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Evaluation of The Effect of Diode Laser on Root Canal Disinfection Canal Cleanliness Fracture Resistance of Tooth Structure and Bond Strength to Root Canal Dentin

An in Vitro Study

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Elbatouty³*

Abstract

Aim

The aim of this study was to assess and investigate the effect of diode laser on root canal disinfection, and root canal cleanliness, as well as its effect on the fracture resistance of tooth structure, and on the bond strength of resin sealer to the root canal wall.

Materials and Methods

A total of 160 single rooted teeth were selected, and separated into two experimental groups (n=80), Group A were finally irrigated using 980 nm diode laser. Group B were finally irrigated using NaOCl/EDTA. Samples were evaluated for canal disinfection using the colony forming unit count, and Polymerase chain reaction. Samples were placed under scanning electron microscopic to evaluate the smear layer removal. A universal testing machine was used to test the resistance of teeth to fracture, and the bond strength of sealer to the root canal walls.

Results

Group A showed higher bacterial reduction and better results in smear layer score than Group B. Also Group A presented higher fracture resistance than Group B, as well as better value of push out bond strength than Group B.

Conclusion

Diode laser is an efficient tool in bacterial reduction and smear layer removal when used as a final irrigation procedure, compared to NaOCl/EDTA.

Keywords Bond strength, Canal disinfection, Diode laser, Fracture resistance, Smear layer.

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Introduction

Successful treatment of the root canal system depends on preparing, disinfecting and hermetic sealing of the root canal system. A proper disinfection of the root canal is a major factor in the success of the treatment not only during the preparation but also after the preparation. During the preparation eradication of persisting bacteria such as *Enterococcus faecalis* is a major challenge, as it is well known that it is a treatment resistant gram positive facultative anaerobe bacteria that has the ability to invade deep into the dentinal tubules, and the strength to survive even after the chemomechanical preparation and intracanal medication⁽¹⁾. Also following the chemomechanical preparation, and instrumentation, a smear layer of 1 to 2 nm thick is formed on the root canal walls, its made of inorganic contents as dentin debris and organic contents as necrotic pulp tissues, fragments of odontoblasts, and microorganisms. This smear layer can harbor bacteria along with its biofilms, so it can act as a source of recurrent infection, and may lead to treatment failure. Currently, Sodium hypochlorite (NaOCl) and Ethylene-diaminetetraacetic acid (EDTA) are the most commonly used root canal irrigation solutions due to its

antimicrobial and tissue-dissolving properties⁽²⁾. However, it does not completely disinfect the root canal system specially the inner layers of dentin, and the apical third of root canal with its high percentage of ramifications and variations, thus an additional disinfection agent is essential. The use of high power diode laser is a currently available disinfectant option that is consider as an advanced approach for disinfection, as it helps to reduce the number of microorganisms in root canals, by its ability to penetrate dental tissues providing access to formerly unreachable parts of the tubular network, as well as its ability to kill the bacteria by the use of energy and wavelength characteristics⁽³⁾. But another important factors to be considered is the ultrastructural alterations in the dentinal wall irradiated with diode laser and also the modification of the dentinal openings, and the creation of cracks and meltings⁽⁴⁾. These surface modifications in the intraradicular dentin is correlated with changes in apical leakage, and the adhesion of sealers⁽⁵⁾, which in return would affect the morphology of dentine and the fracture resistance of laser irradiated teeth.

The aim of this study was to assess, and investigate the effect of diode laser on root canal disinfection,

and root canal cleanliness, as well as its effect on fracture resistance of tooth structure, and bond strength of resin sealer to root canal system.

Materials and methods

A total of 160 single-rooted premolars were selected and prepared using a ProTaper rotary instruments. Samples were divided into two main groups (n=80) based on the final irrigation technique; Group A: samples were finally irrigated with 980 nm diode laser, and further divided into four subgroups (n=20) based on the data to be evaluated; subgroup A1: samples were evaluated for canal disinfection. subgroup A2: samples were evaluated for canal cleanliness, subgroup A3: samples were evaluated for fracture resistance of teeth, subgroup A4: samples were evaluated for the strength of AH plus sealer bond to dentinal wall. Group B: samples were finally irrigated 17% EDTA and 5.25% NaOCl, and further divided into four subgroups (n=20) based on the data to be evaluated; subgroup B1: samples were evaluated for canal disinfection. subgroup B2: samples were evaluated for canal cleanliness, subgroup B3: samples were evaluated for fracture resistance of teeth, subgroup B4: samples were evaluated for the strength of AH plus sealer bond to dentinal wall.

For Bacterial inoculation, a standard strains of *Enterococcus faecalis* were subcultured in agar plate, and then were incubated at 37°C for 24-hr period, a pure single *E. faecalis* colony were isolated from the same cultured plate and Gram's staining was done to confirm its growth, to inoculate the canals before the irradiation we used micropipette with a sterile needle and 10 mL of the bacterial suspension, the teeth were incubated at 37C for 7 days into nutrient broth, and bacterial growth was checked and replenished at several time intervals.

The diode laser 980-nm was used in contact mode at 2.5W with speed of 2 mm/s, the optical fiber tip moved in circular motion over the canal walls for 4 times with total irradiation time approximately 38s.

For evaluation of canal disinfection, teeth were prepared to collect bacterial sample from each root canal, this was done by collecting dentin shavings from the inner third of dentin, the dentin shavings were then immersed in 1 ml of TSA broth in Eppendorf tubes. Then all tubes were vibrated using Fisher Vortex equipment for two minutes. For the Culture methods for colony forming units 10-fold dilutions was prepared and 1 ml of aliquots of suspensions were seeded on a Petri dish with sheep blood TSA plates and then incubated at

37 °C for 48 hours. The colony forming units (CFU) grown was counted using stereomicroscope and log transformation was performed. Polymerase chain reaction using *Enterococcus* virulence factor *efaA* gene primer was also performed, this was done by immersing the dentin shavings in 1 ml of thioglycolate and incubated anaerobically at 37 °C for 24 hours. After incubation, all samples were centrifuged at 10,000 revolutions per minute for five minutes. From this sample 1.0 µl was taken and PCR was carried out in a thermal cycler.

For evaluation of canal cleanliness, the teeth were split vertically in a bucco-lingual direction, and were dehydrated using ethanol solution and coated with gold-palladium particles, and then examines under a scanning electron microscopic (SEM) at 1000x magnification to evaluate the presence of smear layer⁽⁶⁾.

For the fracture resistance testing, teeth were placed vertically in acrylic resin blocks, each block was positioned in a metallic base designed to maintain the specimens at a 45° angle to the horizontal plane during the test, the set of the tooth embedded in the resin and the metallic base were positioned in the Universal testing machine, then secured by tightening screws. The force was applied using a stainless steel ball that has a rectangular tip, force was applied with

an angle of 135° to the long tooth axis. The tip base was coupled to a load cell of 5 KN running at a crosshead speed of 1 mm/min until fracture occur. Fracture was identified by an audible crack and confirmed by a rapid reduction in the strength detected by the testing device.

For evaluation of the bond strength, the canals were obturated using AH plus sealer and single gutta percha cones inserted to the working length. Roots were sliced horizontally at the apical third, middle third, and coronal third, the push-out testing was applied on each slice using a universal testing machine, by operating a continuous load to the apical side for each slice using cylindrical plungers matching the diameter of each canal third till the bond failure took place.

Results

Measurements of canal disinfection showed that subgroup A1 recorded significant higher value in percentage of bacterial reduction 99.8%+/- 0.08 than subgroup B1 98.9%+/- 0.5 as presented in Table (1).

Variable	Reduction %	P-value
A1 Subgroup	99.8%+/- 0.08	<0.001*
B1 Subgroup	98.9%+/- 0.5	

*significant at P <0.001

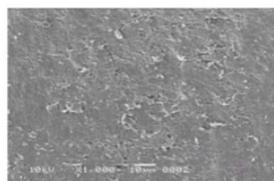
Table (1): Mean percent and log reduction of CFU among subgroups.

Measurements of canal cleanliness showed that subgroup A2 showed significantly higher percentage in removal of the smear layer 67.7% than subgroup B2 33.3% as presented in Table (2), figure (1).

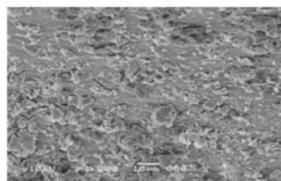
Smear layer Middle	Subgroup A2		Subgroup B2		Total		P-value
	No	%	No	%	No	%	
Smear layer Completely removed	2	66.7%	0	0%	2	33.3%	0.13* NS
Moderate smear layer	1	33.3%	0	0%	1	16.7%	
Heavy Smear layer	0	0%	3	100%	3	50%	
Total	3	100%	3	100%	6	100%	

*Significant at $P < 0.05$

Table (2): showing significant difference in smear layer between subgroup A2 and the subgroup B2



Subgroup A2



Subgroup B2

Figure (1): Representative SEM images showing smear layer scores for subgroup A2 and the subgroup B2

Measurements of fracture resistance showed that subgroup A3 presented statistically higher mean of fracture resistance (497+/- 143.8) than subgroup B3 (384.1 +/-120.9) as presented in Table (3).

Range	subgroupA3	SubgroupB3	t-test	
	245.5-728.9	210.4-624.8	t-value	P value
Mean+/- SD	479 +/- 143.8	384.1 +/-120.9	2.203	0.0341*

*significant at $P < 0.05$

Table (3): Student t-test for fracture resistance measurements (Newton) For subgroup A3 group vs subgroup B3.

Measurements of bond strength showed non significant difference in the value of push out bond strength between the subgroup A4 and subgroup B4 at the the coronal and middle third, but subgroup A4 showed significantly better results (5.545+/- 1.49Mpa) compared to subgroup B4 (4.594+/-0.69Mpa) at the apical third of the canal as presented in Table (4).

Variable	Subgroup A4	Subgroup B4
Mean+/-SDs	5.545+/-1.49Mpa	4.594+/-0.69Mpa
P-value	0.0392*	

*Significant at $P > 0.05$

Table (4): Mean value of Push out bond strength for tested subgroups at the apical segment.

Discussion

The diode laser has shown high performance in the disinfection, and removal the smear layer from the root canal, which would aid in more successful endodontic treatment⁽⁷⁾, but its effect on the resistance of teeth to fracture and the bond strength of sealer should be considered⁽⁸⁾. The combination of EDTA and NaOCl is commonly used as a final irrigation, as its well known that EDTA can dissolve the inorganic contents, while NaOCl can remove the organic contents of the smear layer⁽⁹⁾.

In this study conventional irrigation couldn't completely eliminate the bacteria, while the diode

laser demonstrated significantly better results in bacterial reduction. These results came in accordance with other studies^(10,11) that attributed it to the great penetration ability of laser deep through the dentinal tubules compared to the chemical disinfectants. On the other hand, these results came in disagreement with other studies^(12,13) that reported a high microbial growing in the laser groups, and attributed it to the fact that laser light cannot reach all areas with the same effectiveness as sodium hypochlorite and EDTA rinsing.

For evaluation of canal cleanliness SEM was used at magnification of (X1000) which was appropriate for identification of the smear layer⁽¹⁴⁾. The SEM images revealed that the diode laser subgroup showed better results in smear layer removal than the conventional irrigated subgroup. This could be attributed to the insertion of the laser fiber in direct contact with the canal walls removing the smear layer and other debris, our results also came in agreement with other studies^(15,16). While other studies^(17,18) reported different results where the diode laser had no effect on the smear layer, when used alone without conjunction method.

The teeth fracture resistance results showed that the teeth irradiated with diode laser reported higher

fracture resistance than teeth irrigated with NaOCl/EDTA, these results came in agreement with other studies^(19,20) that attributed it to the ability of the laser to glaze, melt, and recrystallize dentin, this molten dentin layer solidifies and seal minor transient surface cracking. These results came in contradiction with other studies^(21,22) that reported decrease in the fracture resistance of dentin treated with laser, they claimed that this would be due to the alteration of dentin structural composition, as well as the dentin microhardness.

The bond strength measurements showed that teeth irradiated with diode laser reported higher bond strength than those irrigated with NaOCl/ EDTA, these results came in agreement with previous studies^(23,24), and another later study⁽²⁵⁾ that attributed it to the smear layer removal without significant loss in dentin mineral contents, but it came in contrast with other studies^(26,27) that attributed it to inability to remove the smear layer that prevented the adhesion of sealer to the root canal.

Conclusion

Diode laser is an efficient tool in bacterial reduction during final irrigation procedure, with comparative smear layer removal effect to NaOCl/EDTA, and no effect on the fracture resistance of tooth, and bond strength of sealer to root canal.

References

1. Shanshan Dai, Gang Xiao, Ning Dong, Fei Liu, Shu yang He & QingyuGuo BMC. Bactericidal effect of a diode laser on *Enterococcus faecalis* in human primary teeth—an in vitro study Oral Health volume 18, Article number: 154 (2018).
2. Alfredo, Souza Gabriel AE, Silva SR, Sousa Neto MD, Brugnara Junior A, Silva-Sousa YT. Morphological alterations of radicular dentine pretreated with different irrigating solutions and irradiated with 980-nm diode laser. Res Tech. 2009 Jan;72(1): 22-7.
3. Turk T, Kaval ME, Sarikanat M, Hülsmann M. Effect of final irrigation procedures on fracture resistance of root filled teeth: an *ex vivo* study. International Endodontic Journal, 50, 799–804, 2017.
4. Moura-Netto C, Pinto T, Davidowicz H, and Maranhão A. Apical Leakage of Three Resin-Based Endodontic Sealers after 810-nm-Diode Laser Irradiation. Photomedicine and Laser Surgery. December 2009, 27(6): 891-894.
5. Arslan H., Yeter, K.Y., Karatas, E. Effect of agitation of EDTA with 808-nm diode laser on dentin microhardness. Lasers Med Sci (2015) 30: 599.
6. Al Zand, Sheimaa A., Mohammed Abbood Al Maliky, Ali Shukur Mahmood and Tamara Al Karadaghy. Investigating smear layer removal from root canal surface during irradiated with 940 nm diode laser with different aqueous irrigants. International Research Journal of Dentistry Vol.1, April, 2018: 2326-722.
7. Tilakchand M, Singh NN, Yeli MM, Naik BD. "Evaluation of the antibacterial efficacy of EZLASE diode LASER on the infected root canal system:" An in vivo study. J Conserv Dent. 2018;21(3):306–310. doi:10.4103/JCD.JCD_14_18
8. Garcia Lda F, Naves LZ, Farina AP, Walker CM, Consani S, Pires de Souza Fde C. The effect of a 980 nm diode laser with different parameters of irradiation on the bond strength of fiberglass posts. Gen Dent. 2011;59(1): 31-7.
9. Nabi S, Farooq R. Comparison of diode laser with maleic acid and ethylenediaminetetraacetic acid on smear layer removal from root canals: A scanning electron microscope study. Endodontology 2020;32:91-5.
10. Kaiwar A, Usha HL, Meena N, Ashwini P, Murthy CS. The efficiency of root canal disinfection using a diode laser: in vitro study. Indian J Dent Res. 2013 Jan-Feb;24(1): 14-8.

11. Shaktawat AS, Verma KG, Goyal V, Jasuja P, Sukhija SJ, Mathur A. Antimicrobial efficacy of 980 nm diode laser on *Enterococcus faecalis* in conjunction with various irrigation regimes in infected root canals: An in vitro study. *J Indian Soc Pedod Prev Dent* 2018;36: 347-51.
12. Borges, C.C., Estrela, C.R., Lopes, F.C., Palma-Dibb, R.G., Pécora, J.D., Estrela, C.R., & Sousa-Neto, M.D. (2017). Effect of different diode laser wavelengths on root dentin decontamination infected with *Enterococcus faecalis*. *Journal of photochemistry and photobiology. B, Biology*, 176, 1-8.
13. Sohrabi K, Sooratgar A, Zolfagharnasab K, Kharazifard MJ, Afkhami F. Antibacterial Activity of Diode Laser and Sodium Hypochlorite in *Enterococcus faecalis*-Contaminated Root Canals. *Iran Endod J.* 2016;11(1): 8–12. Doi: 10.7508/iej.2016.01.002.
14. Lagemann M, George R, Chai L, Walsh LJ, (2014) Activation of ethylenediaminetetraacetic acid by a 940 nm diode laser for enhanced removal of smear layer. *Aust Endod J* 40: 72–75.
15. Rajakumaran A, Ganesh A. *J Pharm Bioallied Sci.* 2019;11 (Suppl 2): S216–S220. Comparative Evaluation of Depth of Penetration of Root Canal Irrigant After Using Manual, Passive Ultrasonic, and Diode Laser-Assisted Irrigant Activation Technique. Doi: 10.4103/JPBS.JPBS_300_18.
16. Ying Liu, JieGao, 1, Yan Gao, Shuaimei XU, Xueling Zhan, Buling Wu. In Vitro Study of Dentin Hypersensitivity Treated by 980-nm Diode Laser. *J Lasers Med Sci.* 2013 Summer; 4(3): 111–119.
17. Amin K, Masoodi A, Nabi S, Ahmad P, Farooq R, Purra AR, Ahangar FA. Effect of diode laser and ultrasonics with and without ethylenediaminetetraacetic acid on smear layer removal from the root canals: A scanning electron microscope study. *J Conserv Dent* 2016;19: 424-7.
18. De Macheando HS, Colucci V, Messias DC, Rached-Júnior FJ, Fernandes FS, Silva-Sousa YT, Raucci-Neto W. Effect of Nd:YAG (1064-nm) and Diode Laser (980-nm) EDTA Agitation on Root Dentin Ultrastructure Properties. *Photomed Laser Surg.* 2015 Jul;33(7): 349-56.
19. Faria M.I., Sousa-Neto M.D, Souza-Gabriel A.E, Alfredo E, Romeo U, Silva-Sousa.Y.T.C. Effects of 980-nm diode laser on the ultrastructure and fracture resistance of dentine. *Lasers Med Sci* (2.49. 07)2012; 28(1).

20. Quteifan MQ, Madarati AA, Layous K, AL Tayyan M. A Comparative ex-vivo Study of Effects of Different Irrigation Protocols with/without Laser Activation on the Root Dentine's Micro-Hardness. *Eur Endod J* 2019; 3: 127-32.
21. Ayrancı, F., Ayrancı, L.B., Özdoğan, A. Resistance to vertical root fracture of apicoected teeth using different devices during two root canal irrigation procedures *Lasers Med Sci* (2018) 33: 1685.
22. Karatas, E., Arslan, H., Topcuoglu, H. S., Yılmaz, C. B., Yeter, K. Y. and Ayrancı, L. B. (2016) Effect of Diode Laser on Fracture. *Artificial Organs*, 40: 604-609. Doi: [10.1111/aor.12608](https://doi.org/10.1111/aor.12608).
23. Das M1, Kumar GA, Ramesh S, Garapati S, Sharma D. An in vitro evaluation of microtensile bond strength of resin-based sealer with dentin treated with diode and Nd:YAG laser. *Contemp Dent Pract*. 2013 Mar 1;14(2): 183-7.
24. Macedo, Helena Suleiman de et al. "1064-nm Nd:YAG and 980-nm Diode Laser EDTA Agitation on the Retention of an Epoxy-Based Sealer to Root Dentin." *Brazilian dental journal* 27 4 (2017): 424-9.
25. Sreedev C, Raju I, Kumaravadivel K, et al. (April 24, 2020) Influence of Different Types of Root Canal Irrigation Regimen on Resin-based Sealer Penetration and Pushout Bond Strength. *Cureus* 12(4): e7807. DOI 10.7759/cureus.7807.
26. Saghiri M.A, Garcia-Godoy F, Lotfi M, Ahmadi H, Asatourian A. Photomedicine. Effects of diode laser and MTAD on the push-out bond strength of mineral trioxide aggregate-dentin interface. *Laser Surgery*. October 2012, 30(10): 587-59.
27. Tuncdemir, A.R, Cihan Yildirim, C, Ozcan E, Polat S. The effect of a diode laser and traditional irrigants on the bond strength of self-adhesive cement. *J Adv Prosthodont*. 2013; 5(4): 457-463.