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Laser Application and Root Canal Sealing of Endodontically Treated Teeth

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Abstract: ***Aim: The aim of this in vitro study was to investigate the effect of two different types of laser irradiation (Er: YAG and diode laser) on the hermetic sealing of endodontically treated teeth. Methods.48 human single rooted teeth were randomly assigned into 4 groups. Root canal preparation was done using ProTaper Next rotary system up to X3. The laser irradiation was performed at the end of the traditional endodontic preparation as a final means of decontaminating the endodontic system. Teeth were filled with a core-carrier system Guttacore (Dentsply, Sirona) and sealer AH-plus. Results: Statistical analysis showed that all groups had significantly less leakage in apical third than the control group. The laser-treated groups presented better results than Group II (traditional disinfection protocol), without statistically significant difference. The morphological changes on the apical intraradicular dentin surface caused by Er: YAG laser irradiation resulted at least linear dye apical leakage. Conclusion: Application of diode and Er: YAG lasers improves the apical seal of root canals in endodontically treated teeth. Combined use of laser systems with appropriate parameters and routine irrigation protocols facilitates the adhesion of root canal filling materials to root dentin.***

Keywords: Er: YAG laser, Diode laser, Apical microleakage

1. Introduction

The outcome and long-term prognosis of endodontically treated teeth are highly dependent on the thorough removal of microorganisms, tissue remnants and other inflammatory irritants, their proper shaping and hermetic root canal sealing [13]. The presence of a smear layer on the root dentin, with its organic and inorganic ingredients, has a negative impact on the effective sealing of the root canal space [16]. With its removal, the dentin permeability is increased, the adaptation and bond strength of the endodontic sealers to the root dentin is improved and the incidence of micro leakage is reduced [20, 21, 22].

In the course of the endodontic treatment, influenced by the technique used, the amount of the smear layer and the dentin permeability change a lot. The number and dimension of dentin tubules affect the surface permeability, according to Pashley [13]. The exposure of root dentin to the single or combined use of irrigating solutions, such as sodium hypochlorite (NaOCl), ethylene diamine tetraacetic acid (EDTA), chlorhexidine gluconate, citric acid etc, results in better smear layer removal and improves dentin permeability [22].

The effect of irrigants is increased with their activation with sonic and ultrasonic energy or laser irradiation [2, 3, 18]. It was found by some investigators that various types of lasers are suitable for endodontic applications and are able to effectively remove the smear layer, increase the antibacterial activity of the solutions and provide better sealer adhesion. The ultrastructural changes caused by the laser irradiation increase the chance of endodontic success [1, 3, 14].

2. Methods

The **aim** of this *in vitro* study was to investigate the effect of two different types of laser irradiation (Er: YAG and diode laser) on the hermetic sealing of endodontically treated teeth. The null hypothesis tested was that there would be no significant difference between the examined laser irradiation and traditional irrigation protocols with regards to their influence on apical microleakage.

Forty-eight single-rooted non-endodontically treated teeth with straight roots (<5°) were selected for the study and stored in distilled water. All crowns were removed with diamond burs under copious water cooling at the level of the cemento-enamel junction of the teeth, leaving roots with an approximate length of 16 mm. The specimens randomly assigned into 4 equal groups (n=12), depending on the disinfection 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-diode laser λ=970 nm
Group IV-2 % NaOCl-distilled water-17 % EDTA-distilled water-Er: YAG laser λ=2940 nm

ProTaper Next rotary system (*Dentsply, Sirona*) was used for the shaping of all root canals, following the recommended sequence-X1, X2 and X3). The dentinal chips and organic debris were removed by irrigation of each of the canals with 2 ml 2 % Sodium hypochlorite. The inorganic constituents of the smear layer in the root canal were affected by irrigation with 2 ml 17 % EDTA. Distilled water was used after each of the irrigants.

Laser irradiation was performed in two of the studied groups, immediately before the root canal filling**.** Two separate laser devices were used-a diode laser *SiroLaser Blue (Sirona, Germany)* andEr: YAG laser*AT Fidelis (Fotona, Slovenia)*-by a well-trained clinician, following the manufacturers' instructions. The laser irradiation parameters were:

Group III-λ=970 nm, 1.5 W, 15 Hz (Diode laser)
Group IV-λ=2940 nm, 2.4 W, 120 mJ, 20 Hz, VLP, Water-0, Air-2, R14 (Er: YAG laser)

All root canals were dried with paper points and filled with a core-carrier system **Guttacore** (*Dentsply, Sirona*) and **AH-plus sealer**. The specimens were stored at 37°C and 100% humidity for one week to allow the sealer to set.

One week after the sealing, each root was blotted dry and 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. Afterwards, the samples were 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 2 halves. Each section was inspected 3 times for the degree of staining under a stereomicroscope at 20× magnification. The linear dye leakage at the apical third of the root canal was measured in mm (**Fig.1.)**.

Figure 1: Experimental specimens

Data were analyzed using the IBM SPSS 23 statistical software program (version 23; IBM, Chicago, IL) andMann-Whitney and Kruskal-Wallis tests. The level of significance was set to p≤0.05.

3. Results

The analysis of the results revealed significantly less leakage in the apical third of the root canal for the tested groups compared to the control. The laser-treated groups showed better results than Group II (traditional disinfection protocol) but the statistical difference between Groups II, III and IV remained insignificant (p>0, 05). The results of the dye microleakage are presented in Table 1 **(Tabl.1.).**

Table 1: Dye microleakage in the tested groups

	N	Min	Max	Mean	SD	SE Mean	p-value
I	12	0.0	4.0	1.667	1.073	0.310	
II	12	0.0	5.0	0.958	1.544	0.446	0.037*
III	12	0.0	3.0	0.500	1.000	0, 289	0.006*
IV	12	0.0	3.0	0.500	0.879	0.254	0.003*

The morphological changes on the apical intraradicular dentin surface caused by photodynamic therapy with FotoSan *(Group III*) resulted the most linear dye apical leakage of the laser treated groups (**Fig.2**).

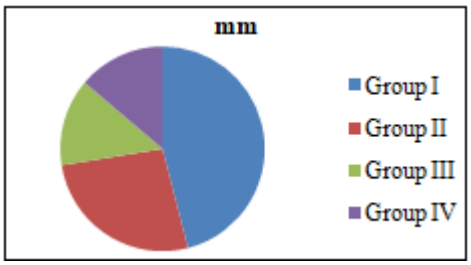

Figure 2: Apical microleakage

4. Discussion

The null hypothesis tested was confirmed as no significant difference was found between the experimental groups. The results differed significantly only when they were compared with the control group.

The presence of a smear layer on the dentinal surface or into the dentinal tubules is detrimental to the successful outcome of the root canal therapy because its presence interferes with the adhesion of the root canal filling materials to the root dentin. [6, 9]. It is a leakage pathway as it slowly dissolves around the root canal filling material. At the same time, the smear layer is a substrate for the growth and ingress of microorganisms whose by-products can further disintegrate it [7, 17, 21].

Different approaches are used for disinfection of the root canal space and smear layer removal but the most frequent is the combination between Sodium hypochlorite and EDTA [12]. Laser treatment of the radicular dentin facilitates the cleaning of the surface, thus promoting better adaptation of the filling material to the root canal walls [4, 10, 15]. Regardless of the amount of debris and smear layer thickness, laser irradiation improvesthe root canal cleanliness [8, 19]. Different laser beam parameters cause different effects on the same tissue, while certain laser parameters provoke various effects in different tissue types. These effects depend on the power and energy regime of the delivery system, the type and condition of the target tissue, the size and form of the optical fiber through which the laser beam is transmitted [3, 5, 11].

Finding the optimal wavelength and irradiation parameters for smear layer ablation without altering the dentin layer is one of the main goals of investigators. The areas of thermal injury, carbonisation, cracks and craters in the root canal wall due to laser treatment are undesirable as they reduce the integrity of the tooth structure and decrease the success rate of endodontic treatment [15].

The present study was designed to evaluate the effect of different wavelengths of laser irradiation on the apical microleakage of root canals. The laser beam combined with the conventional irrigation protocol proved to be significantly better when sealing the root canal space (p<0.05). The morphological changes on the apical intraradicular dentin surface caused by Er: YAG laser irradiation demonstrated the lowest linear apical dye leakage. The application of laser light enables the integration between the root canal filling and the dentinal wall. Our results coincide with the findings of Carvalho et al., Pecora et al. and Su et al. [4, 15, 19].

A review of the literature reveals discrepancies between the studies performed based on the inconsistency of laser parameters and experimental design. Therefore, more standardized experiments are needed to optimize the clinical application of lasers.

5. Conclusion

Application of diode and Er: YAG lasers improves the apical seal of root canals in endodontically treated teeth. Combined use of laser systems with appropriate parameters and routine irrigation protocols facilitates the adhesion of root canal filling materials to root dentin.

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