Investigating smear layer removal from root canal surface during irradiated with 940 nm diode laser with different aqueous irrigants

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The agitation of chemical irrigants was more effective in smear layer removal when canal irradiated with laser. The aim of this work was to study the effect of laser on root canal surface with agitation of different irrigants. A total of (12) teeth were used and randomly divided into 6 groups (n=2), treated with different protocols; with and without chemical irrigants and laser, then prepared for SEM imaging in 2 locations; apical and middle parts of the root. SEM images showed superior effect on smear layer when using 3% NaOCl with 15 % EDTA and 1.5 W of 940 nm diode laser. Within the present parameters, The SEM images showed that diode laser alone do not remove smear layer but cause its melting. It is more effective when used with EDTA and NaOCl irrigation.

Key-words: Diode laser, 940 nm, SEM, smear layer, root canal irrigants

Key Messages: The use of diode laser in endodontic for removal of smear layer and deep cleaning from bacteria harboured within, in combination with public irrigation solutions as NaOCl and EDTA

INTRODUCTION

The smear layer acts as harbor for the bacteria and provides a suitable growth environment; therefore, its removal may facilitate the antibacterial effect of chemical irrigants and also improve the adaptation of the filing material and guarantee a better opturation and more successful endodontic therapy (Wang X et al. 2005).

Sodium hypochlorite (NaOCl) and EDTA improved the endodontic treatment results, but since such chemical agents require a direct contact with dentin surface. (Bilkay U Aktener BO 1993; Takeda FH et al. 1999; Schoop U et al. 2007).

The most recent development in endodontic treatment is the use of lasers. (Bergmans L et al. 2006). The smear layer that covers the prepared walls of canal also impair the cleaning because it covers the root canal wall by superficial layer of 1-2 µm in thickness and deep layer congested in dentinal tubules to depth of 40 µm (Mader CL et al. 1984). This layer contains organic and inorganic materials with bacteria and necrotic debris (Torabinejad M et al. 2002). (Haapasalo M and D, Orstavik 1986.).

Hmud et al proved the removal of smear layer and debris with using both diode lasers (980 nm, 940 nm) with 200 µm fiber (Hmud R et al. 2010), and since these wavelengths have lack of affinity with water, then higher powers would be needed to produce thermal energy, consequently, fluid heating inside canal increases and elevate the capability of smear layer removal by cavitations action. Therefore the authors reported another study to show the safety of using such high powers without overcoming the threshold temperature (Hmud R et al. 2010).
Later Castelo-Baz et al reported the effect of combining NaOCl with 940 nm diode laser in eliminating the E. faecalis biofilm, the SEM test presented extensive disinfection by the dual effect of laser irradiation and the heated NaOCl (Pablo Castelo-Baz et al. 2012). Arslan et al. stated the high effect of EDTA agitation during irradiating the canal with 808 nm diode laser on removing the smear layer in apical portion of the canal(Arslan H et al. 2013)(Arslan, Ayrac et al. 2013). The combination of Laser and irrigants took a wide space in the latest studies, and diode laser was used as an activator for EDTAC and this was proved to enhance its action on smear layer removal (Camargo Selma 2012; Manfred Lagemann et al. 2014). When KTP lasers were compared with diode lasers in (2015) as bactericidal agent, the study evaluated the residual bacterial load accompanied with chemo-mechanical treatments and proved that both laser systems are more effective in bacterial reduction compared with conventional methods (Umberto Romeo et al. 2015).

A study in (2016) found that the Nd:YAG and diode lasers increased the retention of epoxy-based sealers to the root canal walls and hence increased the filling seal (Helena Suleiman de Macedo et al. 2016). The latest published studies in 2017 used the photodynamic therapy in endodontic disinfection by laser and chromophormes to reduce the E. faecalis is. This novel method provided a better results with total elimination of bacteria (Charis Beltes et al. 2017).

The aim of this study was to evaluate the effect of 940 nm diode laser on the canal surface when used as assistant in endodontic treatment as a sterilizing tool.

**Subjects and Methods**

Laser system used was 940 nm epic 10 diode laser (Biolase, USA), with end firing tip (diameter = 200 µm, length = 14 mm).

Samples preparation:

Total of (12) sound single canal premolars were collected, cleaned, and sectioned from cementoenamel junction to 14 mm length for investigating the ultra structural changes on root canal surface during lasing. The flaring of the canal was done by nickel-titanium ProTaper manual system (Dentsply, Switzerland) to size #F3, 1 mm from the apex. D.W was used as irrigant during preparation and then stored with saline at 4°C. Scanning Electron Microscope was used and samples were divided randomly into 6 groups (n = 2), named (A, B, C, D, E and F). The magnification was 1500X. The sample size is noticed to be little since it is a morphological study and (n) is not necessary to be high. The analysis of the work depended on the reading of the images and try to explain the effect and the change in comparison between the groups, therefore, no statistical work was performed.

Lasing protocol:

Lasing time for both groups was as follows: Irradiation begins with the tip moving coronally in a helicoid motion in speed of about 1.5 mm/s in a canal filled with DW. Total irradiation time is 20 s, the total working time for each canal= 50 s

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Samples were treated according to the following protocols:

**Group A:** (Control) After preparation, Samples were irrigated with 2.5 ml of 3% NaOCl for 120 s. then irradiated finally with 10 ml of distilled water.

**Group B:** After preparation, Samples were irrigated with 2.5 ml of EDTA for 120 s, then 2.5 ml of 3% NaOCl for 120 s. finally, irradiated finally with 10 ml of distilled water.

**Group C:** After preparation, Samples were irradiated with laser of 1.5 W power CW irradiation, while saline inside canal.

**Group D:** After preparation, Samples were irradiated with laser of 2.5 W power Pulsed mode with 20 Hz irradiation, while saline inside canal.

**Group E:** After preparation Samples were irrigated with 2.5 ml of EDTA for 120 s, and then irradiated with laser of 1.5 W power CW irradiation while EDTA inside canal, then flushed well with 10 ml saline, followed by 2.5 ml of 3% NaOCl for 120 s.

**Group F:** After preparation, Samples were irrigated with 2.5 ml of EDTA for 120 s, then irradiated with laser of 2.5 W power Pulsed mode with 20 Hz irradiation while EDTA inside canal, then flushed well with 10 ml saline, followed by 2.5 ml of 3% NaOCl for 120 s.

All samples of SEM imaging were sectioned in two halves by making grooves along the buccal and palatal surface of the root without penetrating into the canal to avoid spoiling the canal surface or smear layer, then a bi tapered chisel and surgical hammer were used to crack the tooth in two halves through the grooves. And then samples were placed in appendendorf tube. Later the samples went into fixation process using 2.5% buffer gluteraldehyde and 0.1 M Sodium Cocodylate (pH = 7.4) at 4°C for 12 h, then washed with distilled water for 3 min and immersed in this water for 1 h while changing the water every 20 min. Dehydration process then started afterwards, using an ascending Ethanol series: 25% for 20 min , 50% for 20 min, 75% for 20 min, 95% for 30 min, and lastly 100% (absolute) for 60 min. After dehydration, the samples were placed at incubators at room temperature for 24 h(Melissa Andriá Marchesan et al. 2008). Later, samples were fixed on stubs with double faced carbon tape, then coated with a gold-platinum layer and placed in a vacuum apparatus. The dentin surface of the canal was examined with SEM operating at 20 kV. Multi images were taken at 1500X magnification at points on each sample located at 4 mm and 8 mm from the apex, representing the apical and middle portions respectively.

**RESULTS**

Since this study is mainly a morphological analysis and contain no statistics, the results depended on the
In Control Group A the root canal walls were almost totally covered with heavy smear layer and there were debris closing most of the dentinal tubules, especially in the apical part of the root as shown in Figure 1 A.

In the second group B, the dentinal tubules were almost totally opened and cleaned in middle portion, and the effect of EDTA was clear Figure 2B, in contrast to apical part which showed no effect.

The next group C was treated with 1.5 W laser without any chemical irrigant. The dentinal tubules were slightly opened and the smear layer melted (globules shape) due to the thermal effect of laser. Also in Group D, in which laser power 2.5 W was used. The melting of

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Figure 1. SEM images of Apical portion with (1500X) A- Group A(control group) B- group B (EDTA + NaOCl) C- group C (laser 1.5 W) D- group D (laser 2.5 W) E- group E (laser 1.5 W +EDTA) F- group F (laser 2.5 W+ EDTA).
smear layer was more obvious and the globules were bigger in size. The dentinal tubules were opened in a satisfactory way in the middle part Figure 2 C and D and less in the apical part Figure 1 C and D.

The last two groups (F, G) when we combine the effect of laser with the chemical irrigants, showed the superior results in cleaning the root surface and opening the dentinal tubules especially in the middle third Figure 2 E and F, while in apical third Figure 1 the images showed a slight cleaning in E and closing of the tubules by melting in F. All the groups had no signs of severe melting or cracking over the root surface.

**DISCUSSION**

The “no effect” of this laser on smear layer is considered shortening of its action in endodontic treatment; in order to overcome this, we needed to use other effective method to remove the smear layer. Our SEM results came in accordance with Arslan SEM; the images showed an increase in the number of the opened dentinal tubules in middle and apical parts of the root when irradiated with 20 s of diode laser (Arslan H et al. 2013).

The SEM results come in along with Alfredo work (Alfredo...
E et al. 2009), and also with Saraswathi(Saraswathi MV et al. 2012). In SEM images, the control group where roots treated with NaOCl alone, the least number of dentinal tubules was opened and the surface was covered with smear layer, since the NaOCl has the ability to remove only the organic material of smear layer and has limited bactericidal action on the surface (Estrela C et al. 2002).

In the image of middle portion in case of combining the effect of EDTA with NaOCl Figure 2 B the results were stunning; total removal of smear layer; as EDTA dissolved the inorganic component of the smear layer, and NaOCl removed the organic components, and they both washed the root surface adequately.; while they had no obvious effect on the apical part. This came in acceptance with Teixeira study (CS Teixeira et al. 2005). Also the size of the dentinal orifices is larger than in apical part; this may permit the circulation and entrance of the irrigants to be more effective and consequently, produce better results in washing the smear layer.

On laser Groups, the temperature increase due to lasing caused melting and fusion of the smear layer, which appeared as globules in the images, and this caused opening of the dentinal tubules. This appeared more obvious when laser power increased. Both laser powers did not cause any crack or fissure on the root surface.

In the Apical portion Figure 1 E and F the images showed a week effect of irrigants and laser in washing the surface with limited number of dentinal tubules opened, these results disagreed the results of Wang (Xiaogu Wang et al. 2005) who reported that diode lasers clean the apical third more effectively than middle third due to the narrow space and melting of the smear layer. The different wavelength and power settings and irradiation duration might explain the difference between the two studies. While it came in acceptance with Parirokh et al.(Masoud Parirokh et al. 2008) stated that in apical part of the root, most of the dentinal tubules were closed due to dentine melting in the narrow canal. Our results also came in agreement with Saraswathi (Saraswathi MV et al. 2012) who noticed a better removal of smear layer when agitated NaOCl and EDTA with laser. The use of higher power of diode lasers to 5 W were found to cause vaporization of smear layer and consequently opening of the dentinal tubules in most of the canal walls, while cause localized melting, fusion, and recrystallization of canal walls in the apical part of the canal(Melissa Andréia Marchesan et al. 2008).

When comparing (C and D) with (E and F), the difference can be noticed due to the removal of smear layer by irrigant in the later groups especially in middle third. The samples that are treated by laser alone without chemical irrigants showed clustering shapes that represent the melted smear layer from the thermal energy that was directed to the dentinal matrix, while the other images that are treated with EDTA that had less or no smear layer the melting was not clear and the ultra structural alterations showed melting only in peri and intratubular dentin which cause to reduce the diameter of the tubule and appeared as white shadows around the orifice specially with the settings of higher powers.

In this wavelength limit, some of the energy is absorbed by the mineral structures of dentine such as phosphate and carbonate, the laser thermal ablation cause disturbance of its crystal arrangement which appear as melting of smear layer, this become more clear when laser parameters increase(Alfredo E et al. 2009).

CONCLUSION

The SEM images showed that diode laser alone do not remove smear layer but cause its melting. It is more effective when used with EDTA and NaOCl irrigation.

REFERENCES


Accepted 11 April, 2017


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