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RESEARCH ARTICLE

EFFECT OF 810 nm DIODE LASER DISINFECTION ON BOND STRENGTH OF RESIN SEALER TO RADICULAR DENTIN –AN IN VITRO STUDY

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Objective: The use of lasers in endodontic treatment aims to combine the effects of bio mechanical preparation, irrigants and the energy produced by laser systems to promote debridement and cleaning of root canal walls. Studies have shown that morphological alterations in dentin irradiated with diode laser were observed by scanning electron microscopy. The present study is to evaluate the effect of laser irradiation (ʎ=810nm) on the Push-out bond strength of resin sealer to root dentin at different energy levels.

Materials and Methods: Forty single rooted extracted human teeth were selected for the study. After the coronal part was sectioned the biomechanical preparation up to F5 protaper file was done .The samples were divided into four groups (n=10 per group) and irrigated with 5.25% sodium hypochlorite. In groups 1,2and 3, 810nm diode laser at 1.5W, 3W, 7W continuous mode was used for disinfection respectively. Group 4 served as control. The root canal was coated with AH plus sealer and obturated with gutta percha. The samples were stored in distilled water for seven days. The root samples were mounted in acrylic and sectioned (2mm thick) at coronal and middle1/3rd and subjected to push out bond strength measured using universal testing machine.

RESULTS: The push-out bond strength of the laser irradiated group showed significantly higher values than control group ($p<0.05$).

Conclusion: The application of 810 nm diode laser in the human root canal dentine increased the bond strength of Resin sealer (AH Plus).

INTRODUCTION

Root canal disinfection and smear layer removal can be achieved by use of different chemical solutions. The smear layer forms an interface between the filling material and root canal walls, which reduces the bond strength. Ethylenediamintetraacetic acid (EDTA) is most commonly used solution for smear layer removal. (1)

The diode laser has been used in endodontics as an auxiliary for root canal cleaning, disinfection and removal of the smear layer. Irrigating solutions used during root canal treatment act through direct contact with the target bacteria. However as the irrigants have insufficient penetration depth, the microorganisms in the deeper layers are not destroyed where as Lasers can eradicate microorganisms in the root canal, especially in the lateral dentinal tubuli.(2)

Numerous studies state that an emission of laser light directly in the root canal has bactericidal effect. The high-power diode laser is being used in several areas of dentistry, with promising results in relation to dentinal disinfection by providing access to formerly unreachable parts of tubular network.(3) Diode lasers have a good penetration potential, with high absorption peaks for melanin and hemoglobin and limited interactions with water and hydroxyapatite.(1)

Several root canal sealers have been used in Endodontics, from ZOE-based sealers to the epoxy-resin based sealers. All of them were proposed to be used in association with gutta-percha. It has been demonstrated that ZOE-based sealers have lower bond strength to dentin, when compared to the epoxy-based sealers, especially in the presence of smear layer.(4) Epoxy resin based sealer depicts satisfactory physico-chemical properties, low solubility, high flow rate, adequate viscosity, good adhesion and proper biological properties.(5)(6)

The penetration capability of diode lasers (810–980 nm) is 10,000 times greater than that of Er: YAG, and may reduce the number of microorganisms up to 500 µm in depth within the dentinal tubuli. Gutknecht *et al* reported a reduction of the microbial content in hard-to-reach areas, such as in the dentinal tubules, after diode laser irradiation.(7) The aim of the study is to evaluate the effect of laser irradiation (ʎ=810nm) on the Push-out bond strength of resin sealer to root dentin at different energy levels.

MATERIALS AND METHOD

The study sample consisted of 40 extracted human single rooted teeth. All teeth were extracted because of periodontal disease. All teeth had completely developed roots and were without root caries or previous endodontic treatment. The coronal part was sectioned at Cemento-enamel junction using low speed diamond disc (Addler, Germany). All the teeth were irrigated with 5.25% sodium hypochlorite (NaOCl) and canals were enlarged up to F5 protaper file (Dentsply maillefer Switzerland), using endomotor (Xsmart, Dentsply maillefer, Switzerland) and final flush with 17% EDTA. After biomechanical preparation samples were divided according to laser parameter settings into 4 groups (n=10).

Group -1: Laser irradiation done at 1.5 watt
Group -2: laser irradiation done at 3 watt
Group -3: laser irradiation done at 7 watt
Group –c: No laser irradiation

The laser source was 810 nm diode laser (Denlase, Deheng group.Inc, China). Laser beam was delivered to root canal walls of each specimen using 200 µm diameter flexible optical fibres with helicoidal movement along the canal. It was performed in continuous mode for 30 secs.

AH plus sealer (Dentsply, konstanz ,Germany) was applied with lentilo spiral to canal wall and obturated with F5 protaper gutta percha (Dentsply maillefer Switzerland) by single cone technique. Varnish application was done on coronal and apical surface of each sample and stored in distilled water for 7 days. Each sample was mounted in acrylic and 2mm transverse sections were made at the coronal and middle third using low speed diamond disk (Addler, Germany). Specimens were submitted to push out test. For the push out test, a stainless steel support used to hold the samples in an universal testing machine (Shimadzu,AGS-10Kn,Japan) such a way that the side with the smaller diameter of root canal faced upwards. The specimens were aligned to the shaft that would exert pressure on the sealer. This method assured the alignment of specimen in reproducible manner, and also avoids the contact of shaft with the dentin during testing. Machine was calibrated at a speed of 1mm/min. A stainless steel cylinder of 1.5 mm diameter was used for samples from the coronal third of the root and 1.0 mm diameter tip was used for samples from the middle third of the root. The maximum load at failure (F) was recorded in N and the bonding surface area (A) was calculated using the equation

$$A=2\pi r \times h$$

Where π is constant 3.14, r is the radius of root canal space, h is the thickness of slice in mm

Bond strength (δ), expressed in Mpa, was calculated using the equation: $\delta=F/A$

Statistical Analysis

The data were recorded and submitted to statistical analysis by one way ANOVA and Post hoc tukey's test using the software SPSS 20.0 and significance level of 5% was set.

RESULTS

The mean of bond strength values in MPa for displacement of the sealer from the specimens in the push-out test are given in Table 1. The push-out bond strength of the laser irradiated group showed significantly higher values than control group ($p<0.05$) (table -1). The push-out bond strength of the middle third specimens of all groups show higher value than coronal third specimens ($p<0.05$) (table-2).Regardless of the power, the specimens irradiated with diode laser showed significantly higher values than control group.

There was no significant difference observed between coronal third specimens of 1.5 watt group and 3 watt group (p=o.396) and middle third specimens of 1.5,3 and 7 watt groups (p=0.191) (table-2).

Table 1 Shows Mean Difference between Coronal and Middle Third Groups

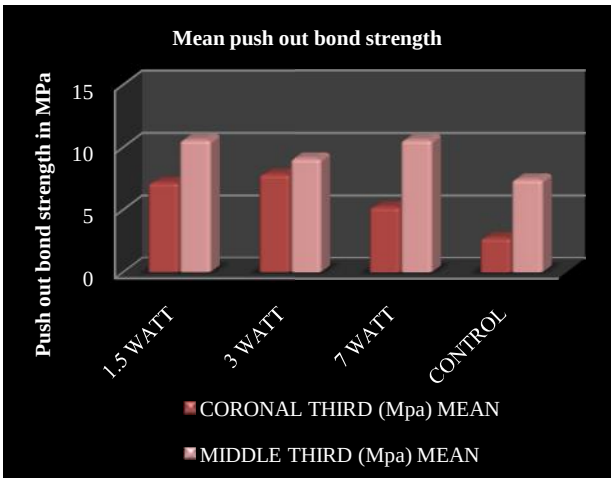
Groups	Coronal Third (Mpa) Mean	Middle Third (Mpa) Mean	Significance
1.5 WATT	7.1732	10.5913	S
3 WATT	7.8380	9.1089	S
7 WATT	5.2251	10.5910	S
CONTROL	2.750	7.4360	S

S-significant difference; ns- significant difference

Table 2 Multiple Comparision between Groups

	I groups	J groups	Mean	Significance
CORONAL THIRD	1.5 WATT	3.0 WATT	0.66488	Ns (P =0.396)
		7.0 WATT	1.94805	S (P=0.000)
		CONTROL	4.42113	S (P= 0.000)
	3.0 WATT	7.0 WATT	2.61293	S (P=0.000)
		CONTROL	5.08601	S (P=0.000)
	7.0 WATT	CONTROL	2.47308	S (P=0.000)
MIDDLE THIRD	1.5 WATT	3.0 WATT	0.72459	Ns (P=0.191)
		7.0 WATT	0.72459	Ns (P=1.000)
		CONTROL	0.72459	S (P=0.001)
	3.0 WATT	7.0 WATT	0.72459	Ns (P=0.191)
		CONTROL	0.72459	Ns (P=0.120)
	7.0 WATT	CONTROL	0.72459	S (P=0.001)

S-significant difference; Ns-no significant difference



Graph 1 Mean Difference between Coronal and Middle Third Groups

DISCUSSION

The key to success of endodontic treatment is to adequate disinfection by using the mechanical and chemical methods. One of the main reason for failure was the presence of smear layer because it was an amorphous structure adhered to root canal walls, produced during the biomechanical preparation, which was a negative factor in root canal obturation, because it is composed of dentinal debris, remnant of odontoblastic components, pulp tissue and bacteria , damaging the adhesion of the filling materials.[8] So far disinfection studies conducted

using 810nm diode laser showed promising results with 1.5 ,3 and 7 watt power output. Lee *et al* stated that 7 watt is the highest power that will not give any thermal side effects on root dentin.[9] Numerous studies have reported that bond strength of epoxy resin based sealers were superior than other sealers. It was because of formation of covalent bonds between epoxide rings and exposed amino groups in the collagen network.[6] NaOCl is used as irrigating solution due to its anti-microbial and tissue dissolving properties but NaOCl alone was not favourable to this sealer as it do not disinfect completely and also promote demineralisation to expose collagen to the sealer.[10]

EDTA was used as final rinse due its chelating property and effective removal of smear layer than NaOCl alone. On Laser irradiation superior bactericidal effect in conjunction to normal irrigation protocol was observed with EDTA as final rinse.[11] Scanning electron microscopic studies have shown morphological alterations in dentin irradiated with diode laser.[10] The push out test provides a better evaluation of bond strength than conventional shear test because in this test fracture occurs parallel to dentine –bonding interface.[12] In present study 2mm thick slice were made in order to prevent premature debonding.

In present study, significant difference observed between laser irradiated specimens and non lased group was because of deeper penetration (600-1000µm) in to the dentinal tubuli as diode laser can penetrate into the dentinal tubule much better than the chemicals used for irrigation.[3] Diode laser has ability to remove smear layer more effectively than other methods so that penetration sealer into dentin is possible. It exposes the collagen network which favours the formation of bond between epoxide rings and amino groups. Laser promotes the formation of micro cracks and fissures which increases surface area of bonding and gives mechanical retention. As epoxy resin sealers has high flow rate it penetrate into the micro cracks and fissures and give good retention and seal.[5] The results of our study correlates with the results of study conducted by Sagsen *et al*.[12] The higher bond strength values in the middle third specimens in all groups may be due to deeper sealer penetration because of high condensation forces and dentin structure in this part of root.

CONCLUSION

Taking into consideration the limitations of this in vitro study, we conclude that application of 810 nm diode laser (continuous mode) in the human root canal dentine increased the bond strength of Resin sealer (AH Plus) irrespective of energy level (1.5 w, 3w and 7w).

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