and technological evolution includes adhesion techniques, fluoride treatment, as well as laser technology. It is important to adopt new technology, not only to offer better quality treatment to our patients, but also to make our profession more enjoyable [10,12].

The present article describes application of the most commonly used lasers and their advantages, considerations, and limitations in pediatric dentistry.

Methods

This article is based on a review of current dental literature related to the use of lasers. It also included database searches using key terms: laser dentistry, dental lasers, laser pediatric dentistry, laser soft tissue treatments, and laser restorative dentistry. Articles were evaluated by title and/or abstract and relevance to pediatric dental care. Thirty citations were chosen from this method and from references within selected articles. When data did not appear sufficient or were inconclusive, recommendations were based upon expert and/or consensus opinion by experienced researchers and clinicians.

Laser applications in pediatric dentistry

Diagnostic applications

Laser fluorescence (LF) can be used as an additional tool combined with conventional methods for detection of occlusal caries [12]. The portable diode laser-based system interprets the emitted fluorescence on the occlusal surface which correlates with the extent of demineralization in the tooth [8,13]. Laser digital readings can indicate the proportional amount of caries present. LF may be used as a complementary instrument in diagnosing occlusal caries in cases of questionable findings after visual inspection [8,12]. LF caries detection is not recommended under dental resins or sealants due to a high probability of unreliable readings as a result of the intrinsic fluorescence from the sealant material [12,13].

Soft tissue Applications (Laser application in oral surgery)

Dental lasers have been used for numerous clinical soft tissue procedures in pediatric dentistry. Clinical applications include maxillary and lingual frenectomies, operculectomy, exposure of teeth for orthodontic purposes, gingival contouring/ gingivectomies, removal of mucosal lesions and biopsies, and treatment of aphthous ulcers and herpetic lesions [8,10,13]. CO_2, diode, and Nd:YAG lasers all have the capability of effectively incising tissue, coagulating and contouring tissues [8,10]. Erbium lasers also have the capability of providing soft tissue procedures; however, the hemostatic ability of these wavelengths is not as effective as CO_2, diode, and Nd:YAG wavelengths [1,13-15].

Many authors agree with the advantages of laser application on soft tissues: quick and easy to use, less use of local anesthesia, excellent control of bleeding during incision, suture-less technique, post-operative recovery often asymptomatic due to the decontaminating effects, and antalgic and bio-stimulant effects. Moreover, the excellent clinical results improve the patient acceptance of the therapy and facilitate the operator's intervention, which at times can be very complicated when using traditional techniques Furthermore the need for analgesics and anti-inflammatory medications is drastically reduced compared to conventional procedures [10,15,16].

Laser application in periodontics and orthodontics

The decontaminating effect of different lasers in the pockets of patients with periodontal disease has been widely documented in adults, but there is little documentation of laser-assisted therapy of periodontitis in young patients. Instead there are many clinical situations that require intervention on soft tissue before, during and after the orthodontic treatment, and the laser can be used in the procedures reported in These procedures, needed for the orthodontic treatment or its completion, become extremely simple, safe and rapid, and can be performed by the orthodontist himself [12]. Different wavelengths can be used for procedures, employing different techniques, according to the different laser-tissue interaction [17-19]. Among the most effective laser applications in orthodontics, and the most widely performed and documented are frenectomies; several authors reported less post-operative pain, discomfort and fewer functional complications, easier speaking and chewing, compared to the traditional techniques, where diode, Nd:YAG, Er:YAG, Er,Cr:YSGG and CO_2 lasers were used, resulting in a better perception of the therapy by the patient [20,21]. Labial upper and lower frenectomies can be performed: the laser is extremely simple and effective even in newborns, in cases of severe ankyloglossia or tight maxillary frenum that make breastfeeding difficult [13].

Hard tissue clinical applications

The Nd:YAG, Er:YAG, and Er,Cr:YSGG lasers have all been used successfully for removal of caries and preparation of teeth for restorative procedures in children and adolescents [12,13,25]. Lasers also have been used effectively for indirect and direct pulp capping treatments [12,24]. The erbium lasers are the pre-dominant lasers used for hard tissue procedures [13,23,24]. Dental lasers have been utilized for endodontic procedures such as primary tooth pulpotomies and root canal disinfection. Success rates of laser pulpotomies have been comparable to those of formocresol pulpotomies [13,25,26].

Laser application for caries prevention

Argon laser at 488 - 514 nm and CO_2 laser at 9300-10600 nm. Also the erbium laser 2780 and 2940 nm was investigated in modifying the physical-chemical characteristics of the enamel surface: the results of these studies were assessed by testing cross-sectional microhardness and enamel solubility [12]. In 1995 Flaitz., *et al*. [27] reported that Argon laser irradiation combined with acidulated phosphate fluoride treatment (APF) resulted in a decrease of lesion depth by more than 50% compared with control lesions, and by 26% to 32% when compared with lased-only lesions. Also it was confirmed that the CO_2 laser was efficient in reducing the subsurface enamel demineralization and that its association with a high-frequency fluoride treatment may enhance this protective effect [28]. Another research reported that the erbium laser wavelengths also have the potential to increase acid resistance: sub ablative erbium energies can reduce enamel solubility increasing caries resistance without severe alterations of the enamel, but without reaching statistical significance [29].

Laser application for cavity preparation and caries removal

Keller and Hibst (1998) were the first to evaluate the cutting ability of the Er:YAG laser on hard tissue of human teeth [30]. Other authors studied the parameters and variables for using the erbium laser, evaluating the morphological effects on hard and pulp tissues: the effects of energy density, pulse repetition rate, and air-water jet were reported [31]. They confirmed the efficacy of the erbium laser in cavity preparation and removal of carious tissue, researching the optimal parameters of use. The idea of substituting the drill with a laser instrument which has less impact on the patient, as the laser works on hard tissue with no contact, no vibration, minimum noise and less pain, this concept has supported the introduction of this device in pediatric dentistry. Various studies and clinical reports showed how the laser, used by numerous operators as an alternative to rotary instruments in pediatric restorative dentistry, brings an added measure of safety even when used in the treatment of very young children, and an overall better acceptance compared to traditional techniques [30]. The use of manual excavators seemed to be the most suitable method for carious dentin removal in deciduous teeth, combining good treatment time with effective caries removal, while the steel bur appeared the fastest but with the highest level of over preparation.

The laser produced intermediate results, among the slowest but with a low level of over preparation according to the minimally invasive concepts [12].

Laser use in Endodontics

Pulp Capping

Nd:YAG laser was used for coagulation with glass ionomer cement as pulp capping agent and proved to be successful [32,33]. The CO_2 laser has a purely thermal effect on the tissue; most of the energy delivered to the tissue is absorbed by a fine tissue layer (100 μ) and transformed into heat. Also the erbium wavelengths are almost completely absorbed by the water in a superficial layer and transformed into heat; however, these lasers have less coagulating effect. Olivi and Genovese in 2006 [34] reported the importance of the use of the Er,Cr:YSGG laser with adjustable air-water jet as a single minimally invasive instrument for carious removal and pulp coagulation to avoid over-preparation and overheating of the residual dental tissue [34]. The same authors compared the efficacy of two laser systems, Er,Cr:YSGG laser and Er:YAG laser, with conventional calcium hydroxide procedure, and reported the superiority of success in the Er,Cr group, and in the Er:YAG group, over the control group had 63% at 2 years [31].

Pulpotomy

Pulpotomy is a very common technique in primary teeth: although pulpotomy with formocresol is used with success, there is a tendency today to seek alternative techniques, considering the carcinogenic and mutagenic potential of its formaldehyde component. Lasers have been proposed for pulpotomy, and a study from Pescheck., *et al*. [26] compared favorably CO_2 laser treatment to formocresol for pulpotomy in primary teeth, with a high survival rate. Other studies reported that the super pulsed mode produced a markedly higher success rate than the continuous wave mode. Guelmann., *et al*. in 2002 [35] instead reported the correlation of the healing with the age and the apex size of the primary teeth. The Nd:YAG laser was also used for pulpotomy on human primary teeth, but recently it showed a lower clinical and a radiographic success rates at 12 months, compared to the formocresol group [36]. Although there are no clinical reports on pediatric endodontics, permanent teeth can be treated with Nd:YAG and diode laser, for their high bactericidal effect in root and lateral canals. Studies comparing the root canal walls cleaning and shaping effect of different procedures in primary teeth, using Er,Cr:YSGG laser with manual or rotary instrumentation techniques, reported that laser treatment provided similar cleanliness when compared with the rotary instrumentation technique and was superior to manual instrumentation, while the laser technique required less time for completion of the cleaning and shaping procedures when compared with both rotary or hand instrumentation [37].

Laser application in dental traumatology

Dental traumas are frequent in children. They can be complex events, and at times real emergencies in which laser-assisted therapy can offer new treatment possibilities [12].

Laser application in dental injuries

Crown fracture may involve the enamel and dentin and sometimes exposes the pulp, if complicated. As it is well known that, only erbium wavelengths can give good results in tooth excavation, reducing post-operative discomfort and sensitivity as well as providing minimally invasive dentistry. These lasers can be used to perform the entire procedure: tooth margin preparation and finishing, coagulation of the exposed pulp, pulpotomy or even pulpectomy [12,38], as well as soft tissue procedures. Crown fracture exposes a large number of dentinal tubules: erbium-chromium and erbium lasers, when used with only a little amount or no water jet, have the capacity to produce fusion and sealing of the dentinal tubules, resulting in a reduction of the tissues permeability to fluids, thus reducing dentinal hypersensitivity. The other laser wavelengths (diode, Nd:YAG, CO_2) also have this beneficial therapeutic action for this application. They can also be applied to; perform indirect or direct pulp capping, decontaminate infected root canals, and to treat soft tissue defects.

Laser application in soft tissue injuries

Trauma to the alveolar bone, gingivae, periodontal ligament, frenum and the lips results in hard as well as soft tissue injuries. Lasers are currently an available option for the treatment of oral soft tissue injuries, as they provide good coagulation with extremely clean working field, effective decontamination, photo- biostimulation and pain reduction effect for the treatment of traumatic injuries, without suturing, with rapid healing and minor discomfort for the patient. The authors have experienced and reported an improvement in these procedures by using lasers in the following applications; decontamination of the alveolus following traumatic avulsion; treatment of a periodontal defect following dental luxation or sub-luxation; gingival surgery for the treatment of traumatic dental injury; gingivectomy and gingivoplasty; surgical incision to remove a remaining root.

Low level laser Therapy (LLLT)

Laser application in biostimulation and pain control

A non-traumatic introduction to dentistry can be represented by low level laser therapy (LLLT) or soft laser therapy. Even though helium-neon lasers were initially used, the semiconductor diode lasers 830 nm or 635 nm are more commonly used nowadays. The LLLT has an important pain-reducing and bio stimulating effect with acceleration of the reparative processes that have a considerable clinical importance, especially in those patients with a compromised immune system, children affected by insulin dependent diabetes, endocarditis, cardiac malformations and cardiac surgical or prosthetic valves reconstruction, oncological patients undergoing chemotherapy or radiation. In short, LLLT stimulates the tissue repair processes, influencing a large number of cell systems, and can also have a series of benefits on inflammatory mechanism, reducing the exudative phase and stimulating the reparative process [39-42]. Biostimulation for few days, can result in a considerable reduction of swelling and an acceleration of the epithelization and collagen deposition. The LLLT has a number of applications in dentistry, both at the soft tissue level biostimulation of lesions such as; aphthous stomatitis, herpetic lesions, mucositis, and pulpotomy, as well as in the hard tissue such as in acceleration of orthodontic movement. At the neuralgic level laser radiation help in inducing analgesia, neural regeneration, temporo mandibular pain, post-surgical pain, and in orthodontic pain. According to Tuner and Hode (2004) [43], and to Gutknecht., *et al*. [22], LLLT has five main indications in pediatric dentistry. The eruption of both deciduous and permanent teeth is sometimes painful: the irradiation of the lymph nodes in the area is advisable for pain relief. A laser radiation dose of 2J has a short anesthetic effect on the mucosa, allowing painless injection with a needle. Direct application of a laser radiation dose of 4 to 6J into an exposed cavity of a deciduous tooth can be used for pain reduction. Laser radiation can be used to relief post traumatic symptoms of lip and anterior tooth to reduce swelling and pain which can be achieved by applying a laser radiation dose of 3 to 4J [12].

Limitations of lasers in pediatric dentistry

There are some disadvantages of laser use in pediatric dentistry. Laser use requires additional training and education for the various clinical applications and types of lasers [3,15-17]. High start-up costs are required to purchase the equipment, implement the technology, and invest in the required education and training [3,17]. Since different wavelengths are necessary for various soft and hard tissue procedures, the practitioner may need more than one laser [3,12]. Most dental instruments are both side and end cutting. When using lasers, modifications in clinical technique along with additional preparation with high-speed dental handpieces may be required to finish cavity preparations [3,16]. Wavelength-specific protective eyewear should be provided and consistently worn at all times by the dental team, patient, and other observers in attendance during laser use [1,3,44]. When using dental lasers, it is imperative that the doctor and auxiliaries adhere to infection control protocol and utilize high-volume suction as the vaporized air droplets may contain infective tissue particles [3,12,26]. The practitioner should exercise good clinical judgment when providing soft tissue treatment of viral lesions in immunocompromised patients; as the potential risk of disease transmission from laser-generated aerosol exists [27,28]. To prevent viral transmission, palliative pharmacological therapies may be more acceptable and appropriate in this group of patients.

Figure 1: *Biolase device (Diode laser).*

Figure 2: *Discuss laser device (Diode laser).*

Figure 3: *Crown lengthening procedure.*

Figure 4: *Laser application for periodontal pockets.*

Discussion

The previous studies on the use of lasers on soft tissue are for the most in accordance, with similar protocols and reproducible results: this is due to the fact that the lasers involved (diode, Nd:YAG, CO_2) make use of a similar technology, allowing the same operative protocols [45,46]. While in the studies on hard tissue utilizing the erbium family of lasers: here there is a variety of types available, not only with different wavelengths (2780 and 2940 nm), but also with different overall construction [12,15]. The studies done cannot be compared for various reasons: power density and fluency are only one aspect of the energy delivered to the target tissue [47]. Above all the delivery systems are different: optical fibers, or articulated arms transmitting energy in a substantially different way so that the energy delivered to the tissue is very different from that selected on the display. Air/water flow and pressure of the integrated spray, the pulse length, the beam profile, are other parameters that affect the results of the laser tissue interaction beyond a presentation of the literature that validates the proposed therapies, it is important to underline that the operator factor is fundamental, even with laser therapy [48]. The resulting minimally invasive therapy is conditioned both by the knowledge of laser technology as well as the application of the correct energy, which also depends on the manual ability of the operator who must learn to act on the tissues with precision. Using an instrument that works without contact requires learning the correct operating technique and a period of training with a more or less extended learning curve [47,48]. A correct psychological approach to the patient also contributes considerably to the success of the therapy, which is often felt by patients and their families as very comfortable and acceptable, sometimes even supreme [12,15].

Conclusion

Laser is proved to be effective in pediatric dental patients as it represents a good treatment modality. It enables optimal preventive, interceptive, and minimally invasive interventions for both hard and soft tissue procedures. Thus it is of utmost importance for the professionals to be acquainted with the physical characteristics of the different laser types according to the different wavelengths.

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Volume 17 Issue 3 March 2018