

## Current Uses of Diode Lasers in Dentistry

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### Introduction

Diodes are useful in soft-tissue surgery to achieve good coagulation and hemostasis [1]. Diodes active medium of aluminium, gallium and arsenide, solid semiconductor operating at 810–980 nm wavelengths absorbs highly pigmented tissues containing hemoglobin, melanin and collagen chromophores. This explains selective action of diode lasers on the soft tissue operations, such as incision, vaporization, blood coagulation, curettage and hemostasis than dental hard tissues [2]. Diodes also exhibit bactericidal capabilities and can be used for adjunctive periodontal procedures. They are used for laser assisted tooth whitening and have excellent photo biomodulation properties. Diodes are emitted in a continuous wave and may be pulsed whenever more control is indicated [3]. Diodes are used either as continuous or pulsed based on its emission of waves and classified as continuous and pulsed mode, based on their emission of waves. In surgical procedures continuous mode is used and pulsed mode in procedures of more controlled and regulated emission of waves are required [4]. Diodes are available in wavelengths of 635,670,810,830,980 nm [5]. 810,940,980 nm wavelengths diodes are used in periodontics, orthodontics and oral surgery. In Low Level Laser Therapy (LLLT) 810 nm is used for Biostimulation and pain control [6].

### Physics

The potential use of diode lasers in dentistry has been in different surgical procedures and particularly in the pediatric dental patients since its introduction in the mid-nineties [2]. Gallium Aluminum Arsenide (GaAlAs) is used as active medium in diodes for its crystalline nature. The crystals of GaAlAs can be selectively polished to achieve relative internal refractive indices to serve the function of optical resonators, which produce totally and partially reflective surfaces of larger laser systems. To achieve the power necessary for various dental procedures, current diodes have bank of individual chips in parallel within the system [7]. This “chip” of material has the optical resonator mirrors directly attached to its ends, and an electrical current is used as the pumping mechanism. Diodes in wavelengths of 800nm–980 nm contains aluminium as a active medium composed of indium and active medium is placed near infrared portion of the invisible non-ionizing spectrum. Diodes necessitates its use in LLLT and other procedures with the options of selecting appropriate power [8].

### Effects on Tissue

Laser light in clinical dentistry is used to maintain controlled effect and precise changes on the target tissue by transferring electromagnetic energy. The transferred light energy reacts with a target tissue by Transmission, Reflection, Scatter and Absorption. The factors that affect absorption and thermal effects on the target tissue

separately and/or collectively are: Laser wavelength and tissue composition, Incident angle of Laser Beam, Exposure time and Laser emission mode, beam diameter and beam movement. In the tissue that absorbs laser light energy are known as chromophores. Several chromophores in the oral tissue are: hemoglobin, melanin and other pigmented proteins, (carbonated) hydroxyapatite and water. Visible or NIR (near infrared radiation) wavelengths are absorbed by pigmented whereas non-pigmented tissues absorb longer wavelengths. Maximum control of laser-tissue interaction can be achieved if the incident laser beam is perpendicular to the tissue surface. Reducing the incident angle towards the refractive angle of the tissue surface will allow true light reflected with increased potential of associated tissue changes.

The divergence of laser beam as it exits optic fiber will determine the amount of laser energy being delivered over an area. The spot size of the laser beam is consequent to its distance from the target tissue. Longer the distance of laser beam from the optic fiber to the target tissue the spot size is larger and conversely the shorter the distance smaller the spot size. Thermal effects on the tissue in the any given power setting will be of greater concentration of heat with the smaller beam diameter. Therefore, thermal changes at the target site can be effectively controlled by modifying the amount of energy delivered to the target site by moving the handpiece closer or farther from the target site. Faster laser beam movement will also reduce heat build-up in the target tissue and aid thermal relaxation [9].

### Modes

Diode lasers are used in continuous wave and pulsed wave mode following Einsten's theory of stimulated emission. The dental procedures are performed in both continuous wave (CW) and pulsed wave mode. Continuous wave mode is used for surgical procedures and pulsed mode in frenectomy, pulpotomy and periodontal procedures and as canal disinfectants. CW mode can ablate tissue faster and build up heat resulting in collateral damage of the target tissue and adjacent tissue. This heat buildup can be reduced by moving the laser beam faster. In pulsed wave mode, pulse width is measured in a given period and the number of pulses per second. The pulsed wave mode is dependent on the current power setting and Duty Cycle setting. Duty cycle is a phenomenon defining the ratio between pulsed width and number of pulses per second.

Diode devices are available with basic model and the current model. The basic model have fixed pulsed rate and duration, in the current model each pulse can be controlled also the interval of time between each pulse can be adjusted [4,7].

### Optic Fiber

An optic fiber in dental diodes is a flexible handpiece used for comfortable handling and aid lasers beam to the target tissue. The

diameter of an optic fiber in the lasers and the power density delivered are inter-related. For instance, the smaller diameter fiber will deliver the increased power density; this allows the decreased power setting.

The rule of thumb followed while using diode lasers is to achieve the same rate of work from either larger or smaller diameter of fiber. In small diameter fiber, decreased power setting is used and conversely an increased power setting in large diameter fiber [7].

### How to Use?

'Paint brush' type strokes are used when working in soft tissue. The fiber tip is used 1 to 2 mm away from soft tissue. (Non-contact mode). It is recommended to clean the fiber tip from debris accumulated during surgery, otherwise fiber tip becomes blackened and retain heat at the tip leading to unlimited tissue heating and tip deterioration and subsequent breakage. Faster laser beam movement will reduce heat build-up in the target tissue [7].

## Clinical Applications of Diodes

### For detection of caries and sub gingival calculus

Diagnodent is a caries detection tool, which is the Diode laser with wavelength of 655 nm. Laser fluorescence appears to compare favorably with standard methods of caries detection in occlusal fissure and the detection of sub gingival calculus. To assess pulpal blood flow diodes of 633 nm and 655 nm are used [5].

### Soft tissues surgery

The soft tissue procedures recommended using diodes are frenectomies, Hypertrophic lesion surgery, opercullectomy procedures, gingival contouring, uncovering submerged implants and periodontal surgeries [2]. It has several advantages when compared to conventional scalpel surgeries [2]:

- Its great precision, its reliability and visual access of the area operated.
- The hemostasis control is high and no harm to the tissue.
- Tissue recovery is fast with reduced edema, inflammation and pain.
- Can perform without local anesthesia infiltration or block, but the use of topical anesthesia is necessary.

### Disinfection of periodontal pockets and root canals

Diodes of 810-980 nm are used in the disinfection of periodontal pockets and root canals. In Photoactivated dye disinfection of pockets diodes of 635,670 830 nm are used.

Diode laser optic fibres are inserted within the canals, 3 mm short of apex and withdrawn gradually approximately at one minute of lasing time per canal. The wavelengths of diode lasers are well absorbed by the pigmented anaerobic microorganisms (*Prevotella intermedia* and *Porphyromonas gingivalis*). The laser photonic energy penetrates diseased epithelium and granulation tissue leading to coagulative changes due to increase in temperature of microorganism and reduce their colony forming activity. Disinfecting primary canals using diode lasers can be beneficial owing to its canal morphology and the co-operation levels of the children. Lasing primary canals can be more time effective and provokes less anxiety in children compared to conventional methods of disinfection [4].

### Photothermal bleaching

Diodes of 810-980 nm are used. The power setting for photothermal bleaching should be within the safety limits of 2 W to prevent thermal effects on pulp. At the same the power setting should be high enough to activate hydrogen peroxide in bleaching agent to breakdown into free radicals. These free radicals penetrates the tooth structure (enamel) and oxidates the stained molecules within the tooth structure [7].

### Use of diode lasers in orthodontics

Diode lasers of 635 nm are used in orthodontics for scanning of models and holographic storage. The other uses can be management of soft tissue before orthodontic treatment. The soft tissue procedures required before orthodontic treatment are frenectomies and removal of gingival tissue covering tooth either partially or completely. Diode lasers provide dry and bloodless field at the time of surgery this allows the immediate bonding of brackets [4].

### Root canal therapy

Diode lasers in root canal therapy are used for disinfecting the canals and as pulpotomy medicaments. In pulpotomy procedure the pulp amputation is done using 810 nm diodes at 2 W power setting in continuous mode. Immediate hemostasis is achieved using lasers compared to other pulpotomy medicaments [2].

### Low level laser therapy (LLLT)

LLLT is the ability of the lasers to non-thermally and non-destructively change the cell function. Diodes are the only lasers used for LLLT in the medical field. LLLT has claimed significant neuropharmacologic effects on the synthesis, release and metabolism of neurochemicals in the cells including serotonin, acetylcholine, histamine and prostaglandins. LLLT has demonstrated a significant increase in the fibroblast production and collagen synthesis. These effects on cell exhibits wide range of benefits on biological tissue and altered pain threshold. LLLT also known as 'Biostimulation' or 'Soft laser Therapy' [10].

### Laser Hazards and Safety

Diode Laser's direct beam cause definitive damage of retina and lens of the eye and its reflected beam may cause damages of the eyes. It is mandatory to use safety glasses specifically rated for a particular wavelengths and device for the patient, operator, staff and observer. To protect from inhaling the vapors produced from lasing tissue containing bacteria, gases and virus particles, face mask with the filter particle size of 1/10 of a micron must be used [3].

Hands- on training in using Lasers is a gold standard for the dental practitioners to expand the scope of use of lasers in their practice.4

### Research on Standardization of Exposure Time and Power of 810 nm Diode

#### In pulpotomy

The duration of exposure to achieve haemostasis of the pulp tissue using Diode Laser was not standardized. The histological changes of the pulp observed from the previous studies without standardizing the

exposure time were periapical abscess; dentin bridge formation, necrosis, carbonization, inflammatory infiltration, odema and haemorrhage were observed [11-15]. Hence the histological response of the pulp to 810 nm diode laser at 2 W power setting and 1 s, 3 s and 5 s exposure time in dog's teeth was evaluated. Regressive changes were observed in 5 s application and intact odontoblasts in 1 s and 3 s exposure time. These findings were suggestive 1 s or 3 s exposure time at 2 W power setting can be recommended to achieve haemostasis in pulpotomy.

### In laser applied fluoride therapy (LAFT)

Stern and Sognaes in 1972 first suggested the use of laser irradiation to inhibit dental caries. After that several investigations by multiple researchers have demonstrated that treatment with CO<sub>2</sub>, Argon, Nd:Yag, Erbium and diode lasers can reduce the rate of subsurface demineralization in enamel [16]. Different explanations for the increased acid resistance of laser treated enamel have been suggested, such as decreased enamel permeability, alteration in chemical composition or a combination of both. Similar results have been found when investigating the effect of addition of fluoride application before or after laser treatment, leading to an increased fluoride uptake and decreased rate of dissolution in acidic solution [16]. In the past decade lot of attention has been given to the role of firmly bound fluoride in caries prevention but the current attention in fluoride research is the role of loosely bound fluoride in caries prevention. Ambient fluoride released from calcium fluoride CaF<sub>2</sub> has greater caries preventive measure than firmly bound fluoride [17]. Degree of absorption of laser energy will vary with the wavelength and power or an energy output of the laser. Diode with reduced wavelength 810-980 nm has highest coefficient of thermal absorption of hemoglobin with minimal interactions with hydroxyapatite and water. This property of diode makes it suitable to use in LAFT therapy without affecting the tooth structure. However the thermal effects on the pulp also to be considered. Loosely bound calcium fluoride and firmly bound fluoride was evaluated in LAFT using diode laser at 2 W and 5 s exposure time. The synergic effect of diode laser as both loosely formed fluoride and firmly formed fluoride was observed.

The pulpal response after LAFT therapy using 810 nm diodes at 2 W power setting and 5 s and 15 s exposure time and at 3 W power setting and an exposure time of 5 s, 15 s and 30 s were evaluated in pulp of the Guinea pigs. The minimum inflammatory infiltrate and reversible pulpal changes was observed in the power settings of 2 W and 3 W and exposure time of 5 s, 15 s and 30 s these findings were suggestive that for LAFT using 810 nm diodes 2 W 5 s can be recommended. However to benefit the enhanced firmly bound fluorides formation in LAFT procedures can use increase the power settings of diodes to 3 W and 15 s.

### As canal disinfectant

810 nm Diodes at 2.5 W power setting and 5 s per cycle and the cycle was repeated 4 times with 2 s interval to disinfect the canals. The diodes disinfection of the canals was compared with, Sodium hypochlorite, Chlorhexidine and combination of Diodes with 2% chlorhexidine in experimentally contaminated root canals with *Enterococcus faecalis*.

Diodes as canal disinfectant and combination of Diodes with 2% chlorhexidine solution combination showed the highest antimicrobial efficacy against *Enterococcus faecalis*. These findings are suggestive

that Diodes laser can be an effective tool for cleaning and disinfecting the root canal system when used alone or in combination as canal irrigants at 2.5 power setting and 5 s exposure time with cycle repeated 4 times'

### In frenectomy

810 nm diodes used in the treatment of Ankyloglossia and frenectomy exhibited faster wound healing without affecting the inflammatory function, very easy to perform, less time, no suturing required. The patient hardly noticed any discomfort and there was absolutely no bleeding. No post-operative pain reported and there was no need of antibiotics. These observations are suggestive that diodes were preferred in frenectomies compared to conventional surgical procedures.

### Conclusion

The diodes have a wide range of clinical application in dentistry. Diodes offers practitioners expanded scope of dental procedures in their clinical use. However judicious selection of the power and exposure time for different clinical procedure is recommended.

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