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Review Article

Synopsis is Using Dental Diode Laser in Endodontic

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Abstract

Root canal treatment is currently performed using a combination of hand and rotary instruments to remove the necrotic tissue, clean and disinfect the root canal space and shape the space to receive the obturating material. In this abstract, it is the 1st part, we will review the new clinical concept using diode laser in aiding root canal disinfection and removal of smear layer as a promising tool to increase the success rate of the root canal treatment.

Keywords: *Diode Laser, Root canal, Endodontic, photons*

Laser light as a general

Laser is an abbreviation of light amplification of stimulated emission of radiation, so it's a light, but what make laser different from the normal light?

I mean what is the secret of laser over ordinary light. To make the life easy, we start with the most accepted definition for the light, it's an electromagnetic radiation, and the unit of light is the photon.

The photon is a package of energy. so, imagine the light as a trop of photon spreading in the medium. During spreading of photon in the medium it exists 2 field, magnetic field and electric field, both are perpendicular to each other and both are perpendicular to the pass of propagation, so these photons moving in wavy motion existing the 2 fields.

When we call this light a laser light?? If the bundle of radiation is:

- Coherent
- Collimated
- Monochromatic

What is the secret of laser light?

If we compare between the light beam and laser beam if we focus with convergence lens, the laser beam can cut a steal but on the other hand light can burn blank paper.

The secret is:

Because laser waves are parallel to each other and all the photons has the same energy and frequency so when this beam is focus it will focus in very tiny point in compare to the normal light, which waves are not parallel and has different photon energy so it will focus is large point from physics knowledge the power density of the laser light will be very high than that of the normal light as power density = power per unit area of spot beam.

The higher power density can cut the steal of metal and on the other hand the low power density can just burn a plank paper, so when we speak about laser, we speak about energy, if we look to the laser waves or beam when interact with tissue either soft or hard tissue we have 4 possibilities:

Transmission, Reflection, Diffuse, Absorption
In dental field the most important effect is the absorption
To the absorption of laser beam to happen there must be photosensitive

Component, which will absorb the beam
In soft tissue the photosensitive components: Water, Blood, Pigments
In hard tissue: Water, Hydroxyl apatite

As we are focus on diode laser which highly absorbed in blood and hemoglobin, so it's called soft tissue laser.

If we look to the physics knowledge again, the first conservative law states that energy cannot be existed nor destroyed, but transform from one form to another form. From this point of knowledge, we use the laser light is dentistry so the laser energy will have absorbed by the photosensitive (chromophore) and transforms to thermal energy by which we can use the laser to do majorities of dental procedures.

In our article, we will focus on diode laser
Diode group: 810 nm, 940 nm, 980 nm, and 1046 nm
All these wave lengths sharing the same optical property
All of them absorb either in blood or pigment

Diode laser can:

Incision soft tissue
Excision soft tissue
Stop minor oozing of blood (hemostasis)

Disinfection

As in this review we focus on diode laser, Diodes rapidly found their way into laser-assisted dentistry thanks to their small size, ease of use and affordable price. Diode lasers with a big range of different wavelengths from visible to infrared contributed a lot to the field of endodontic especially endodontic disinfection.

The effect by which diode kill the microorganisms are the photo thermal effect (laser energy converted to thermal energy).

The near-infrared lasers (from 810 nm - 1340 nm) have negligible affinity for water and the hydroxyapatite of hard dental tissues and therefore penetrate to a large extent, through dentinal tubules and are absorbed by the bacteria pigments. This allows for a bactericidal effect in deeper dentin layers [1]. In addition to killing the endodontic bacteria, the removal of smear layer by using the diode in low power with pulses to induce agitation to the irrigating solutions.

Both effects can increase the successful rate of routine endodontic treated teeth and in treating the recurrent infected teeth.

Limitation of conventional root canal treatment

The root canal treatment is the removal of the infected tissue, disinfect the root canals and accessory root canals, and obturation of it, so we can preserve the tooth and at the same time maintain the health of surrounding structure (gingiva-bone) and prevent the reinfection, so the goal of the root canal treatment:

Cleaning

Disinfection

Circumferential obturation with hermetic seal but in fact we cannot obtain these goals perfectly due to:
Complex anatomy of the root canals (the canal not the one we see on the x-ray).

Smear layer

Pathway of the dentinal tubules at the coronal part (s shape).

During the development of the root canal procedure huge devices, materials are existed to:

- Ensure complete cleaning of the canal
- Ensure complete disinfection of the canal
- Ensure removal of smear layer
- Ensure hermetic seal of the canal walls

But still we saw daily recurrent infection for many teeth looks perfectly on the x-ray, unfortunately we don't see all the already present as accessory canal which first we cannot reach to clean or disinfect, at the end decrease the success rate of endodontic. Many studies have shown that preparation of canals with manual and rotary devices whether stainless steel or nickel titanium cannot sufficiently disinfect root canals [2,3].

Literature Review

Regarding endodontic treatment

The statistics show that the success rate of root canal treatment depends on the probable presence of bacteria. In vital teeth where the number of bacteria in the canal is low, success rate is high. In necrotic teeth and teeth with lesions around the roots, success rate decreases due to the high presence of microorganisms inside the canal [1]. Different types of microorganisms such as bacteria, fungi, and probably viruses can infect dental pulp and lead to periodontitis. Spread of infection to the surrounding area of the teeth root significantly reduces the treatment success. Therefore, Microorganisms have a major role in the treatment failure of the teeth roots [4,5]. Researchers have shown that following canal preparation a layer of 1-2 microns' forms on the canal walls named smear layer containing organic and inorganic substances with microbes which can penetrate to a depth of 40 microns in dentin [3] Removing the smear layer or not, has been a controversy for years. Some scientists have reported that presence of a smear layer delays the disinfection work, but doesn't completely prevent it, and when the canal is infected between the treatments sessions, it acts as an appropriate barrier to block entry of microorganisms inside the dentinal tubules. On the opposite, some other researchers believe this barrier to be an obstacle for passage and penetration of rinsing solutions in the dentinal tubules [4,6]. Pashley stated that smear layer contains bacteria and their products, and can act as an intra canal stimulus. In consequence, its removal can help root canal treatment and seal to succeed [7].

Different types of microorganisms such as bacteria, fungi, and probably viruses can infect dental pulp and lead to periodontitis. Spread of infection to the surrounding area of the teeth root significantly reduces the treatment success. Therefore, microorganisms have a major role in the treatment failure of the teeth roots [2,3]. Ideal irrigating solutions such as sodium hypochlorite dissolve vital and necrotic tissues and eliminate bacteria but are not able to sterilize the canals [8]. The elimination of microorganisms from the root canal system, is accomplished by means of biomechanical instrumentation of the root canal. Studies have shown, however, that complete removal of microorganisms from the root canal system is virtually impossible [5,9] and smear layer covering the instrumented walls of the root canal is formed [10,11]. The smear layer consists of a superficial layer on the surface of the root canal wall approximately 1 to 2lm thick and a deeper layer packed into the dentinal tubules to a depth of up to 40lm [11]. It contains inorganic and organic substances that also include microorganisms and necrotic debris [12]. In addition to the possibility that the smear layer itself may be infected, it also can protect the bacteria already present in the dentinal tubules by preventing the application of successful intracranial disinfection agents [13]. Pashley

[7] considered that a smear layer containing bacteria or bacterial products might provide a reservoir of irritants. Thus, complete removal of the smear layer would be consistent with the elimination of irritants from the root canal system [14]. According to Oguntebi [15], the most currently used intracanal medicaments have a limited antibacterial spectrum and some of them have a limited ability to diffuse into the dentinal tubules. It also was clearly demon-strated that more than 35% of the canals surface area remained unchanged following instrumentation of the root canal using four nickel-titanium preparation techniques [16]. It is well known that apical periodontitis is caused by the communication of root canal microorganisms and their byproducts to the surrounding periodontal structures. Exposure of dental pulp directly to the oral cavity or via accessory canals, open dentinal tubules or periodontal pockets is the most probable route of the endodontic infection [17].

Regarding Diode Laser

Diode laser with various parameters show that this laser can be effective in reducing intra canal bacterial count and penetration in the depth of 500 microns in dentin. In studies performed on Diode laser in combination with canal irrigating solutions such as sodium hypochlorite and oxygenated water better results were obtained. In a comparative study designed, 810 nm diode could reduce bacteria contamination up to 88.38 percent with a distal output of 0.6 watts in CW mode. A 980nm diode laser has an efficient antibacterial effect in root canals contaminated with *Enterococcus faecalis* at an average between 77 to 97 percent. Energy outputs of 1.7 watts, 2.3 watts and 2.8 watts were tested. Efficiency was directly related to the amount of energy and dentin thickness. An endodontic laser therapeutic plan brings benefits to conventional treatment, such as minimal apical leakage, effective action against resistant microorganisms and on external apical biofilm, and an increase in periapical tissue repair. Based on that, laser procedures have been incorporated into conventional therapeutic concepts to improve endodontic therapy. The traditional approach for destroying bacteria is mainly antibiotic drugs which are not very efficient because of the development of resistant species. In addition, the limited penetration of drugs into bacterial biofilm results in reduced susceptibility to this kind of treatment. Obviously, there is a growing need for innovative approaches leading to bacteria eradication. Stationary contact of fiber tip with dentin leads to overheating and melting the dentin and further thermal damage to surrounding tissues. For this reason, constant moving of fiber during irradiation is fundamental [18,19]. Combination of diode laser and EDTA results in smear layer elimination. in another study, activation of EDTA by a 940-nm diode laser seems to be an ideal protocol to remove smear layer, but irradiation of hydrogen peroxide with same parameters develops no significant effects on smear layer (20,21). Diode lasers might contribute to activation of irrigation solutions with frequency that reaches to 20-50KHz. This property of diode laser could promote cavitation effect inside root canal irrigants and subsequent better debridement. Neelakantan demonstrated the diode laser is as efficient as Er: YAG laser to activate irrigants in the root canal and disturb microbial biofilm. However, in another study it has been indicated that there are some differences in quality of explosive vapor initiated by diode and Er: YAG lasers. The peak of cavitation and bubbles formation with diode laser happens with a delay after irradiation starts. Due to slower fluid movement during irradiation by diode laser, the possibility of irrigants extrusion beyond dental apex is less than that of Er: YAG laser. However, there is a proportional relationship between irrigant volume in root canal spaces and the power needed to activate it. The form of the fiber may enhance the outcome. George introduced a modified light delivery fiber called honeycomb tip to enhance the agitation and cavitation properties of diode laser. Using this fiber, diode laser makes more bubbles toward root canal walls and less in apical direction. As well the time needed to achieve peak cavitation is inferior to that of plain fiber. However, the factor of power is playing an important role. The cavitation occurs always in a power level more than 2W.

Laser-Activated Irrigation (LAI) with Diode-lasers

Hmud., *et al.* [22] examined whether near infrared 940 and 980 nm diode lasers (Biolase Ezlase and Sirona Sirolaser, respectively) could induce cavitations in aqueous media (distilled water, water, aerated tap water, degassed distilled water, ozonated water, 3 and 6% hydrogen peroxide). It appeared that both diode laser systems could induce cavitation in water-based media by the formation and implosion of water vapor. Laser power played a more important role than pulse frequency or pulse interval. These cavitations, however, developed after several seconds of laser operation and were visible to the human eye with the aid of light and magnification. This clearly differs from the action of erbium lasers, where the bubble forms instantly (only a few microseconds after onset of the pulse) at the fiber tip and is invisible to the human eye because it exists for only a few hundred microseconds (Blanken., *et al.* 2009). Deleu., *et al*. [23] investigated cavitation with a 980-nm diode laser (Fox diode laser, A.R.C. laser GmbH, Nürnberg, Germany). Bubble formation was only observed beyond 7W. However, this setting can present serious concerns towards thermal safety in the clinical situation and should be considered inappropriate. In this study, the diode laser was significantly more effective at removing debris from the groove than conventional syringe irrigation, but significantly less effective than the Er: YAG laser with conventional fiber [23]. The bubble formation for the diode laser was limited to the area just around the fiber tip and was considered more to be the result of steaming than of generation of vapor bubbles (cavitation) [24].

Guide line of using diode laser in Disinfection of root canal

After removal of the roof of the pulp chamber, disinfect the field well before removal of the content of the canal, to disinfect the pulp chamber so decrease the pushing of microorganisms inside the canal during mechanical preparation (diode 980 nm 2,5w non-contact).

Regular removal of the necrotic content of the canal, apical patency, working length and chemico-mechanical preparation.

Fill the canal with sodium hypochlorite, enter the laser fiber inside the canal 1 to 2 mm before apex and start lasing by moving the fiber up and down inside the canal (980 nm 2,5w).

The purpose of using the laser in wet canal, to worm the irrigating solution to increase its disinfecting effect, in addition laser induces cavitation, which enhance the removal of the smear layer.

Dryness of the canal

Again, insert the fiber tip 1 to 2 mm less than the final working length and we start disinfect the canal while its dry.

We move the fiber tip in circular motion and avoid touch the internal wall of the canal with the tip of the fiber (to avoid melting of dentin and transfer the thermal effect to the periodontal ligament space, and also to keep the tip of the fiber free of debris to get proper laser beam - we move the fiber in circular motion from the apex to the coronal end and from the coronal end to the apex (5 passes with 5 seconds in-between) to ensure that the laser cover all the internal wall of the canal, finally we obdurate the canal regularly with any obturating material.

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