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ORIGINAL RESEARCH

An *in vitro* Evaluation of Microtensile Bond Strength of Resin-based Sealer with Dentin Treated with Diode and Nd:YAG Laser

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ABSTRACT

Background: Smear layer is a negative factor which prevents adhesion of the filling material to the dentinal walls. Recent advances in dental research have incorporated lasers as a potential adjunct in root canal treatment by removing the smear layer before filling the root canal system, enhancing the adhesion of sealers to dentin and improving the sealing ability.

Aim: To evaluate the microtensile bond strength of AH-Plus resin-based sealer to dentin after treatment with 980 nm diode and 1,064 nm neodymium-doped:yttrium aluminum garnet (Nd:YAG) laser *in vitro*.

Materials and methods: Thirty specimens prepared for three groups namely group I (control), group II (980 nm diode–lased specimens) and group III (Nd:YAG–lased specimens). One tooth from each group was observed under scanning electron microscope for evaluation of intracanal root dentin morphology. Remaining specimens were used for making microsections by hard tissue microtome. Specimens for groups II and III were lased with 980 nm diode and 1,064 nm Nd:YAG laser. AH Plus sealer was applied onto specimens and mounted onto Instron universal testing machine for microtensile bond strength testing. Results were subjected to statistical analysis using one-way analysis of variance (ANOVA) and Tukey's test.

Results: Group III Nd:YAG had maximum mean microtensile bond strength values (11.558 ± 0.869), followed by group II diode (9.073 ± 0.468) and group I control (6.05 ± 0.036). Statistically significant differences were seen among all the groups. SEM analysis shows removal of smear layer in both groups II and III.

Conclusion: Both Nd:YAG and diode laser were more effective than control group in improving the microtensile bond strength of AH Plus sealer to dentin.

Clinical significance: Lasers have the potential to increase the adhesiveness of root canal sealer to dentin surface, thereby improving the quality of root canal obturation.

Keywords: Adhesion, AH-Plus, Microtensile bond strength, Nd:YAG laser, Diode laser.

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INTRODUCTION

Endodontic therapy consists of thorough biomechanical preparation, antiseptic irrigation and sterilization of the root canal with three-dimensional (3D) obturation.[1]

To achieve 3D obturation, a fluid tight apical and coronal seal is essential. Various materials have been tried for sealing the root canal system for more than 10 decades. Recently, adhesive sealing materials have been tried and their results were encouraging.[2]

Advances in adhesive technology have lead to the search for a sealing material which minimizes apical and coronal marginal leakage by increasing sealing ability between the filling material and root canal walls. Resin-based sealers bond better to the dentinal walls because of deeper penetration of these sealers into the dentinal tubules.[3]

AH Plus is an epoxy resin-based sealer containing no formaldehyde. It was found that, it has better sealing property to dentin when compared to other sealers, due its better and deeper penetration into the dentin forming resin tags.[3]

During the chemomechanical preparation of the root canal, iatrogenically produced smear layer is a negative factor in root canal bonding. Removal of the smear layer improves the adhesion of bonding materials to dentin.[3]

In addition to the routinely used chemical substances, other surface-altering means have been investigated for removal of smear layer from root-dentin walls, such as laser irradiation like diode laser and neodymium-doped:yttrium aluminum garnet (Nd:YAG) laser.[2] The use of lasers has been a great asset for root canal therapy. Studies have shown that they remove the smear layer and debris, has better bactericidal effect and improved intracanal cleanliness by evaporation of debris when used along with hand instrumentation.[4,6] They also have shown to increase the sealing ability of root canal sealers to dentin walls. This may be attributed to the morphologic changes in the dentinal walls caused by the lasers.[5]

The aim of this study is to evaluate the microtensile bond strength of resin-based sealer AH Plus to dentin after treatment with diode and Nd:YAG laser.

MATERIALS AND METHODS

Tooth Preparation

Thirty specimens were taken and examined under magnification for presence any root fractures. The roots of each tooth was standardized to a length of 16 mm, as measured from cementoenamel junction. Teeth were then decoronated using a diamond disk attached to a straight hand piece at the cementoenamel junction.

A 15 size hand K-file was inserted into each root canal until it is visible at the apical foramen. The working length of each root canal was then established 1 mm short of the apical foramen. All canals were instrumented using step-back technique up to a size 35 hand K-file. Copious irrigation was done with 3 ml of 2.5% sodium hypochlorite and final rinse with saline to remove the intracanal debris and remnants of pulp tissue if present. The root canals were then dried with absorbent paper points. All teeth were divided randomly into three groups of 10 specimens each.

- Group I: Control (n = 10)
- Group II: Teeth treated with 980 nm diode laser (n = 10)
- Group III: Teeth treated with Nd:YAG laser (n = 10).

Microsection Preparation

Out of 10 teeth in each group, one tooth from each group was selected and studied under scanning electron microscope (SEM) for evaluation of intracanal root dentin morphology after laser irradiation. The remaining teeth were used for microtensile bond strength testing. These were mounted onto an acrylic block using self-cure acrylic resin material. Then, they were placed in the hard tissue microtome (Leica SP 1600, Germany) to prepare microsections (1 × 1 mm cross-section). The microsections were then stored in saline until the microtensile bond strength testing was done.

Control Group Specimens

Group I specimens were kept as control group without any laser treatment.

Groups II and III (Laser Treatment)

Group II specimens were irradiated with a pulsed 980 nm diode laser (Giga diode laser, Italy). The laser parameters used were 125 mJ/pulse and 20 Hz pulse frequency for 20 seconds. In group III, the specimens were irradiated with a pulsed Nd:YAG laser (Fotona laser, Fidelis plus, Slovenia) of wavelength 1,064 nm and the laser parameters used were 100 mJ/pulse and 15 Hz pulse frequency for 20 seconds.

SEM Observation

One specimen from each group selected for SEM study was grooved and split longitudinally into two halves with the help of diamond disk. The sections were dehydrated by a series of graded ethanol solutions. After dehydration, the samples were sputter-coated with gold ion and observed under SEM (S-34OON, Hitachi Ltd, Tokyo, Japan) at a magnification range of 500× to 2,000× for assessment of smear layer and patency of dentinal tubules.

Microtensile Bond Strength Testing

The specimens were mounted onto customized jigs having length 25 mm and inner diameter 12 mm with the help of self-cure acrylic resin material. After the acrylic was set, the mounted specimens were placed in place, so that the dentin surface comes in contact and specimens are then held together undisturbed (as shown in Fig. 1). AH Plus resin-based sealer (Dentsply, DeTrey, Germany) was then applied onto the dentin specimen surfaces. The resin sealer was allowed to set undisturbed for at least 8 hours. The specimens were later mounted in place and subjected to microtensile testing using an Instron universal testing machine (Lloyd instruments, UK) at 2 mm/min cross-section speed (Fig. 2). Forces at which debonding of the sealer occurred for different groups of specimens were recorded. Then the data collected were statistically analyzed using one-way analysis of variance (ANOVA) followed by Tukey's multiple comparison test ($p < 0.05$).

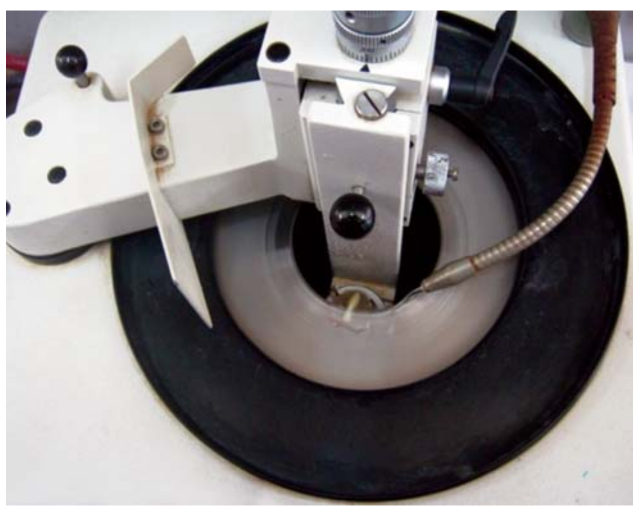


Fig. 1: Sectioning of the teeth into microsections

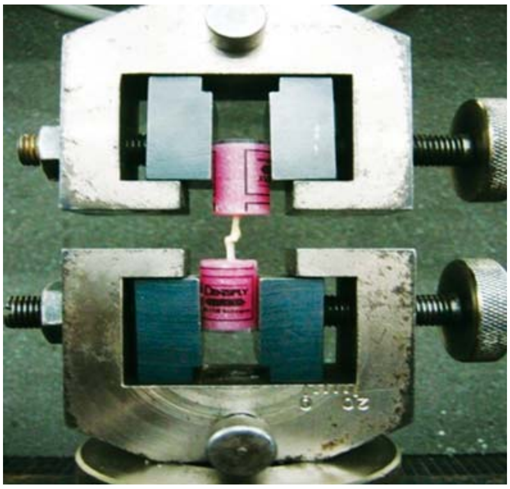
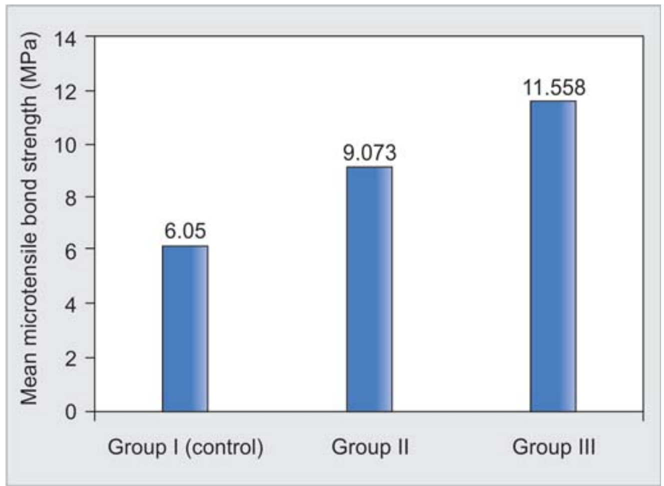


Fig. 2: Specimens mounted onto an Instron universal testing machine



Graph 1: Comparative evaluation of microtensile bond strength of AH Plus sealer to dentin after treatment with diode and Nd:YAG laser

RESULTS

The values of microtensile bond strength of all groups are given in Table 1.

Statistical Analysis

The data were represented as mean and standard deviation (Table 1). Mean values were compared by one-way ANOVA and Tukey's multiple comparison test to identify the significant groups, with a significant level set at $p = 0.05$.

The results showed that group III (11.558) had the maximum mean microtensile bond strength values, followed by group II (9.073). Group I (6.05) being the control group showed the lowest microtensile bond strength compared to all the other groups (Graph 1).

SEM Analysis

The control specimens showed dentin surface with smear layer intact, smear plug was found occluding the dentinal tubules. Dentinal debris was seen on the surface (red arrow) (Fig. 3).

Diode laser–treated specimens showed melting and recrystallization of dentinal tubules and melted dentin was seen on the surface (red arrow) (Fig. 4).

Nd:YAG laser-treated specimens showed a spongy-like appearance, smear layer was removed, open dentinal tubules seen and melted and recrystallized dentin present on the surface. Globules of ablated dentin were seen on the dentin surface (red arrow) (Fig. 5).

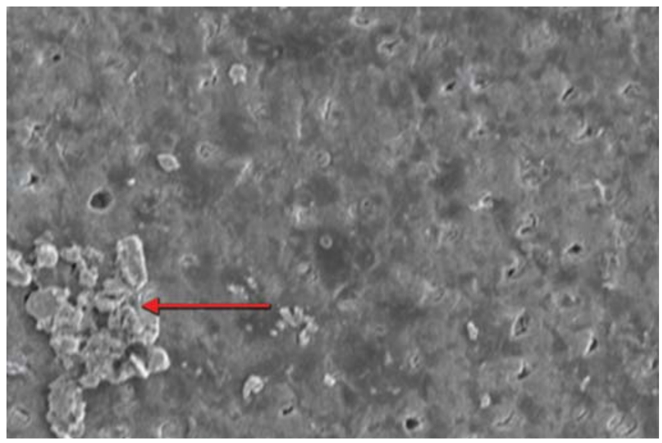


Fig. 3: Group I—control

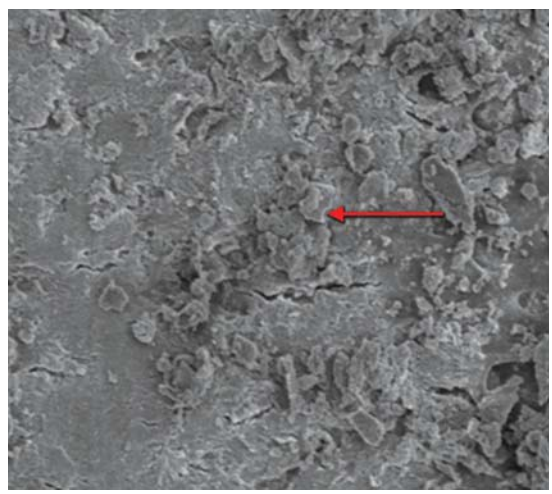


Fig. 4: Group II—980 nm diode laser

Table 1: Comparative evaluation of microtensile bond strength of AH Plus sealer to dentin after treatment with diode and Nd:YAG laser

Groups	*Speed (mm/min)*	*Mean ± SD*	*Significance*
Group I (control)	2	6.05 ± 0.036	Groups II, III
Group II (980 nm diode laser)	2	9.073 ± 0.468	Groups I, III
Group III (Nd:YAG laser)	2	11.558 ± 0.869	Groups I, II

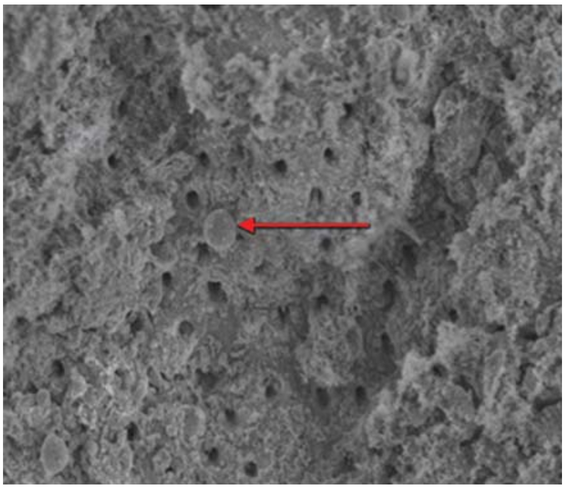


Fig. 5: Group III—Nd:YAG laser

DISCUSSION

The key to successful endodontic treatment is to adequately disinfect the root canal system by using a combination of mechanical and chemical methods. One of the reasons for failure of endodontic treatment is the presence of smear layer which prevents adhesion of the filling material to the dentinal walls. Thus, it acts as a physical barrier interfering with adhesion and penetration of sealers into the dentinal tubules, thereby preventing complete locking and adhesion of root canal filling material to the dentinal wall (Kennedy et al 1986).[5,21]

Epoxy resin-based cements have shown good physicochemical properties as well as excellent sealing ability compared to the zinc oxide-eugenol–based sealers.[1] AH Plus which is an epoxy resin sealer was selected for this study since it had shown satisfactory physicochemical properties, low solubility and disintegration, good adhesion, antimicrobial action and good biological properties like biocompatibility compared to many other sealers.[2,12] This has been confirmed by various other investigators who evaluated the bond strength by push-out technique, shear bond strength of AH Plus, microleakage by using microbial tracer, dye penetration method and confirmed good adhesion and sealing ability to the dentinal walls.[17,23]

Recent advances in dental research have incorporated laser technology as a potential adjunct in root canal treatment (Moritz et al 2001, Stabholz et al 2004) which aimed at reducing the number of microorganisms within the root canal system, cleaning and shaping of the canal walls and removing smear layer from the root canal walls.[8,14] The removal of smear layer before filling the root canal system enhanced the ability of the filling materials to enter the dentinal tubules. This in turn increased the adhesive strength of sealers to dentin and improved the sealing ability of the filling.[2,21]

The effect of lasers on dentin is caused mainly by the changes in temperature that can be extremely high at the irradiated spot even for a short action time. Consequently, the dentin tissue melts, vaporizes and a crater is formed at the irradiation site. Laser energy causes a quick local rise in temperature and prompts melting, recrystallization and decomposition of the apatite crystals.[15,18]

The surface changes after laser treatment was mostly due to the thermal effects on the dental hard tissues. It has been shown by a number of investigators that, during interaction of a laser with the tooth structure, photon energy is converted to heat. The photoablative effects include surface modifications like melting and recrystallization of dentin.[13,22]

Lasers have been used to improve adhesion of epoxy resin–based sealers. MD Sousa et al found that the epoxy resin–based sealer had better penetration in the microirregularities created by the surface alteration of dentin by Nd:YAG and diode lasers, thus increasing mechanical retention and resistance to shear forces.[9] There was melting and recrystallization of dentin, so dentin permeability decreased, thus decreasing the microleakage after obturation. AH Plus sealer adhesion was increased onto the dentinal walls after laser irradiation due to complete removal of smear layer.[5,16,19,20]

Advantages of microtensile bond strength testing are that it permitted testing of very small surface areas (1 × 1 mm cross-section) with higher interfacial bond strengths. It allowed testing of bonds made to irregular surfaces and were more accurate compared to other methods.[7]

Results of the present study showed highest microtensile bond strength values of AH Plus sealer to Nd:YAG laser–treated surface (11.558), followed by diode-treated surface (9.073) and lastly control (6.05).

The highest microtensile bond strength values of AH Plus to Nd:YAG laser–treated surface (group III) was mostly due to the better penetration of AH Plus into the microirregularities created in the dentin surface as a result of surface remodification, increased patency of the dentinal tubules and increased resistance to dislocation of the AH Plus sealer resin tags to the tensile force applied by the Instron universal testing machine.[3,25]

SEM of the control group (group I) revealed thick debris layer on the dentinal surface, with no smear layer removal. No surface alteration was seen in the control group. These results were in accordance with the study done by Chengfei et al.[11] But the smear layer was completely removed in both the laser-treated surface (groups II and III) and globules of ablated dentin were seen on the surface (Monica de Souza et al).[10,24]

From the foregoing analysis and discussion, it is evident that the specimens in the control group showed the lowest bond strength. Although diode laser caused removal of smear layer, its penetration depth was less. Less irregular surface was seen after diode laser treatment which might have been the reason for lesser bond strength compared to Nd:YAG laser.

CONCLUSION

Group III Nd:YAG laser–treated specimens showed higher microtensile bond strength to AH Plus sealer than group II diode and group I control specimens. Hence, both Nd:YAG and diode laser were more effective than the control group in improving the microtensile bond strength of AH Plus sealer to dentin.

REFERENCES

1. Dultra F, Machado J, Danicia L, Capelli A. Evaluation of apical microleakage of teeth sealed with four different root canal sealers. J Appl Oral Sci 2006;14(5):341-45.
2. Alfredo E, Silva SRC, Ozorio JEV, Sousa-Neto MD. Bond strength of AH Plus and Epiphany sealers on root dentin irradiated with 980 nm diode laser. Int End J 2008;41:733-40.
3. Huberto V, Gariba R, Edson A. Adhesion of Epiphany and AH Plus sealers to human root dentin treated with different solutions. Braz Dent J 2008;19(1):46-50.
4. Koba K, Kimura Y, Matsumoto K, Takeuchi T, Ikarugi T, Shimizu T. A histopathological study of the morphological changes at the apical seat and in the periapical region after irradiation with a pulsed Nd:YAG laser. Int End J 1998;31:415-20.
5. Sousa Neto MD, Silva Coelho FI, Marchesan MA, Alfredo E. Ex vivo study of the adhesion of an epoxy-based sealer to human dentin submitted to irradiation with Er:YAG and Nd:YAG lasers. Int End J 2005;38:866-70.
6. Scoop U, Kluger W, Moritz A, Sperr W, Apostolos G. Bactericidal effect of different laser systems in the deep layers of dentin. Lasers Surg Med 2004;35:111-16.
7. Pashley DH, Sano H, Ciucchi B, Yoshiyama M. Adhesion testing of dentin bonding agents: A review. Dent Mater 1995;11:117-25.
8. Anic I, Tachibana H, Masomoto K. Permeability, morphologic and temperature changes of canal dentin walls induced by Nd:YAG, CO_2 and argon lasers. Int End J 1996;29:13-22.
9. Depraset FJHW, De Bruyne MAA, De Moor RJG. The sealing ability of an epoxy-resin root canal sealer after Nd:YAG laser irradiation of the root canal. Int End J 2005;38:302-09.
10. Anic I, Segovic S, Katanec D, Prskalo K, Fleger DN. Scanning electron microscopic study of dentin lased with Argon, CO_2 and Nd:YAG Laser. J Endod 1998;24(2):77-81.
11. Zhang C, Kimura Y, Matsumoto K, Harashima T, Zhou H. Effects of pulsed Nd:YAG Laser irradiation on root canal wall dentin with different laser initiators. J Endod 1998;24(5):352-55.
12. Leonardo MR, Bezerra LA, Tanomaru M, Bonifacio KC. In vitro evaluation of antimicrobial activity of sealers and pastes used in endodontics. J Endod 2000;26(7):391-94.
13. Turkmen C, Gunday M, Karacorlu M, Basaran B. Effect of CO_2 Nd:YAG and ArF excimer lasers on dentin morphology & pulp chamber temperature: An in vitro study. J Endod 2000;26(11):644-48.
14. Berkiten M, Berkiten R, Okar I. Comparative evaluation of antibacterial effects of Nd:YAG laser irradiation in root canals and dentinal tubules. J Endod 2000;26(5):268-70.
15. Lan WH, Chen KW, Jeng JH, Lin CP, Lin SK. A comparison of the morphological changes after Nd:YAG and CO_2 Laser irradiation of dentin surfaces. J Endod 2000;26(8):450-53.
16. Goya C, Yamazaki R, Kimura Y, Matsumoto K. Effects of pulsed Nd:YAG Laser irradiation on smear layer at the apical stop and apical leakage after obturation. Int End J 2000;33:266-71.
17. Timpawat S, Amornchat C, Trisuwan WR. Bacterial coronal leakage after obturation with three root canal sealers. J Endod 2001;27(1):36-39.
18. Lin CP, Lee BS, Lin FH, Kok SH, Lan WH. Phase, compositional and morphological changes of human dentin after Nd:YAG Laser treatment. J Endod 2001;27(6):389-93.
19. Park DS, Lee HJ, Yoo HM. Effect of Nd:YAG laser irradiation on the apical leakage of obturated root canals: An electrochemical study. Int End J 2001;34(4):318-21.
20. Wang X, Sun Y, Kimura Y, Kinoshita JI, Tatsunari N, Matsumoto K. Effects of diode laser irradiation on smear layer removal from root canal walls and apical leakage after obturation. Photomed Laser Surgery 2005;23(6):575-81.
21. Torabinajed M, Handysides R, Khademi AA, Linda L, Bakland LK. Clinical implications of the smear layer in endodontics: A review. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002;94:658-66.
22. Lee BS, Lin CP, Lin FH, Lan WH. Ultrastructural changes of human dentin after irradiation by Nd:YAG laser. Lasers Surg Med 2002;30:246-52.
23. Kopper PMP, Figueiredo JAP, Dello Bona A, Vanni JR, Bier CA, Bopp S. Comparative in vivo analysis of the sealing ability of three endodontic sealers in post-prepared root canals. Int End J 2003;36:857-63.
24. de Souza MR, Watanabe IS, Azevedo LH, Tanji EY. Morphological alterations of the surfaces of enamel and dentin of deciduous teeth irradiated with Nd:YAG, CO_2 and diode lasers. Int J Morphol 2009;27(2):441-46.
25. Kokkas AB, Boutsioukis ACh, Vassiliadis LP, Stavrianos CK. The influence of the smear layer on the dentinal tubule penetration depth by three different root canal sealers: An in vitro study. J Endod 2004;30(2):100-02.

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