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Enhancing Endodontic Success: Exploring Laser-Based Techniques for Root Canal Therapy Improvement

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Abstract: ***Failures in root canal therapy may be due to many causes. Some of them, such as incomplete obturation of the root canal space and coronal microleakage, may be amenable to endodontic retreatment. Usually retreatment isconducted through the root canal system as a first approach.Endodontic success is dependent on disinfection and debridement of the canal system. Once our knowledge of optimal laser parameters for each treatment is complete, lasers can be developed that will provide dentists with the ability to care for patients with improved techniques. The use of dental lasers for root canal filling removal is an alternative to conventional endodontic therapy and can be the last chance before surgery.***

Keywords: Laser, Root canal filling removal, Retreatment, LAI, PIPS

1. Introduction

Failures in root canal therapy may be due to many causes. Some of them, such as incomplete obturation of the root canal space and coronal microleakage, may be amenable to endodontic retreatment. Usually retreatment isconducted through the root canal system as a first approach.The first and main parameter for success is the possibility to return to the apical constriction or the radiographic apex. Elimination of biomaterials such as gutta-percha is not difficult for the clinician and the same can be said for sealers used in conjunction with gutta-percha, although some problems regarding the amount of debris have been discussed.The presence of gutta-percha in the lumen of the canal space facilitates the access to the working length. It's elimination using conventional (hand instrumentation plus solvents), mechanical (rotary instrument), or biophysical means (sonic and/or ultrasonic devices) does not present a problem[15]. When the root canal is filled with pastes without gutta-percha and when those materials are zinc oxide, epoxy resins, or phenoplastic resins, the endodontic retreatment may be difficult to impossible. For instance, there are no specific solvents for phenoplasts (dimethylsulfoxide or perchlorethylene are not really effective) and the usual methods mentioned above are of no help. The removal of filling materials from the root canal system is a fundamental step for the success of endodontic retreatment and depends on several factors that influence the final quality of the procedure, such as the type of the obturation material used, the removal methodology applied, and the time required for each technique to reach satisfactory results. Although several methods have been proposed to endodontic retreatment over the years, further studies are required to evaluate the quality of these techniques to suggest, with scientific basis, the most efficient method for each case. In the attempt to reduce treatment time and improve the outcome of retreatment different type of laser systems were introduced and developed in dentistry[1]. According to National Academy of Sciences, laser development is one of the greatest achievements after one century of innovations in engineering. A laser is a device which transforms lights of various frequencies into a chromatic radiation in the visible, infrared and ultraviolet regions with all the waves in phase capable of mobilizing immense heat and power when focussed at close range [3, 11]. Laser light has specific properties as monochromaticity, coherence and directionality, that can enhance the outcome of the endodontic therapy[13].

2. Laser Light Retreatment Possibility

It is well known that success in endodontic treatment, as well as in endodontic retreatment, requires the complete elimination of debris from the canal space.Root canal preparation with steel and nickel-titanium instruments is today considered the goldstandard in Endodontics. Recent years, with the aim of increasing the efficiency of the root canal treatment, there has been a development and rapid implementation of new technologies in endodontics as the use of laser light [2]. When a laser fi ber/tip is inserted into the canaland laser irradiation starts, it interacts with thecanal surface following the optical characteristicof every wavelength. The presence and concentration of specific chromophores on the canal surface and inside thedentinal tubules determine absorption, diffusionor transmission of laser light. Depending on thewavelength, there are different effects and differentdepths of penetration. Under the same conditions, the medium infrared wavelengths, which are well absorbed by the dentin water (chromophore), spread theirenergy superfi cially over the canal surface, whilethe near-infrared wavelengths, which are not wellabsorbed by the dentin chromophore, are morepenetrating in depth.The combined useof laser systems, associated withmanual preparation, demonstrated better cleaningafter preparation, with very small debrisremnants.Laser energy increases the percentage of cleaning of the root canals, removes debris and the smear layer and has a proven antibacterial effect. The laser wavelength described for cleaning of root dentine are CO_2, 9600 to 10,600 nm; Er: YAG, 2940 nm ; Er:Cr:YSGG, 2790 nm; Nd YAG, 1064nm; Diode, 635 to

980nm and KTP laser, 532 nm [8]. Thanks to the laser light specific properties the results of endodontic treatment and the healing process can be improved.

Endodontic retreatment is generally tedious and time-consuming, and the common rule is that instruments should not be forced to remove root canal filling material. Thanks to the laser light, we could soften materials before removal, thus reducing canal wall stress and the risk of cracking produced by rotary instrumentation. This, in addition to reducing the risk of intracanal instrument breakage, made it possible to avoid overheating the tooth, which is very dangerous for periodontal ligament and bone. A main advantage of the application of laser light is the possibility to work without solvents that can be toxic. The use of tips with increased flexibility and radiating irradiation reduces the risk of ledges, perforations and transportation in curved canals, despite the reduced tactile sensation. According to scientific data, different type of laser systems such as diode, Nd:YAG/ YAP and Er:YAG laser can be used to remove root canal contents as an alternative to apical surgery.

The use of Nd:YAG (λ= 1064 nm) and Nd:YAP (λ= 1340 nm) lasers in root canal retreatment has been evaluated and described in the late 90s [12,14]. Early development of the fiberoptic system of Nd:YAG laser, which enables the delivery of the light in a narrow root canal, made this laser the most widely used in endodontic research[5]. Although the wavelengths of these lasers are well absorbed in pigmented material (gutta-percha), the problem was the photo-thermal effect of the irradiation on the guttapercha which resulted in carbonization and partial dissolution of the material and dentin causing its difficult removal from the canal. Also the temperature increase can be deleterious to the tissues surrounding the tooth, especially for the bone, because of its lower degree of vascularization.

These adverse effects also explain the preference for the Er:YAG laser when endodontic treatment is needed. Its specific wavelength (λ= 2940 nm) is very well absorbed by water and provides a minimal thermal effect to adjacent tissues [5]. It works with water-air cooling and pulse mode of radiation at different powers. The use of an optical fiber, because of it's dimension (300 µm) allows beam progression into root canals previously prepared to # 30 K file. The main presence of remnants of canal contents, was established in the apical 1/3 of the root canal. Applying a higher frequency and power reduces the operating time, but increases the risk of unwanted side effects as carbonisation and dentin damage.It is has been proved that Er:YAG laser aid in eliminating endodontic hard materials such as ZnO cements and phenoplastic resins [16]. The sequence of lasing (intervals between a series of pulses) must be spaced out as opposed to rapid and continuous successions. It was observed that this mode avoids temperature elevations when used in combination with a continuous flow of water irrigation and prevents root canal perforations.

Currently, the first problem of using lasers in endodontics is finding the proper settings for the given operation, since the literature does not contain all the pertinent information. Further investigations and future developments are needed to define, as well as possible, the operative protocols (energy, distance mode, spaced out sequences, combination with solvents). The authors strongly recommended improving the endodontic tip to enable irradiate all areas of root canal walls. The development of oblique light transmission systems, side firing tips and rotation, effectively reflect the function of the laser and significantly improved the results of laser-assisted endodontic treatment. Despite of elaboration of laser systems the application to extremely curved and narrow infected root canals appears difficult.

3. Laser Activated Irrigation

One of the more recent techniques available forautomated agitation/activation of irrigant in theroot canal is laser-activated irrigation (LAI). This application uses laser energy to agitate and activatethe irrigant [17]. The lasers typically used forLAI are the erbium laser family such asErCrYSGG and Er:YAG. These lasers havewavelengths in the medium-infrared region(2780–2940 nm) which is highly absorbed inwater and NaOCl. The laser light is delivered through an optical fiber or an articulated arm to a handpiece witha terminal flat or conical tip, suitable for insertioninto the root canal close to the root apex. To beeffective in the whole root canal, different LAIprotocols are used to apply the laser tip in the differentsegments of the root canal. In a variationon thistechnique, the fiber tip is placed just abovethe root canal entrance, in the pulp chamberwhich is filled with irrigant [7, 8]. This leads toagitation/activation and streaming of the irrigant throughout the entire root canal system. This specific LAI technique, referred to as photon-induced photoacoustic streaming (PIPS), usesspecially developed tapered and stripped laserfiber tips in combination with low energy and short pulse duration.PIPS allows for deeper penetration in dentinal tubules of irrigant and can disinfect the dentinal tubules [4]. Studies have reported that PIPS can remove the smear layer and debris more efectively than syringe-based irrigation and ultrasonic activation [5,6,10]. PIPS uses only a laser fber tip placed inside the access cavity, avoiding the risk of thermal damage of the teeth and periodontal tissue. Te combined use of PIPS with a NiTi rotary system to remove sealers is more efective than the use of NiTi alone [9]. A lot of researches have demonstrated that addition of laser activated irrigation greatly enhances not only the efficiency of the recommended irrigation solutions (NaOCL and EDTA), but also improves disinfection and cleaning of the root canal system[7].

4. Conclusion

With the development of more advance mode of laser delivery the laser treatment will be more readily accepted. Lasers have become standard equipment in the dental practice and are a good tool for enhanced endodontic treatment/ retreatment. All laser types have their advantages and cons, and the choice of which laser to use depends on the treatment to be performed. Once our knowledge of optimal laser parameters for each treatment is complete, lasers can be developed that will provide dentists with the ability to care for patients with improved techniques. The use of dental lasers for root canal filling removal is an alternative to conventional endodontic therapy and can be the last chance before surgery. Side effects resulting from irradiation with laser light do not appear if the correct parameters are used.

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