ELECTRON MICROSCOPIC STUDY ON THE EFFECT OF DIODE LASER AND SOME IRRIGANTS ON ROOT CANAL DENTINAL WALL

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ABSTRACT

This study was carried out to determine the effect of diode laser and some irrigants such as sodium hypochlorite and hydrogen peroxide on surface morphology of the root canal dentinal wall by using Scanning Electron Microscope. Forty extracted single rooted teeth with fully developed apices were used and divided equally into four groups: Group I: Irrigated with distilled water (control group). Group II: Irrigated with Sodium hypochlorite. Group III: Irrigated with Hydrogen peroxide. Group IV: Treated with Diode laser irradiation. The results showed that, laser irradiation removed debris and the smear layer that resulted from root canal preparation better than sodium hypochlorite and hydrogen peroxide. It also obliterates the dentinal tubule orifices and the dentin surface appeared glazed.

INTRODUCTION

The major goal of endodontic treatment is to achieve a clean environment in the root canal to minimize any risk which leads to unsuccessful root canal treatment(1).

Because of the complexity of the root canal system, irritants are used to supplement mechanical preparation of canals. An ideal irrigation solution should be capable of penetrating and disinfecting the entire root canal system by dissolving both organic components (necrotic and non-necrotic pulpal tissue, predentin and microorganisms) and inorganic components (mineral content of the dentinal tubules) of the smear layer. In addition, an ideal irrigant should mechanically flush any loose debris, lubricate canals during biomechanical preparation and have low tissue toxicity(2). The most frequently used irrigants are sodium hypochlorite and hydrogen peroxide, or the combined use of both. Their benefits, good tissue dissolving and disinfecting capability have been demonstrated in several investigations(3,4,5). However studies of the interaction mechanism of sodium hypochlorite and hydrogen peroxide suggested that, the fear of toxicity of sodium hypochlorite as an irritant to periapical tissue has tended to discourage its use; also hydrogen peroxide generates O₂ with a catalase reaction that might cause periapical discomfort (6,7).

With the introduction of lasers to the field of conservative dentistry, endodontic treatment was enriched by multitude of new treatment methods that improved the
Lasers were shown to be feasible and effective tools for cleaning and disinfecting the root canal system, particularly because they helped to overcome the problem of insufficient depth of penetration of commonly used disinfecting agents. The effects of laser irradiation on dental hard tissues may cause chemical, thermal, and/or mechanical changes. The latter effect is useful in removing carious dentin, while melting of dentin can seal the dentinal tubules and alleviate pain in cases of dentinal hypersensitivity.

Several studies on the impact of different laser systems on the root canal and the surrounding dentin have been published. Laser systems such as Nd:YAG and CO₂ lasers have proved to be very effective in cleaning and disinfecting the root canal wall and the lateral dentinal tubules, which are not fully accessible in conventional treatment and can be considered a reservoir for microorganisms. With the great progresses in the field of laser technology, semiconductor lasers such as diode laser are gaining increasing importance. The diode laser can achieve an output power of several watts and shown to be highly reliable and effective; the diode laser can be recommended for endodontic treatment because its wavelength of 980nm which is within the infrared range, it is also have thin, flexible light-conductor fiber. Both Diode laser and Nd:YAG laser are equally effective and can be used as alternatives in medicine.

Investigations of the thermal effect of diode laser on periodontal tissues revealed that the extent of tissue vaporization and zones of thermal necrosis produced by this type of laser is within safe limits and it can be used for endodontic purposes at the investigated parameters.

The antibacterial effect of diode laser had been studied, and it was found that, the high power diode laser seems to be highly suitable for killing bacteria in infected root canals. It also prevents bacterial growth due to complete closure of the dentinal tubules on the irradiated root canal walls.

Studies of the morphological changes of root canal wall after irradiation with diode laser proved that, the diode laser is useful for removing smear layer and debris from root canal walls, and reducing apical leakage after obturation in vitro and suggest that it would be useful for root canal treatment in clinic.

This experiment was carried out to study the effect of diode laser and some irrigation solutions such as sodium hypochlorite and hydrogen peroxide on root canal dentinal wall by using scanning electron microscope.

**MATERIALS AND METHODS**

Forty extracted single rooted teeth with fully developed apices were used. The teeth were cleaned from attachment debris and calculus, and then stored in deionized water until used.

The crowns were then removed 2 mm above the cemento-enamel junction by using a high-speed diamond bur with water coolant. All the specimens were endodontically prepared. The pulp of each tooth was removed with a barbed broach, the canal were instrumented to size 60 with H-file 1 mm from apical foramina using step-back technique. The coronal part of the root canal was flared using Gates-Glidden burs size 2,3,4 and 5 respectively.

The selected prepared teeth were randomly divided into four groups (ten teeth for each group):

- Group (I): control group.
- Group (II): Sodium hypochlorite (NaOCL) group.
- Group (III): Hydrogen peroxide (H₂O₂) group.
- Group (IV): Diode laser group.

After instrumentation, the group (I) was irrigated with distilled water, the group (II) was irrigated with Sodium hypochlorite 5.25%, while the group (III) was irrigated with Hydrogen peroxide 10% and the group (IV) was lased with diode laser.

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* Maillefer Instruments SA, CH-1338 Ballaigues, Switzerland.
**Laser device**

In this study Diode laser* with a wave length of 980 nm, was used to deliver a laser beam through a flat-end quartz fiber with a diameter of 200μm. The plastic cover of the optical fiber was peeled off by a surgical blade to allow a bare part longer than the working length of the tooth by a few millimeters. Several rubber stoppers were added to the bare part of the optical fiber and were used to adapt and fix its length to be 2mm beyond the apical foramen of the tooth. The fiber was introduced to the canal till it reached the pre-adjusted length. The device was activated to deliver a beam with a power of 1.5 Watt in a continuous mode for 15 seconds. During this time, the fiber was moving in a clockwise direction combined with inward and outward movements (spiral motion).

**Irrigation solutions:**

In this study the irrigation solutions were:

- Sodium hypochlorite (NaOCL): which is strongly alkaline, a good necrotic tissue solvent and has mild bleaching action.

- Hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>): This has effervescence or bubbling action due to rapid release of nascent oxygen ion (O). It has a mechanical debridment by dislodging particles of necrotic tissue and floating them to the surface, also has low germicidal properties.

**Scanning Electron Microscopic assessment**

The specimens of all groups were kept in individual veils containing 50% alcohol until they were prepared for scanning electron microscopy.

The coronal portion of the root canal of each specimen was closed by rubber base to protect it from dust. Two longitudinal shallow grooves were made on the buccal and palatal aspects of each tooth by a disc so that the grooves did not penetrate the root canal. The teeth were then left for two minutes in liquid nitrogen then separated by gentle strokes using mallet and chisel.

Dehydration was performed using a series of ethanol concentrations (50, 60, 70, 80, 90, 96, 100%), and 100% of acetone, and the specimens were left in each concentration for three hours. The specimens were dried in a drying machine for 24 hours under active vacuum as a protection against moisture and dust. Specimens were mounted on SEM holder by polyvinyl chloride cement (PVC). A thick silver paste was used around the margins of the specimens as a conducting agent. Then the specimens were spattered using a gold-palladium mixture. SEM assessment was made by using Scanning Electron Microscope**. Photographs were taken at x1000 magnifications. The surface topography of the four groups was examined and the results were recorded photographically.

**RESULTS**

**Scanning Electron Microscopic Picture (SEM)**

Dentin surface of the root canal were examined by SEM after different surface treatments (with Distilled water, Sodium hypochlorite, Hydrogen peroxide and Diode laser).

In the group I, the dentine surface of the root canal when irrigated with distilled water, it was covered by heavy coherent deposits of smear layer and crystals with irregular shape and size with some detached areas of variable sizes. The intertubular and peritubular dentine were appeared with few open dentinal tubules. Fig (1).

In the group II, the dentine surface of the root canal when irrigated with sodium hypochlorite, it showed decreased in number of crystals precipitation. The intertubular and peritubular dentin were decreased in size and number. Fig (2).

In the group III, the dentine surface of the root canal when irrigated with hydrogen peroxide, it showed more removal of dentin surface (peritubular and intertubular dentin) with multiple opening of the dentinal tubules and the surface appeared more homogenous. Fig (3).

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* Premer Laser system, model LM-25003, morgan irvine, CA.
** JEOL JSM-T330A Scanning Microscope, JAPAN.
In the group IV, the dentin surface of the root canal when treated with diode laser, it showed surface ablation, sealing of the dentinal surface and obliteration of the dentinal tubule orifices with few precipitated crystals and few slit like orifices of dentinal tubules and also the dentin surface appeared glazed. Removal of smear layer and craters were found. Fig (4).

**DISCUSSION**

The smear layer is a combination of organic and inorganic debris present on the root canal after instrumentation; this layer has been described as being superficial on the dentinal surface and has been packed into the dentinal tubules (23). Biologically, the presence of the smear layer has been postulated to be an avenue for...
leakage and a source of substrate for bacterial growth and ingress. When canals were obturated, the frequency of bacterial penetration in the presence of the smear layer has been shown to be significantly higher than with smear layer removal\(^{(24,25)}\). Also the smear layer may interfere with the penetration of gutta-percha into the tubules and the adhesion and penetration of root canal sealers into dentinal tubules leading to increase incidence of microleakage\(^{(26)}\).

Irrigating solutions were used for the removal of tissue debris and microorganisms and prevent formation of dentine mud that can block the root canal which produced by instrumentation. It can also clean the canal from smear layer and increase cutting efficiency by decrease the chance for fracture of the instruments. It also lubricates the root canal wall and makes mild bleaching to prevent the tooth discoloration during root canal treatment\(^{(6)}\). The requirement for ideal irrigating solution was: dissolving action, germicidal effect, bleaching agent and non irritant to the periapical tissue. Unfortunately, no single irrigant fulfills all of these criteria\(^{(7)}\).

Lasers emitting wavelengths in the infrared region have been proposed for various dental hard tissue applications because Enamel, dentin, and cementum contain hydroxyapatite, which has absorption bands in the infrared region (9.0 through 11.0\(\mu\)m) due to the presence of phosphate, carbonate, and hydroxyl groups in the crystal structure\(^{(27,28,29)}\). The wave length of diode laser is within the infrared range, it is also have thin, flexible light- conductor fiber so it can be recommended for endodontic treatment\(^{(30)}\).

In a comparison of the results obtained from SEM, it was found that SEM micrographs of the group I (control group) showed the presence of a smear layer and collections of surface debris. This can be explained by the inability of control group (distilled water) to remove the smear layer which is in agreement with Garberoglio et al.\(^{(32)}\), and Mahmoud et al.\(^{(33)}\).

In case of group II (sodium hypochlorite group), SEM micrographs showed that there is partial sealing of the dentinal tubules and decreased crystals precipitation while SEM micrographs of group III (hydrogen peroxide group), revealed more removal of debris with multiple opening of the dentinal tubules. The numbers of the dentinal tubules were decreased and the surface appeared more homogenous.

Based on SEM observation of group IV (diode laser group), there was removal of smear layer and crater, sealing of the dentinal tubules of the irradiated root canal wall, charring, which produced a glazed-like surface. Also carbonization, isolated balls of recrystallized material appeared with few precipitated crystals. This could be explained that, diode laser causes vaporization of water within the dentin due to temperature increase which vaporized into steam during destruction of the matrix and zones of thermal necrosis. This was agreed with Wyman et al.\(^{(16)}\), Pashley et al.\(^{(34)}\), Anic et al.\(^{(35)}\), Millared et al.\(^{(36)}\), Turkmen et al.\(^{(37)}\) and with Mortiz et al.\(^{(17,19)}\) who revealed that the high power diode laser seems to be highly suitable for treatment in case of infected root canals.

Our results are in agreement with Turkmen et al.\(^{(37)}\) who concluded that carbonization, isolated balls of recrystallized material and presence of smear layer at some dentinal tubule orifices as a results of Nd:YAG laser application which give the same effect of diode laser. Also the results of the present study confirm what concluded by Anic et al.\(^{(35)}\) that Nd:YAG laser application produce a glazed-like surface and craters which is the same effect as diode laser.
CONCLUSION

From the results of this study, it could be concluded that the scanning electron microscope showed a smoother dentin surface with removal of smear layer and debris when treated with laser irradiation compared to irrigation with sodium hypochlorite and hydrogen peroxide. This will improve the adaptability of sealer to root canal dentinal wall. Thus, Diode laser is the future therapy in endodontic treatment for cleaning the root canal of the tooth.

REFERENCES

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