

Influence of prior 810-nm-diode intracanal laser irradiation on hydrophilic resin-based sealer obturation

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Abstract: Dentin wall structural changes caused by 810-nm-diode laser irradiation can influence the sealing ability of endodontic sealers. The objective of this study was to evaluate the apical leakage of AH Plus and RealSeal resin-based sealers with and without prior diode laser irradiation. Fifty-two single-rooted mandibular premolars were prepared and divided into 4 groups, according to the endodontic sealer used and the use or non-use of laser irradiation. The protocol for laser irradiation was 2.5W, continuous wave in scanning mode, with 4 exposures per tooth. After sample preparation, apical leakage of 50% ammoniacal silver nitrate impregnation was analyzed. When the teeth were not exposed to irradiation, the RealSeal sealer achieved the highest scores, showing the least leakage, with significant differences at the 5% level (Kruskal-Wallis test, $p = 0.0004$), compared with AH Plus. When the teeth were exposed to the 810-nm-diode laser irradiation, the sealing ability of AH Plus sealer was improved ($p = 0.0282$). In the RealSeal groups, the intracanal laser irradiation did not interfere with the leakage index, showing similar results in the GRS and GRSd groups ($p = 0.1009$).

Descriptors: Dental Pulp Cavity; Root Canal Filling Materials; Laser Therapy; Root Canal Therapy; Endodontics.

Introduction

The complete seal of a canal system is extremely important for achieving success in endodontic therapy. Many products have been tested for complete disinfection and sealing of the root canal system.^{1,2} The use of laser devices, such as the Nd:YAG and diode lasers, has been shown to be a great asset for root canal treatment in endodontics.³⁻⁶ Diode laser irradiation has been proposed for endodontic therapy and has been shown to increase the level of disinfection, as well as produce morphological changes that occlude dentin tubules, improving the seal of the root canal system.^{3,4,6-12} There are several studies about materials and root canal filling techniques that aim to achieve apical sealing of teeth.¹³⁻¹⁷ Currently, studies with Epiphany (Pentron Clinical, Orange, USA) and RealSeal (Sybron Endo, Redmond, USA), both methacrylate-based resin sealers, have shown promising results in comparison with other base sealers.^{1,18,19} However, it is not well-known if the combined association of intracanal

laser irradiation and methacrylate-based resin sealers, which separately improve an endodontic seal, could enhance endodontic treatment.

Thus, the objective of this study was to evaluate the apical leakage of AH Plus and RealSeal resin-based sealers with and without prior diode laser irradiation.

Methodology

This study was approved by the Ethics Committee at the Dentistry College of the University of São Paulo (Protocol 92/2008). Fifty-two single-rooted mandibular premolars, stored in 1% thymol solution, were selected from a tooth bank from the same institution. After coronal access, a size 15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) was inserted into the root canal until the tip was visible at the apical foramen, and a working length 1.0 mm short from the apical foramen was established. All teeth were prepared by the “crown down” technique, utilizing .04 taper K3 rotary files (Sybron Endo, Redmond, USA) up to size 40 with 2.5% sodium hypochlorite. Once the preparation was complete, each root canal was flushed with 10 mL of 2.5% NaOCl followed by 10 mL of a 17% EDTA-T solution and a final rinse of 20 mL of sterile water to remove the other irrigants. The samples were then randomly divided into four experimental groups ($n = 12$) according to the endodontic sealer used and whether canals were lased or non-lased.

Diode laser irradiation

For the irradiated groups, an 810-nm-wavelength-diode laser device (Twilite with laserSmile, Biolase Technology Inc., Irvine, USA), set at 2.5W continuous wave in scanning mode, was used.⁶⁻⁷ With the root canal moistened with sterile water, the optical fiber tip (0.3 mm in diameter) was inserted into the root canal 1 mm short of the working length without activating the laser. Once the tip was in position, the laser was initiated, and the fiber worked in contact mode, moving coronally in circular movements over the root canal wall at a speed of 2 mm/s (calculated according to the working length of each tooth, based on a time of 0.5 s of irradiation per millimeter). This process was repeated 4 times

with 20-second intervals between exposures. Assuming that the mean root length of the sample was 15 mm, it could be calculated that the total irradiation time for each tooth was approximately 28 s.

SEM analysis

Two lased and two non-lased roots were split (by fracture) in the buccal-lingual direction, and the sections were dehydrated by a series of graded ethanol solutions, and then coated with a gold layer after drying. The selected dentinal surface of the apical third, 3 mm from the apex and equidistant from lateral walls, was observed by scanning electron microscopy (SEM) (XL30, Philips, Eindhoven, Netherlands) at a working distance of 10 mm and beam acceleration of 10 kV. The surface topography of non-lased roots and the extent of morphologic changes caused by laser irradiation were analyzed in comparison with those in the non-irradiated group.

Root canal filling

The root canals of all four groups were filled by the lateral condensation technique.¹² The canals of the AH Plus sealer (Dentsply, Konstanz, Germany) groups were then dried with suction (0.014” Capillary tips, Ultradent Products, Salt Lake City, USA), and paper cones (Dentsply Maillefer) and a taper (0.4 #40 size gutta-percha cone; Dentsply Maillefer) were fitted to the working length. AH Plus sealer was mixed according to the manufacturer’s instructions and placed in the canal with the master cone, which was carefully seated to working length. Lateral condensation was then completed by the placement of accessory gutta-percha cones with endodontic finger-spreaders (Dentsply Maillefer) until the spreader could not enter more than 3 mm.

The RealSeal sealer (SybronEndo) groups were dried with suction and 1 or 2 paper cones, to maintain moisture in the dentin walls. Following the manufacturer’s instructions, RealSeal sealer and taper .04 #40 Resilon cones (Resilon Research, LLC, Madison, USA) were placed by a lateral condensation technique. The excess of cone and sealer from each of the groups was removed with a hot plugger and vertically condensed by means of a cold plugger. The coronal openings of all samples were sealed with

glass-ionomer cement and stored in 37°C and 100% humidity for 48 h. All teeth were radiographed in bucco-lingual and mesial-distal positions for the assessment of filling quality. The teeth were then externally coated with two layers of ethyl cyanoacrylate (Superbonder, Loctite, São Paulo, Brazil), except for the last 2 mm of the apical third. The specimens were immersed and kept in 50% silver nitrate solution for 24 h, followed by a thorough rinse in running water. Each specimen was then embedded in acrylic blocks and split into two sections, longitudinally. Next, the hemi-sections were rinsed and placed in photodeveloper solution (Kodak Eastman, Rochester, USA) for 8 h to reduce the silver ions to metallic silver.²⁰ The samples were then scanned with a high-optical-resolution scanner (24000 dpi - CX7300, Epson, São Paulo, Brazil), and the impregnation on each side of the sample was blindly measured (mean value), with Image J Software (NIH, Bethesda, USA). The leakage measures were converted to scores (1 to 6; see Table 1) and subjected to the Kruskal-Wallis test for non-parametric data to determine whether there were statistically significant differences ($\alpha = 0.05$) between and among the groups. If statistically significant differences were present, pairs of groups were compared by the Student-Newman-Keuls test.

ESEM analysis of resin tag penetration

Assessment of the penetration of the sealers into dentinal tubules (presence of tags) was used to perform the qualitative analysis; two sections of the roots of each group were randomly chosen and prepared for observation. The root surfaces were conditioned with a 37% phosphoric acid solution for 30 s, followed by irrigation with distilled water, immersion in 2.5% sodium hypochlorite for 10 min,

and a final flush with distilled water.²¹ Non-dehydrated and uncoated specimens were fixed for platform-specific analysis in an environmental scanning electron microscope (ESEM) (Quanta 600 FEG, FEI Company, Eindhoven, Netherlands). To standardize the surfaces analyzed, we chose the ESEM images of the apical root third at a distance of 4 mm from the edge of the cone, in mesial and distal interfaces between the dentin wall and filling material (magnification, 1500×).

Results

SEM analysis showed that the non-lased surfaces presented clean dentin walls with open dentin tubules. The canals irradiated with the diode laser showed melting and re-solidification of the dentin surface and partially occluded dentin tubules (Figure 1).

Table 1 shows a frequency distribution of the leakage scores of the four groups, with the Real-Seal groups exhibiting lower leakage scores than the AH Plus groups. In the non-lased groups, Real-Seal sealer showed significantly lower leakage rates than AH Plus ($p = 0.0004$). When lased and unlased groups were compared, it was observed that the 810-nm-diode laser improved the sealing ability of AH Plus sealer, with a statistically significant difference ($p = 0.0282$). In the RealSeal groups, intracanal laser irradiation did not interfere with the leakage index, and similar results were observed in the GRS and GRSd groups ($p = 0.1009$).

Figure 2 shows ESEM images of resin tag penetration in the experimental groups. It can be observed that the penetration of sealer was similar among the experimental groups independent of the laser application ($p < 0.05$). The resin tag penetra-

Table 1 - Distribution of leakage scores, median and means \pm standard deviations (mm) of the experimental groups.

Group	Scores*						median	mean \pm sd	Kruskal-Wallis
	1	2	3	4	5	6			
GAH (AH Plus)	-	-	2	4	4	2	4.5	2.04 \pm 0.46	A
GAHd (AH Plus + diode laser)	-	-	6	5	1	-	3.5	1.57 \pm 0.28	B
GRS (RealSeal)	-	4	7	1	-	-	3	1.20 \pm 0.26	C
GRSd (RealSeal + diode laser)	-	1	8	3	-	-	3	1.34 \pm 0.24	B,C

*leakage scores: 1, up to 0.5 mm; 2, 0.55–1 mm; 3, 1.05–1.5 mm; 4, 1.55–2 mm; 5, 2.05–2.5 mm; 6, 2.55–3 mm.

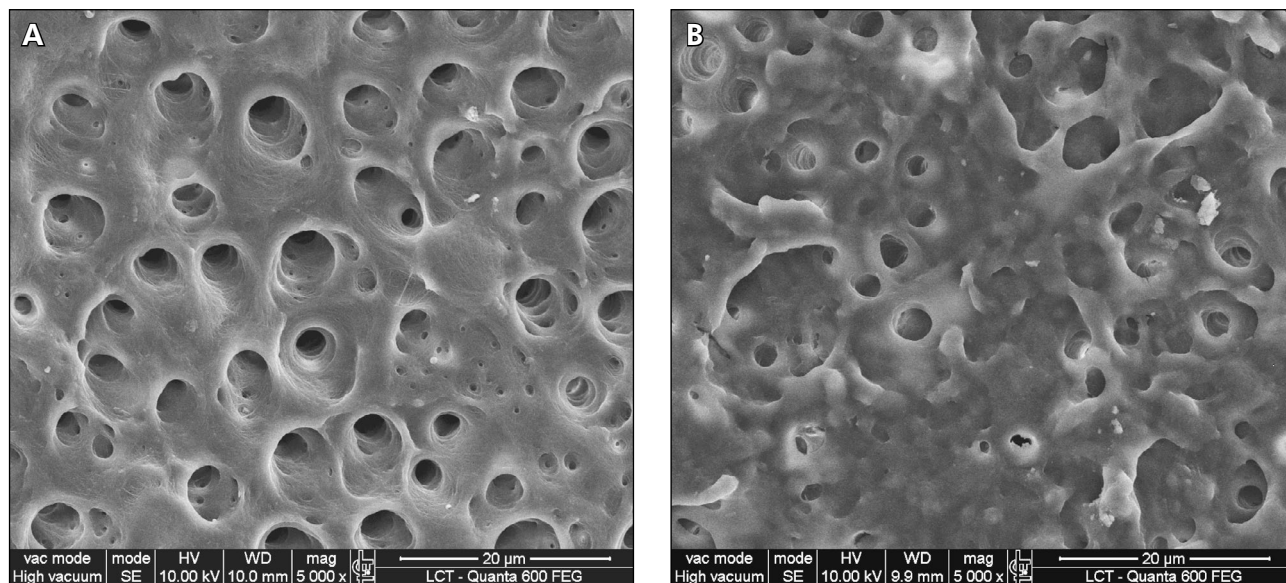


Figure 1 - SEM images of the dentin surface without laser irradiation (**A**), showing a clean wall free of smear layer and open dentin tubules; after diode laser irradiation (**B**), melting of the dentin surface can be noted, along with a few dentin tubules, most of them occluded.

tion of RealSeal sealer was apparently deeper than that of AH Plus. In a comparison of the RealSeal groups, a higher concentration of resin tags was noted in the non-lased group.

Discussion

The perfect apical seal of a root canal system is the goal of successful endodontic treatment.² After endodontic instrumentation, but prior to filling of the root canal, the treatment of the root canal wall may influence the marginal sealing of the filling, as has been demonstrated in studies with chemical substances, such as EDTA,^{1,2,13-15} or with laser irradiation.^{4,11-12,22} The high intensity of the diode laser has notable effects on intracanal irradiation, including bacterial reduction^{8,10} and melting and re-solidification of dentin walls, with partial occlusion of dentinal tubules.^{6,9} Moura-Netto *et al.*⁶ showed similar results when comparing Nd:YAG and diode laser irradiation with regard to morphologic changes and debris removal on the intracanal dentin surface. The diode laser melted the dentin, creating a more uniform circular pattern than the Nd:YAG laser, and apparently occluded several dentin tubules. In that study, the authors did not find statistical differences when the effects of these two laser de-

vices were compared. Therefore, these effects could increase the sealing success of the endodontic treatment.⁴ In addition, research completed over the last few years, evaluating apical leakage of new methacrylate resin-based endodontic sealers, has shown good results.^{2,18}

In the evaluation of different endodontic techniques, dye is commonly used for *in vitro* studies as an indicator of apical leakage, which is illustrated by the dye penetration between the canal walls and the obturating materials.^{18,22,23} In this study, 50% silver nitrate impregnation was used to measure apical leakage. This method is commonly used to assess micro- and nanoleakage of composite fillings, by tracing gaps and spaces between the composite and dentin walls.^{17,20,22} As with any other method, dye or tracing tests do not represent or simulate the exact behavior of these sealers in clinical conditions. However, since there is no single, universally accepted model of leakage testing in endodontics, this leakage test can be used to compare the sealing abilities of the tested materials.²³

Several studies concerning root canal sealers classify AH Plus sealer as the product with the lowest apical marginal dye index.^{4,14-16,24,25} However, as found in this and other studies (e.g., Onay *et al.*),²⁶

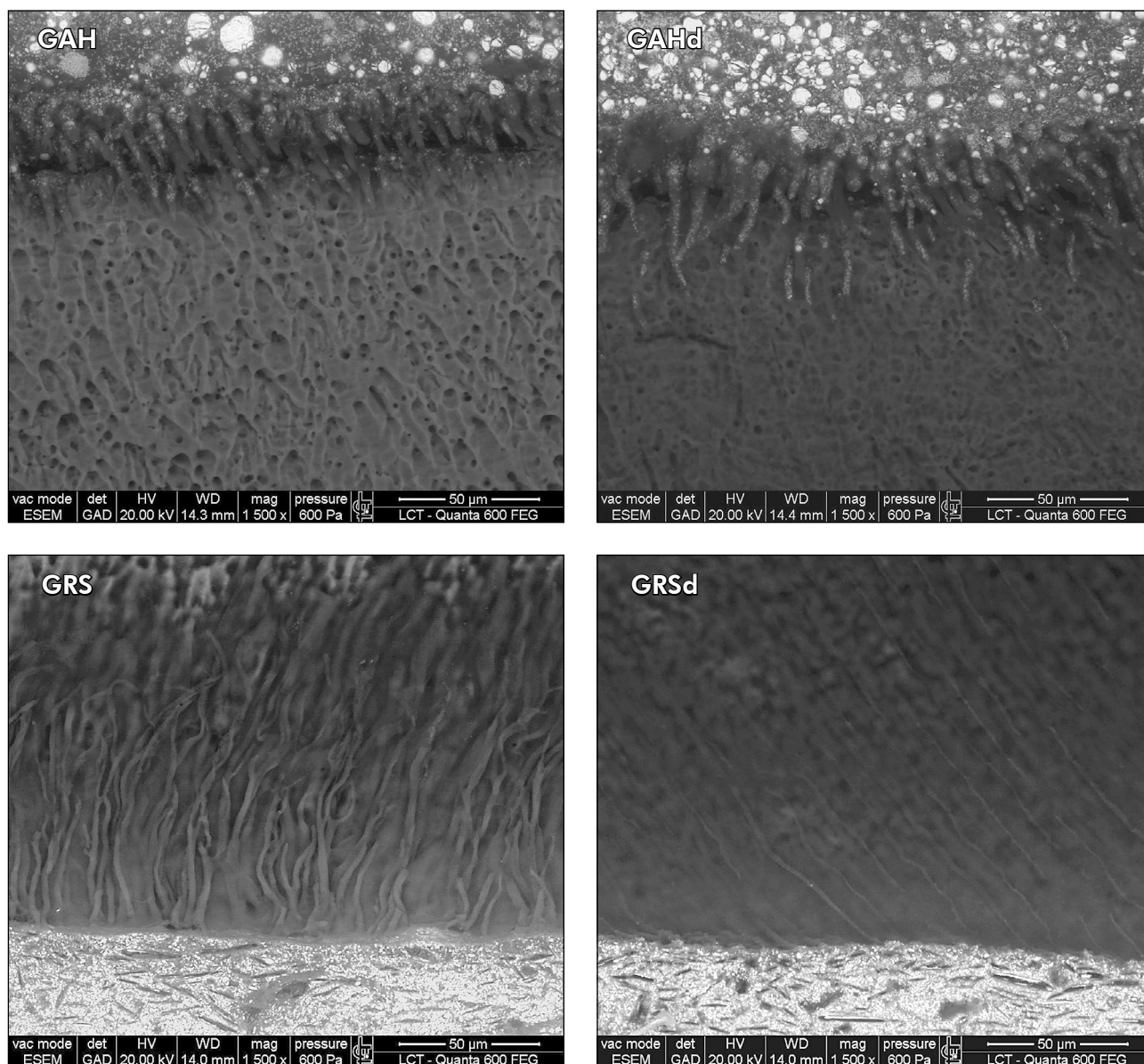


Figure 2 - ESEM images of resin tag penetration in the experimental groups. GAH: AH Plus; GAHd: AH Plus + diode laser; GRS: RealSeal; GRSd: RealSeal + diode laser. Resin tags appeared longer in the RealSeal groups than in the AH Plus groups.

better microleakage scores, denoting better apical sealing, were achieved with the use of methacrylate-based sealers in comparison with AH Plus.^{27,28}

The present study compares a hydrophobic epoxy resin sealer with a hydrophilic methacrylate resin-based sealer, with the additional variable of irradiation by the 810-nm-diode laser. Differences in the mean values and scores of apical leakage between the tested cements are evident. It could be noted that the RealSeal groups (GRS and GRSd)

promoted better apical sealing, followed by AH Plus + laser (GAHd) and AH Plus (GAH).

These findings should be a consideration for general practitioners and endodontists who associate new technologies and materials with increased endodontic treatment success. In our results, the leakage index decreased in the GAHd group, showing a tendency of compatibility between a diode laser and epoxy resin-based sealer. However, laser intracanal irradiation did not seem to be useful in promoting

better apical sealing on methacrylate resin-based sealers.

Also, in this study, the penetration of sealers into the dentinal tubules was observed by ESEM. It can be observed that the penetration of sealers was similar among the experimental groups, independent of the laser application. However, it seems that Real Seal (GRS and GRSd) showed a deeper penetration than the other sealers. This could be explained by

the hydrophilicity of this sealer, which improves its penetration into dentinal tubules.

Conclusion

According to our results, Real Seal root canal sealer showed better apical leakage results than AH Plus. Previous diode laser irradiation improved the sealing ability of AH Plus cement, but did not interfere with Real Seal obturation.

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