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Influence of Diode Lasers on the Apical Leakage in Endodontic Treatment

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Abstract: ***The outcome of root canal treatment is based on efficient disinfection of the root canal system and prevention of reinfection. Current chemomechanical cleaning methods do not always achieve these goals, and insufficient root canal disinfection is the main reason for endodontic failure. The aim of our in vitro study was to evaluate the effect of diode laser irradiation (λ=660 nm and λ=970 nm) on the intracanal dentin and their interference in the apical seal of filled root canals. 48 human single rooted teeth were randomly assigned into 4 groups. Root canal preparation was done using ProTaper Universal rotary system up to F3. 2 % Sodium hypochlorite, 17 % EDTA and distilled water were used as irrigants. The laser irradiation was performed at the end of the traditional endodontic preparation and teeth were filled with gutta-percha and AH- plus. The apical leakage was report on mm. Statistical analysis showed that the laser-treated groups had significantly less leakage in apical third than the control group. Certain lasers can help in removing the smear layer and debris and can modify the morphology of the root canal wall for better root canal sealing.***

Keywords: diode laser, apical leakage, Protaper rotary instruments

1. Introduction

The outcome of root canal treatment is based on efficient disinfection of the root canal system and prevention of reinfection [4,17]. The ultimate goal of root canal treatment is to close the root canal system, especially in the last 1/3 of the root tip. The correct apical sealing prevents bacteria in oral environment from entering and reinfecting the root canal, prevents the tissue fluid from going into the root canal and becoming the residual bacteria culture media, and prevents the occurrence of periodontitis. Therefore, the apical sealing of the root canal is one of the important indicators to a successful root canal treatment. It has been shown that 58.66% of the endodontic cases failure was caused by incomplete root canal closure.

Current chemomechanical cleaning methods do not always achieve efficient disinfection. For that reason different type of laser systems have been widely used in endodontics in recent years [7,12]. Due to high energy content and specific characteristics of laser light, the laser treatment has been proposed for cleaning and disinfecting the root canal system. The dentin wall changes caused by laser irradiation could improve the sealing ability of endodontic cements [19]. The possibility of the laser irradiation to promote the cleaning and disinfection of the radicular canal system has become this type of treatment in a viable and real alternative in endodontics.

2. Material and Methods

The aim of our ***in vitro*** study was to evaluate the effect of diode laser irradiation with two different wavelengths- **λ=660 nm and λ=970 nm**, on the intracanal dentin and their interference in the apical seal of filled root canals.

48 human single rooted teeth were used for preparation of 48 specimens with equal working length. They were randomly assigned into 4 groups, depending on the desinfection protocol:

Group I- distilled water (control group)
Group II- 2 % NaOCl; distilled water; 17 % EDTA; distilled water
Group III-2 % NaOCl; distilled water; 17 % EDTA; distilled water; Photodynamic therapy (laser λ=660 nm+ FotoSan Agent Low); distilled water
Group IV-2 % NaOCl; distilled water; 17 % EDTA; distilled water; laser λ=970 nm
Root canal preparation was done using ***ProTaper Universal rotary system*** following the recommended sequence (S1, S2, F1, F2 and F3).

The laser irradiation was performed at the end of the traditional root canal therapy as a final means of decontaminating the endodontic system before root canal filling (**Figure 1**). Laser therapeutic instrument (***SiroLaser Blue, Sirona, Germany***) was used in the study. The diode laser with 970nm in wavelength and 1Hz±10kHz in frequency delivers energy in pulsed or continuous wave mode, with a maximum output power of 7 W. The 200μr plain ended fibre is suitable for the endodontic application. The continuous wave mode was employed for this laser. The protocol for diode laser was followed according to the manufacturer's instructions by a well-trained clinician.

Laser irradiation parameters:
a) λ=660 nm, 25 mW, 60 sec.
b) λ=970 nm, 1.5 W, 15 Hz

Figure 1: Diode laser irradiation

After irrigation and laser therapy all root canals were dried with paper points and were filled with ***tapered gutta-percha***

cones and sealer AH- plus. The specimens were stored at 37ºC and 100% humidity for one week to allow the sealer to set.

One week after the sealing each root was blotted dry and then covered with two coats of nail polish, except for the apical 2 mm. Nail polish was allowed to air-dry for 24h. The specimens were immersed in 2% methylene blue dye for 72 h.

At this point, the sample was rinsed under the water for 15 minutes. Two opposing longitudinal grooves were made into the dentin on the root surfaces, in order to facilitate the split of the root in half. Each section was then viewed under a stereomicroscope at 20× magnification. Evaluation of the staining of each part was done for three times. The linear dye leakage at the apical third was measured in mm (**Figure 2**).

Figure 2: Experimental specimens

Statistical analysis was done with SPSS 19.0 statistical software package, using Mann-Whitney and Kruskal-Wallis Tests.

3. Results

Results of microleakage of dye in each group are presented in Table 1 (**Table 1**).

Table 1: Microleakage after root canal filling

	N	Min	Max	Mean	SD	SE Mean	p-value
I	12	2.0	11.0	5.125	3.163	0.913	
II	12	0.0	5.0	2.000	1.719	0.496	0.008*
III	12	0.0	3.0	1.458	0.941	0.272	<0.001*
IV	12	0.0	3.0	1.300	1.242	0.359	<0.001*

Statistical analysis showed that the laser-treated groups had less leakage in apical third than the control group. The results are statistically significant ($p<0.05$).

There is no statistical significance between group II, III and IV ($p>0,05$).

The morphological changes on the apical intraradicular dentin surface caused by diode laser irradiation resulted in less linear dye apical leakage (**Figure 3**).

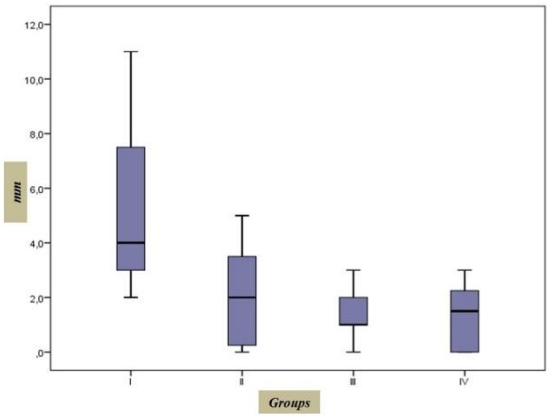

Figure 3: Apical microleakage

4. Discussion

The prognosis of root canal therapy positively correlates with the degree of root canal filling. About 45% of the root canals that are not tightly filled will develop lesions, whereas only 7% of the root canal with tight canal fillings will develop the lesions [10]. As the root canal system is complex and there are many traffic branches and collateral root canal, applying root canal instruments only cannot completely remove infectious substances from the root canal [2,11].

During root canal preparation, the dentin smear layer will be attached to the root canal wall, which will affect the adhesion of the root-filling material to the root canal wall. It may also lead to apical leakage, causing recurrence of apical infection. At present, the main clinical approach is to use the rinse solution for disinfection and removal of smear layer [3]. EDTA combined with sodium hypochlorite wash is most commonly used. Sodium hypochlorite remove the organic debris, and EDTA helps in removal of smear layer and inorganic debris [6,16]. The combination of sodium hypochlorite and EDTA can remove the organic and inorganic components in the smear layer, so that the dentinal tubules are opened, which can effectively remove the smear layer.

The bacteria can invade the root canal dentin tubules up to 1mm in depth, while the flushing fluid can only reach the distance of 100μm [22]. Another study found that although the EDTA and sodium hypochlorite alternate flush could effectively remove the neck 1/3 and middle 1/3 of the smear layer wall, it performed poorly in removing the root tip 1/3 smear layer. Because of the narrow lumen of the apical third of the root, it is difficult for the flushing fluid to reach, and to maintain an effective concentration [8] .

At present lasers have been widely used in dentistry self-dependent or in combination with dye in the photodynamic therapy [1,5,9,21]. A number of studies have indicated that after the root canal preparation, the diode laser irradiation in the root canal may reach the area of the root canals which the conventional disinfection fail to enter [20,23,24]. Diode laser irradiation may carry out multiple functions, including disinfection and sterilization, removal of the smear layer, and melting and sealing of the dentin tubule to improve the sealing performance of the root canal [13,14,15,18]. The

present study was designed to evaluate the effect of diode laser irradiation on root canal obturation after routine root canal therapy. The apical sealing after root canal filling was compared between the four groups, namely the laser irradiation root canal after root canal preparation group, photodynamic therapy group, conventional irrigation group and control group. Overall the treated groups significantly improved the sealing performance compared with the control group ($p<0.05$), and the laser irradiation combined with conventional root canal preparation is superior in improving the performance of root canal sealing ($p<0.01$). Application of diode laser in root canal therapy effectively removes the smear layer within the root canal. It allows the root canal filling material and the root canal tightly integrated.

However, discrepancies are also noticed among different studies because of the inconsistent laser parameters and experimental conditions used in each study. The application of diode laser in clinics is just being explored. Therefore, more standardized experiments are needed to optimize the application of laser in clinic. Nevertheless, results from our study now reveal the great the promise of clinical application of laser during root canal teratment. Results from our study demonstrated the application of diode laser prior to root canal obturation increases the apical sealing of the roots treated.

Conclusion

Root canal instrumentation produces a smear layer that influence the adaptation of filling materials to canal walls. Certain lasers can help in removing the smear layer and debris and can modify the morphology of the root canal wall for better root canal sealing. They still cannot replace sodium hypochlorite and EDTA and should be considered as an adjunct to the current chemical root canal disinfection protocols.

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