LASERS IN PEDODONTICS

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ABSTRACT

The use of lasers has made it possible for clinicians to more easily and ably address the challenges faced on a daily basis in practice. Understanding the various uses of lasers is simply to accept the cutting edge of present day pedodontics. Laser technology in pediatric dentistry today is a new treatment modality for children and teens; it represents an alternative instrument that sometimes complements, and at other times substitutes for traditional techniques. Laser treatment of hard and soft tissues allows for a more comfortable and minimally invasive intervention. In addition to the use of high technology, the psychological effect on the child represents an important benefit which may positively influence the acceptance of subsequent dental treatments. Lasers are our tool of tomorrow, only if we are ready with knowledge of it today.

Keywords: Laser, Pedodontics, Diode Laser, Pulpotomy, Frenectomy.

INTRODUCTION

Laser is the acronym for “Light Amplification by Stimulated Emission of Radiation” that dates back to approximately 50 years ago [1]. The dental lasers of today have benefited from decades of laser research and have revolutionized several areas of treatment in the last three and a half decades of the 20th century [2]. In 1916, it was Albert Einstein who postulated the theory of lasers (i.e., spontaneous and stimulated emission of radiation) in the Zur Quantum Theorie Der Strahlung. Einstein’s atomic theories on controlled radiation can be credited for the foundation of laser technology. His article on stimulated emission of radiant energy is acknowledged as the conceptual basis for amplified light [3].

It was in 1960, that the first functioning laser was built by the American physicist Theodore Maiman at the Hughes Research Laboratories by using a synthetic ruby crystal made of aluminum oxide and chromium oxide. However the first use of laser in dentistry was on an extracted tooth 47 years ago [4].

The experimental work into the physics of laser light production highlighted the attraction of the use of intense radiation energy of single wavelength, in many military and communications applications. Maiman’s laser used a solid ruby as an ‘active medium’, which was energised or ‘pumped’ by an electrical source. Ranking among the most significant laser applications are those in medicine and dentistry. Recent advances in laser technology and research to explore its potential have set the stage for a revolution in dental practice with improved patient outcomes, fewer traumas, reduced post-operative complications and in most cases no need for injections.

In general, lasers are composed of the three principal parts: An energy source, an active medium and a set of two or more mirrors that form a resonator. Properties such as wavelength are determined primarily by the active medium, which can be a gas, crystal or solid-state conductor. Laser light is produced as a result of the stimulation of the active medium with an external agent such as a flash lamp strobe device, an electrical current or an electrical coil. A laser beam has several physical characteristics that distinguish it from a typical white light source, including collimation, coherence (phase correlation) and monochromaticity (single wavelength).

For dental laser systems, the light is typically delivered to the target tissue through an optical fiber cable, a hollow waveguide or an articulated arm. A wide variety of laser systems have been established in dentistry.

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Numerous different applications have been developed, depending on the varying parameters of the emitted laser light. The various laser system having application in dentistry are enumerated as follows- argon ion laser, helium – neon laser, semiconductor laser, neodymium: YAG laser, erbium family lasers, carbon dioxide laser.

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 [5].

The advantages of lasers in dentistry are vast as it enables dry and bloodless surgeries, minimal post-operative swelling and pain whereas lasers for hard tissue encourage efficient diagnosis of caries, cavity preparation and sterilization of root canal system [6].

Classifications of lasers
I. According to modes of emission
• Fractionated- which means there are periodic alternations of the laser energy being on and off, similar to a blinking light. This mode is achieved by the opening and closing of a mechanical shutter in front of the beam path of a continuous-wave emission.
• Continuous wave emission means that laser energy is emitted continuously as long as the laser is activated—and produces constant tissue interaction.
• Pulsed- The second mode is termed free-running pulsed mode, sometimes referred to as “true pulsed.” Free-running pulse emission occurs with very short bursts of laser energy due to a flash lamp pumping mechanism.

II. According to power
• High power- These lasers increase tissue kinetic energy and produce heat. As a result, they leave their therapeutic effects through thermal interactions.
• Medium power- These lasers leave their therapeutic effects without producing significant heat.
• Low power- These lasers have no thermal effect on tissues and produce a reaction in cells through light, called photobiostimulation or photobiochemical reaction. Output power of these lasers is less than 250 mW. eg. Diode laser.

III. Based on the emitting material
• Gas lasers – Argon, carbon dioxide lasers
• Solid state lasers – Nd:YAG, Er:YAG, Ho: YAG
• Semi conductors – Diode lasers

IV. According to the type of tissue being acted upon
• Soft Lasers: Soft tissue lasers penetrate soft tissue while sealing blood vessels and nerve endings. This is the primary reason why many people experience virtually no postoperative pain following the use of a laser. Also, soft tissue lasers allow tissues to heal faster.
• Hard Lasers: The hard tissue lasers are used to cut precisely into bone and teeth, to prepare teeth surfaces for bonding, to remove small amounts of tooth structure, and to repair certain worn down dental restorations [7].

Basic types of lasers
Three types of lasers are available for use in dentistry: the CO2 laser, the erbium laser, and the diode laser. The CO2 laser is a gas-active medium laser that incorporates a sealed tube containing a gaseous mixture with CO2 molecules pumped via electrical discharge current. The light energy, whose wavelength is 10,600 nm, is placed 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. The CO2 laser does not contact the tissue during the cutting phase; thus there is no tactile feedback during the surgical incision. It operates with a wavelength that is invisible to the eye, so the fiber optic delivery system has a helium-neon (He- Ne) laser with a wavelength of 632 nm incorporated as an aiming beam. There is slight delay between incision and when it can be seen.

There are two distinct wavelengths that use erbium, and these two lasers are discussed together because of their similar properties. Erbium, chromium: YSGG (2780 nm) has an active medium of a solid crystal of yttrium scandium gallium garnet that is doped with erbium and chromium. Erbium:YAG (2940 nm) has an active medium of a solid crystal of yttrium aluminum garnet that is doped with erbium. Both of these wavelengths are placed at the beginning of the mid infrared, invisible, and non-ionizing portion of the spectrum. The erbium laser has a wavelength of 2790 to 2940 nm, which makes it ideal for absorption by both hydroxyapatite and water. It can also be used to cut soft tissue, but it does not control bleeding.

The diode laser has a wavelength of 812 to 980 nm, which is in the same range of the absorption coefficient of melanin. The laser energy is absorbed by pigmentation in the soft tissues, and this makes the diode laser an excellent hemostatic agent. Because it is used in contact mode, it also provides tactile feedback during the surgical procedure. The diode laser can often be used without anesthesia to perform very precise anterior soft tissue aesthetically surgery or surgery in other areas of the mouth without bleeding or discomfort [8].

Diagnostic applications
Laser fluorescence (LF) can be used as an additional tool combined with conventional methods for detection of occlusal caries. The portable diode laser-based system interprets the emitted fluorescence on the occlusal surface which correlates with the extent of demineralization in the tooth. Laser digital readings can indicate the proportional amount of caries present. LF
may be used as a complementary instrument when diagnosing occlusal caries in cases of questionable findings after visual inspection. 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. Enamel demineralization with white spot formation on buccal surfaces of teeth is a relatively common side effect from treatment with fixed appliances. Treatment with fixed appliances makes conventional oral hygiene for plaque removal more difficult, thus increasing the cariogenic challenge on surfaces that normally show a low prevalence of dental caries. White spot formation has been attributed to the effect of prolonged accumulation and retention of the bacterial plaque on enamel surfaces adjacent to the appliances. There is evidence, however, that suggests that such small areas of superficial enamel demineralization may remineralize. Sensitive methods that enable early detection and quantification of caries lesions make it possible to monitor changes in the enamel over time. Laser light induced fluorescence can be used as a diagnostic method for detection of enamel caries at an early stage. When enamel demineralization takes place, minerals will be replaced mainly by water causing a decrease in the light path in the tooth substance. This will result in reduction of light absorption by enamel. Because fluorescence is a result of absorption, the intensity of fluorescence will decrease in demineralized regions of the enamel, which appear darker than the sound tooth structure. Studies have indicated that changes in mineral contents of enamel lesions may be accurately recorded with the laser fluorescence method [9].

2. Soft tissue clinical applications

Dental lasers have been used for numerous clinical soft tissue procedures in pediatric dentistry. One of the benefits of laser use in pediatric dentistry is the selective and precise interaction with diseased tissues. Less thermal necrosis of adjacent tissues is produced with lasers than with electrosurgical instruments. During soft tissue procedures, hemostasis can be obtained without the need for sutures in most cases. With the benefit of hemostasis during soft tissue treatments, wound healing can occur more rapidly with less post-operative discomfort and a reduced need for analgesics. Little to no local anesthesia is required for most soft-tissue treatments. Reduced operator chair time has been observed when soft tissue procedures have been completed using lasers. Lasers demonstrate decontaminating and bacteriocidal properties on tissues. Clinical applications include maxillary and lingual frenectomies, operculectomies, exposure of teeth for orthodontic purposes, gingival contouring /gingivectomies, removal of mucosal lesions. Lasers can provide relief from the pain and inflammation associated with aphthous ulcers and herpetic lesions without pharmacological intervention. CO2, diode, and Nd:YAG lasers all have the capability of effectively incising tissue, coagulating and contouring tissues. Erbium lasers also have the capability of providing soft tissue procedures; however, the hemostatic ability of these wavelengths is not as effective as CO2, diode, and Nd:YAG wavelengths [10]. Lasers also have been used effectively for indirect and direct pulp capping treatments. The erbium lasers are the predominant lasers used for hard tissue procedures. 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 [11].

3. Hard tissue clinical applications

The erbium lasers can remove caries effectively with minimal involvement of surrounding tooth structure because caries have a higher water content than healthy tissue. The noise and vibration of the conventional high-speed dental handpiece has been postulated as stimulating discomfort, pain, and anxiety for the pediatric patient during restorative procedures. The non-contact of erbium lasers with hard tissue eliminates the vibratory effects of the conventional high-speed handpiece allowing tooth preparations to be comfortable and less anxiety provoking for children and adolescents. Nd:YAG and erbium lasers have been shown to have an analgesic effect on hard tissues, eliminating injections and the use of local anesthesia during tooth preparations.

The erbium lasers can remove caries effectively with minimal involvement of surrounding tooth structure because caries have a higher water content than healthy tissue. 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.

Laser analgesia

Among the several advantages of lasers in dental applications, laser-induced analgesia represents a unique way to treat an infantile patient with minimal or no discomfort. Laser irradiation of the operatory site with low energy prior to any surgical or non-surgical procedure generates disruption of the N\text{a}^{+}/K^{+} pump of the cell membrane of the nervous fibers, causing a temporary loss of conductance of the nervous impulse and a consequent analgesic effect in the irradiated area. Naturally, operating below the threshold of pain (by using the minimum effective energy and power) helps to avoid betraying the child’s trust [12].

Limitations of laser in Pedodontics

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. High start-up costs are required to purchase the equipment, implement the technology. Since different wavelengths are necessary for various soft and hard tissue procedures, the practitioner may need more than one laser.

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 tooth preparations. 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. When using dental lasers, it is imperative that the doctor and auxiliaries adhere to infection control protocol and utilize highspeed suction as the vaporized aerosol may contain infective tissue particles. 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. To prevent viral transmission, palliative pharmacological therapies may be more acceptable and appropriate in this group of patients.

**CONCLUSION**

Lasers have demonstrated their effectiveness and safety for pediatric dental care. The Erbium:YAG laser, in particular, allows the clinician to perform an innovative, minimally invasive form of dentistry that is very well accepted by children. Before starting to use a laser, it is important to understand the physical characteristics of the different laser wavelengths and their interaction with biological tissues to assure that they are used in a safe way, in order to provide the benefits of this technology to young patients. It is therefore highly recommended to invest in the appropriate training and education before applying this technology in pediatric patients.

**REFERENCES**

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