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# A study of the potential effects of the 940nm diode laser compared to those in the 2780 nm erbium laser on the removing of the smear layer and the permeability of the root canal dentin

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**Abstract**

The current presented work was purposed to evaluate the effect of 5.25% NaOCl activated using 940nm-based diode laser on the permeability of root-canal-based dentin (PRCD) and the smear-layer-based removal (SLR) compared to the effects of Er:Cr:YSGG laser. Here, 28-extracted mandibular premolar teeth of a human origin were divided, after specific preparation and irrigation with 1ml of 5.25% NaOcl, into 2 groups, diode laser (DL) and erbium laser (EL). Later, nail-varnish secure-coating was applied to the roots externally, and 2%methylene blue dye filling was performed. After that, it was divided horizontally into 3 parts of apical, middle, and coronal thirds. Stereo-microscope (SM) and scanning electron microscope (SEM) were used to study their features. The results showed no significance employed between DL and EL for those 3 parts; however, the dye display in the DL group was significantly higher, covering the complete length of the root, than that in the control group. The results of SEM revealed a recognized SLR in the DL group preserving the dentinal tubule-based annular structure. However, an ablative-related effect was noticed in the EL group on the dentin-belonged structure and the smear-based layer, more pronounced in the apical third.

**Keywords:** diode-based laser, erbium laser, permeability of dentin.

## INTRODUCTION

Some of the main purposes for the endodontic-based treatment are cosmetic and curing such as shaping and root-canal disinfecting. Favoring of the canal sealing is enhanced by the space provided by the telescopic shape (1). Some of the setbacks of the root canal (RC) preparation mechanically are debris and dentin-chip-based smear layer formation leading to generating dentinal tubular-based blocking (2). Flushing the RC using specific irrigants uncovers well removing of debris, chips, and microorgansims (3). To typically flush the RC using an irrigant, no direct contact with the walls of the RC is allowed. Sometimes, irrigants cannot do their successful work due to the blocking of the apical third induced by the vapor. In some cases, and according to some studies (4,5), irrigants could be exchanged using a specific way involving gentle moving of a well-fitting master gutta-percha cone up and down with the best choice of using manual dynamic irrigation (6). Processes of debridement and disinfection could be enhanced using laser-activated irrigations (LAI) reaching deep into the tubules and the apical parts (7–10). The current presented work was purposed to evaluate the effect of 5.25% NaOCl activated using 940nm-based diode laser on the permeability of root-canal-based dentin (PRCD) and the smear-layer-based removal (SLR) compared to the effects of Er:Cr:YSGG laser.

## MATERIALS AND METHODS

Sampling and preparation

Here, 28-extracted mandibular premolar teeth, extracted for orthodontic demands from patients at ages of 18-34 years of age, of a human origin were divided, after specific preparation (rinsing with distilled water (DW), ultrasonic-based removing of soft tissues, pumice-based polishing, 5-minitue-ultrasonic-based bathing, 0.1% thymol with DW-based storing, and 5.25% NaOcl-based irrigation), into 2 groups, diode laser (DL) and erbium laser (EL). Standard length at 14mm-based sections of the obtained canal were performed utilizing a diamond disc with double faces with a water-based cooling process. Flaring of the orifices that belong tot the canal was made with a small-size round-bur leading to a working length at size #10 ISO K file 1mm at the apex part, 13mm. A rotary system protaper Next (Dentsply, Switzerland) was used to prepare the canal reaching the size X4. Then, a 29-gauged needle was used to irrigate the canal. After that, length at 27mm was used with 1ml of 5.25% NaOcl 5.25%. In the end, DW at 1ml was used and paper-based dried using a protaper Next X4 (Dentsply, Switzerland). The methodology was followed from (11).

SEM process

Here, 4 samples/group were employed to read the changes might have been induced. The process was produced using information from (12) and using a SEM (Inspect S50, Czech Republic) under 2000X.

Permeability test

Evaluating of the dye presentation was performed for the three thirds of the teeth. Later, nail-varnish secure-coating was applied to the roots externally, and 2%methylene blue dye filling was performed. Multiple rinsing steps until clean and clear white appearance were done. After that, it was divided horizontally into 3 parts of apical, middle, and coronal thirds, figure 1. Exclusion to some parts such as cut reaching the cement-enamel junction. The sections were screened using a stereomicroscope (Hamilton, Italy) using 40X. Dye presentation area was analyzed using Measure

Pictures V1.0 software (CAD-KAS, Germany), figure 2. Dye penetration percentage was calculated by multiplying the area of the dye by 100% that was divided by the area of the third part of the root.

Statistics

SPSS version 21 was used with Shapiro-wilk test. Wilcoxon sum rank test was performed for the significance detection.

## RESULTS

The permeability results are shown in table 1.

For the DL group, SEM-based features revealed dentin with irregular surface indicating the remove of the smear layer. The dentinal tubules were open with no melting or carbonization. The dentinal tubules were protruded facing the surface irradiated with the laser, figure 2.

In the case of the EL group, ablated and removed smear layer in the middle and the apical thirds. This ablation was more pronounced in the canal dentin more than the inter-tubular dentin, figure 3.

Table 1: Penetration area by the dye.

| Thirds | Laser | Minimum | Maximum | Median | Mean rank | Wilcoxon sum rank test | |
|---|---|---|---|---|---|---|---|
| | | | | | | Z | P value |
| Apical | Erbium | .00 | 100.00 | 66.96 | 10.70 | 0.151 | 0.912 NS |
| | Diode | 23.08 | 100.00 | 52.06 | 10.30 | | |
| Middle | Erbium | 10.76 | 100.00 | 100.00 | 13.85 | 2.616 | 0.009 HS |
| | Diode | 47.31 | 100.00 | 73.82 | 7.15 | | |
| Coronal | Erbium | 71.87 | 100.00 | 100.00 | 11.40 | 0.745 | 0.529 NS |
| | Diode | 58.25 | 100.00 | 91.99 | 9.60 | | |

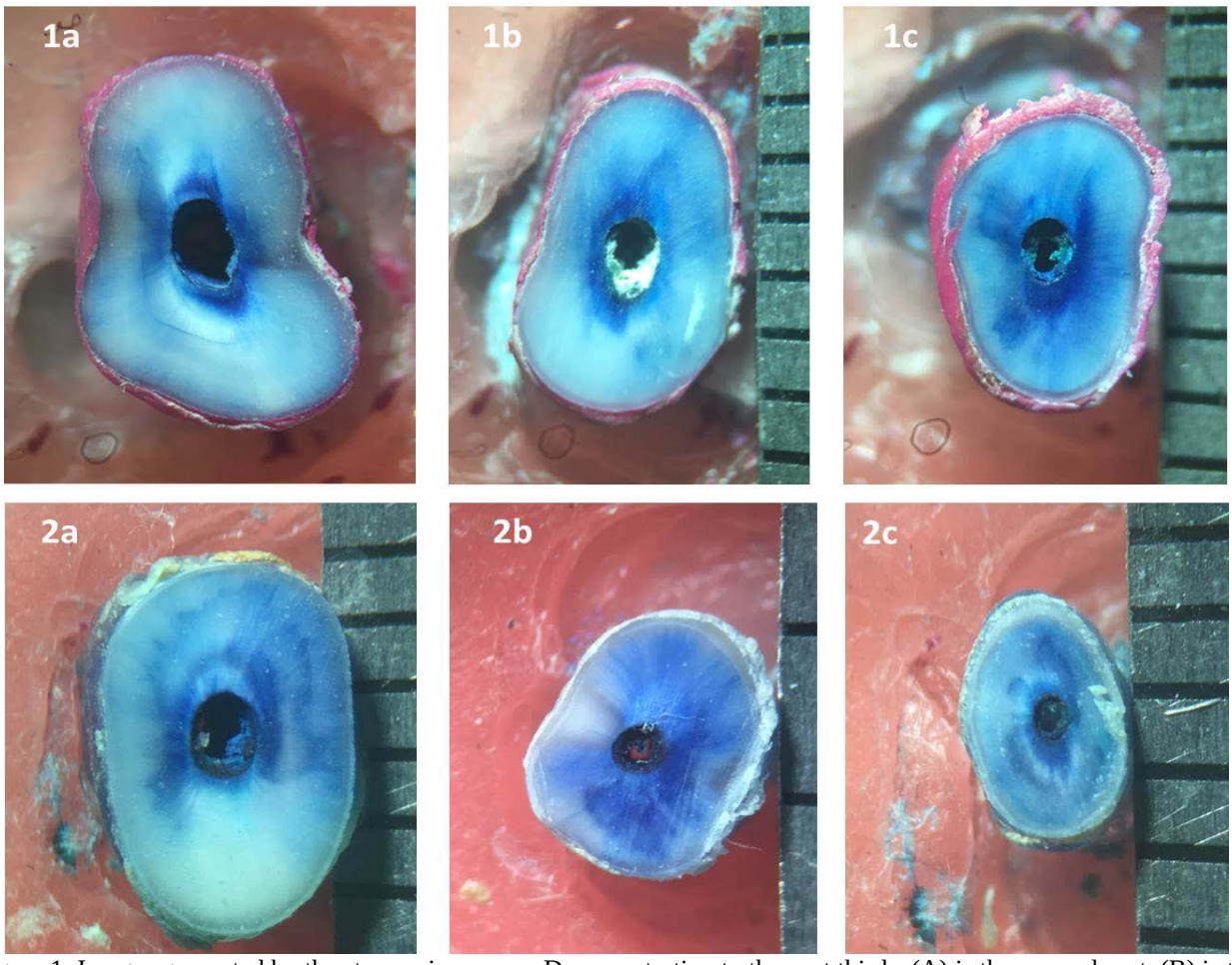


Figure 1: Images generated by the stereomicroscope. Dye penetration to the root thirds, (A) is the coronal part, (B) is the middle part, and (C) is the apical part. The numbers in the figure represent the groups, 1 is the DL group and 2 is the EL group.

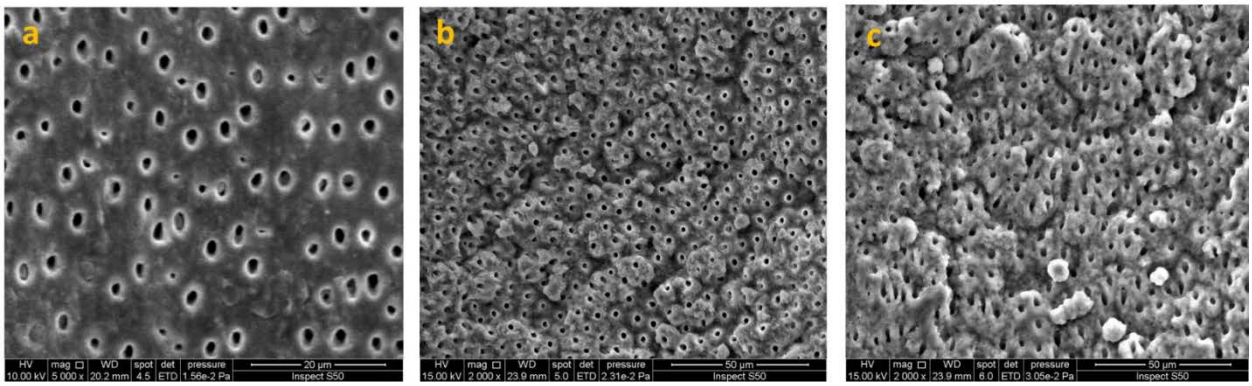


Figure 2: Images of root canal dentin produced by a scanning electron microscope for DL group at 2000x. A is the coronal part, b is the middle part, and c is the apical part.

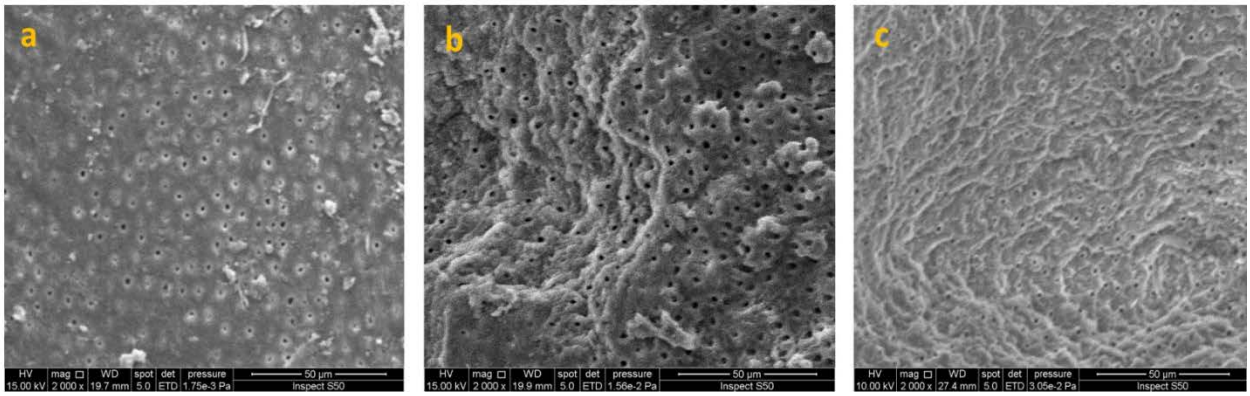


Figure 3: Images of root canal dentin produced by a scanning electron microscope for DL group at 2000x. A is the coronal part, b is the middle part, and c is the apical part.

## DISCUSSION

One of the setbacks that appear after preparation of the root canal mechanically is the formation of the smear layer, a good place for bacterial growth and blocking the dentinal tubules, that must be removed for better treatment (13–15). A standard method using a syringe to irrigate the root canal is commonly used; however, this method has some limitations with some thirds such as the apical part (16). Removing the smear layer completely is a difficult process especially in the apical part (17). For this reason, the current work was initiated to compare the effect of DL to the EL effect on the dentin permeability and the removing of the smear layer. The irrigation of the root canal is to make a good space with a good shape (16). A combination of EDTA and NaOCl was previously studied to measure its effects on the removing of smear layer. Here, this study was generated with the common used methodology (14,18–21). EDTA showed removing of the smear layer in all groups. Vapor bubbles were generated in the EL group via irrigant absorption of the laser energy leading to expansion of the volume reaching 1600 times than the original volume. This volume is then collapsed inducing an acoustic streaming with cavitation-based effect (22). For the DL group, SEM-generated images revealed clear dentinal tubule openings. This agrees with (17) who detected the same results informed in the current study.

In conclusion, employing the use of 940nm diode laser to generate an active irrigant is important for the root canal irrigation for better removing of the smear layer.

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