
The sealing ability of resilon and gutta-percha following different smear layer removal methods: an ex vivo study

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Objective. The objective of this study was to compare the ex-vivo sealing ability of Resilon/new Epiphany (SE) sealer to that of gutta-percha/AH-Plus following smear layer removal with EDTA or MTAD.

Study design. One hundred extracted single-rooted human teeth were divided into 4 experimental groups and 2 positive and negative control groups. EDTA was used in groups 1 and 2. In groups 3 and 4 MTAD was used. The root canals were then obturated with gutta-percha/AH-Plus in groups 1 and 3 and Resilon/Epiphany (SE) in groups 2 and 4. After sterilization, the samples were coronally exposed to human saliva and monitored every 24 hours for 60 days.

Results. In groups 1, 2, 3, and 4, 45%, 65%, 90%, and 65% of specimens leaked within 60 days, respectively. There were statistically significant differences between group 1 and 3 ($P < .05$).

Conclusions. Resilon/Epiphany (SE) system is as effective as gutta-percha/AH-Plus in preventing saliva leakage. MTAD did not adversely affect the sealing ability of Resilon/Epiphany (SE). (*Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2010;110:e45-e49)

The main purpose of root canal therapy is to eliminate microorganisms and their by-products from the root canal system in addition to the prevention of reinfection. The most commonly used material for root canal obturation is gutta-percha combined with a sealer; however, this standard approach does not provide a completely hermetic seal of the root canal system.¹⁻³

Resilon (Resilon Research LLC, Madison, CT) is a synthetic material developed recently to replace gutta-percha and traditional sealers for the obturation of endodontically treated teeth. The Epiphany obturation system consists of 3 main items: the core material, the sealer, and its bonding agent.^{2,4} More recently, new Epiphany self-etch (SE) soft resin endodontic obturation system (Pentron Clinical Technologies, Wallingford, CT) has been marketed consisting of 2 components: Epiphany self-etch sealer and the core material

(Resilon). The manufacturer states that with the addition of Epiphany SE sealer, no change in technique is needed when transferring from gutta-percha to the Epiphany system.

A resin-based adhesive material may have the potential to reduce the microleakage of the root canal because of its adhesive properties and penetration into dentinal walls.^{2,5}

The studies comparing the sealing ability of gutta-percha/epoxy-resin-based sealer versus Resilon/Epiphany sealer have shown conflicting results. Several authors showed that Resilon/Epiphany prevented leakage to a greater extent than gutta-percha.⁶⁻⁸ Alternatively, some studies found no significant difference between the sealing ability of Resilon and that of gutta-percha.⁹⁻¹¹ In all studies mentioned, conventional 3-component Resilon/Epiphany system was compared with gutta-percha/sealer.

Mechanical instrumentation of the root canals leaves a smear layer covering the dentinal walls.¹² It has been suggested that the removal of the smear layer allows the sealer to penetrate into the dentinal tubules. Therefore, this may possibly increase the bond strength of resin-based sealers to dentin, as well as achieving an enhanced seal.¹³ For effective removal of both organic and inorganic components of the smear layer, combined application of NaOCl and a chelating agent, such as EDTA, is recommended.¹⁴

MTAD, which is a mixture of a tetracycline isomer, citric acid, and a detergent, has recently been developed for removing the smear layer.¹⁵ Torabinejad et al.¹⁵

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showed that MTAD is effective as a final rinse to remove the smear layer with minimal erosive changes to the surface dentin compared with EDTA. Some chemical and structural changes in human dentin composition have been attributed to dentin surface treatment by different irrigation regimens. These changes may affect the adhesion capability of materials to the dentinal walls. Therefore, the use of appropriate conditioners of root dentin, to enhance bonding characteristics, cannot be overemphasized.

De-Deus et al.¹⁶ showed that the bond strength of Resilon/Epiphany root fillings, following smear layer removal using EDTA, was not significantly different from those in which MTAD was used.

According to current information, there are no published articles related to the effect of MTAD on the sealing ability of Resilon/Epiphany. In addition, no published articles are available comparing the sealing ability of Resilon/new Epiphany SE sealer with gutta-percha/epoxy-resin-based sealer. Therefore, this study was designed to compare the *ex vivo* coronal leakage of human saliva in roots filled with either gutta-percha/AH Plus sealer or Resilon/new Epiphany SE sealer, after smear layer removal using EDTA or MTAD.

MATERIALS AND METHODS

Preparation of specimens

A total of 100 freshly extracted single-rooted human teeth, stored in 0.5% chloramine T, were selected for this study. The teeth were decoronated to a standardized root length of 13 mm. The working lengths were determined by deducting 1 mm from the length recorded when the tips of #10 or #15 K-files (Dentsply Maillefer, Ballaigues, Switzerland) were visible at the apical foramina. The root canals were prepared using Mtwo Ni-Ti rotary instruments (VDW, Munich, Germany). Six instruments were used to the working length in each canal according to the manufacturer's instructions in the following sequence: (1) size 10/0.04 taper, (2) size 15/0.05 taper, (3) size 20/0.06 taper, (4) size 25/0.06 taper, (5) size 30/0.05, and (6) size 35/0.05 taper. All canals were irrigated between the use of each file with 3 mL of 1.3% NaOCl. The roots were then divided randomly into 4 experimental groups of 20 roots each and 2 control groups of 10 as follows.

Group 1

At the completion of instrumentation the smear layer was removed with 5 mL of 17% EDTA for 1 minute. The root canals were then dried with paper points and obturated with a size 35/0.02 gutta-percha (Gapadent Co., Ltd., Korea) master cone coated with AH Plus sealer (Dentsply Maillefer) using the cold lateral compaction technique.

Group 2

The smear layer was removed with 5 mL of 17% EDTA for 1 minute. The root canals were then dried with paper points and obturated with Resilon/ Epiphany SE sealer (Pentron Clinical Technologies, LLC, Wallingford, CT) using the following technique. Epiphany SE sealer was mixed on a mixing pad, and then a Resilon master cone (size 35/0.02) was lightly coated and placed in to the canal to the working length. Lateral compaction with accessory Resilon size 20/0.02 was performed until the entire root canal was filled. The excess Resilon was removed with a heated instrument and then compacted vertically using a plugger. The coronal surface of the obturation was light-cured for 40 seconds to create an immediate coronal seal, according to manufacturer's instructions.

Group 3

The smear layer was removed using BioPure MTAD (Dentsply Tulsa Dental, Tulsa, OK) according to manufacturer's instructions. At the completion of instrumentation, 1 mL of MTAD was placed in each canal for 5 minutes. Each canal was then rinsed with 4 mL of MTAD. The root canals were finally obturated with gutta-percha and AH Plus sealer in the manner described for group 1.

Group 4

The smear layer was removed using BioPure MTAD, as described for group 3. The root canals were then obturated with Resilon/Epiphany SE sealer in the same method used for group 2.

Positive control group

Five roots were filled only with a single gutta-percha cone (size 35) without any sealer. Another five were filled with a single Resilon cone (size 35) without Epiphany sealer.

Negative control group

Five root canals were obturated using laterally compacted gutta-percha/ AH Plus sealer. A further 5 canals were filled using laterally compacted Resilon/Epiphany.

All preparation and obturation procedures were performed by an endodontist. Radiographs of all specimens were taken in buccolingual and mesiodistal directions to evaluate the quality of the root canal fillings.

All specimens were left to set in an incubator for 7 days at 37°C and 100% humidity. The external surfaces of the experimental specimens and the samples from the positive control group were covered by 2 layers of nail varnish (Arcancel, Paris, France), apart from the apical 3 mm around the foramen. The roots from the

negative control group were entirely covered with 2 layers of nail varnish, including the apical and coronal regions.

Microleakage assessment

A modification of the 2-chamber microbial leakage model as described by Torabinejad et al.¹⁷ was used. The tapered end of a 2-mL Eppendorf plastic tube (Eppendorf-Elkay, Shrewsbury, MA) was cut and the roots inserted individually into the tubes until the roots protruded through the end. The junction between the root and plastic tube was sealed with sticky wax. The Eppendorf tube was then placed in glass tube containing 10 mL sterile Brain Heart Infusion (BHI) (Merck, Darmstadt, Germany), so that at least 2 mm of the root apex was immersed in the broth. The junction between the Eppendorf and glass tube was sealed with sticky wax. The testing apparatus was sterilized by exposure to 25 Kilo Gray (KGy) Gamma irradiation. Sterility of the whole system was verified by incubating the specimens at 37°C for 3 days. After that, the upper chambers were filled with human saliva and replenished every 3 days. Human saliva was collected from a single volunteer who did not brush for at least 12 hours before collection.¹⁸ The whole system was incubated at 37°C and checked daily for the appearance of turbidity for 60 days in the lower chamber, which was filled with BHI.

Data analysis

The chi-square test was used to compare the number of teeth displaying leakage at the end of the observational period. Survival analysis and log-rank testing compared the survival curve patterns of the 4 groups. Kaplan-Meier survival curves were constructed based on the leakage of specimens over time. The level of significance was set at $P < .05$.

RESULTS

All specimens in the positive control group showed broth turbidity within 4 days of incubation. The negative controls prevented leakage for the whole experimental period of 60 days. Nine teeth (45%) in group 1 (EDTA/gutta-percha/AH Plus), 13 (65%) in group 2 (EDTA/Resilon/Epiphany), 18 (90%) in group 3 (MTAD/gutta-percha/AH Plus), and 13 (65%) in group 4 (MTAD/Resilon/Epiphany) leaked after 60 days. The chi-square test revealed a statistically significant difference among the 4 groups ($P = .006$). The Tukey post hoc test showed a significant difference in the number of teeth that leaked at the end of the observational period between groups 1 and 3 ($P = .032$). Kaplan-Meier survival curves for all groups are shown in Fig. 1. Survival analysis and log-rank test revealed a significant difference between groups 1 and 3 ($P = .025$).

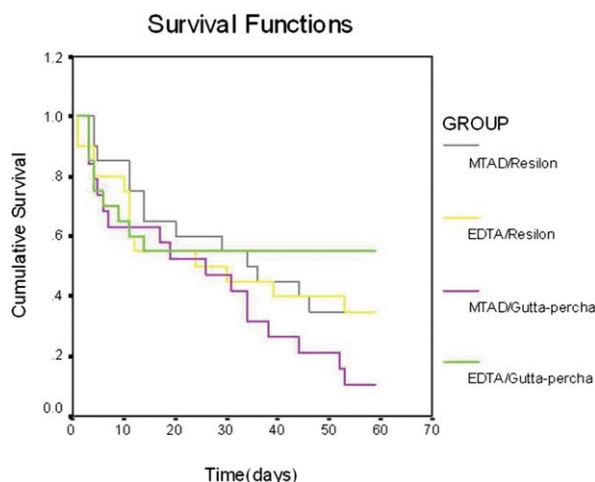


Fig. 1. Kaplan-Meier survival curves for experimental groups.

DISCUSSION

The recent introduction of bonded root-fillings reinforced the importance of knowledge of the dentin status before insertion of the filling material.¹⁹ Treatment of the dentin surface with different irrigation regimens may induce chemical and structural changes in dentin.²⁰ Consequently, this structural change affects the adhesion of materials to the dentin surface.²¹ Alternating use of 17% EDTA and 5.25% NaOCl has been recommended for efficient removal of the smear layer.²² Similarly, an initial rinse of the root canals with NaOCl is advised for enhancing the efficacy of MTAD.²³ NaOCl is a strong oxidizing agent and creates an oxygen-rich layer on the dentin surface resulting in reduced bond strengths of subsequently placed resins.²⁴ Therefore, NaOCl was not used after EDTA in this study.

In the present study, no growth was observed while sterilization was being monitored in the present study. This could confirm the ability of Gamma rays to sterilize the whole apparatus.

The findings of this study are controversial in relation to the sealing ability of Resilon/Epiphany sealer compared with gutta-percha/epoxy-resin-based sealers; however, there are no data regarding the sealing ability of new Epiphany SE sealer. In this study there was no significant difference between the results of the EDTA/Resilon/Epiphany SE group compared with the EDTA/gutta-percha/AH Plus. This result is in accordance with Pitout et al.,²⁵ Fransen et al.,⁹ and Baumgartner et al.¹¹ These studies found no significant difference in the penetration of *Enterococcus faecalis* comparing root canals filled with either gutta-percha/AH Plus or Resilon/Epiphany. Alternatively, several studies have found leakage to be reduced when

bonded root fillings were used compared with gutta-percha, following smear layer removal with EDTA.⁶⁻⁸ These conflicting results may be attributed to the differences in root filling lengths,¹⁰ application time and the quantity of EDTA used, methodology,⁴ and the experimental period chosen.^{26,27}

The root canal system has an unfavorable geometry for resin bonding.²⁸ A perfect seal is difficult to achieve with bonded root fillings for a number of reasons. The extremely high configuration factor (C-factor) of the root canals results in maximizing the polymerization shrinkage stress of adhesive systems.²⁸ In addition, the incomplete removal of the smear layer⁶ and the incomplete infiltration of resin into the demineralized dentin²⁹ also reduce bonding efficacy. Therefore, it is not possible to achieve the gap-free monoblock that would be created by bonding Epiphany sealer both to the Resilon and the root canal dentin.⁷

Gutta-percha is a relatively inert material. In contrast, polycaprolactone (the raw material of Resilon) is biodegradable under microbial attack.³⁰ The lipase released by microorganisms is capable of cleaving the ester bonds of polycaprolactone.^{31,32} It is susceptible to alkaline and enzymatic hydrolysis.^{33,34} However, the resistance of EDTA/Resilon/Epiphany SE to bacterial penetration was not significantly different to that of EDTA/gutta-percha/AH Plus in the present study. Therefore, further research into the hydrolysis of Resilon by salivary or microbial enzymes would be beneficial to clarify this issue.

The specimens in the MTAD/gutta-percha/AH Plus group showed inferior results in comparison with the other experimental groups in the present study. However, MTAD did not adversely affect the resistance to bacterial penetration of roots filled with Resilon/Epiphany SE. It is possible that the treatment of the dentin surface with MTAD might be the cause of this favorable result. Tay et al.¹⁹ showed that MTAD created 10- to 12- μm -thick collagen matrices compared with the 4- to 6- μm -thick matrices produced by 17% EDTA irrigant. The matrices created by MTAD provide the opportunity for dentin hybridization with hydrophilic resin-based sealers¹⁹ like Epiphany. Furthermore, Tween80, the detergent incorporated in formulation of MTAD, results in increased dentin surface energy and wetting ability. This may have negatively affected the adhesion of the hydrophobic AH Plus sealer.³⁵ Therefore, the increased bacterial penetration experienced by MTAD/gutta-percha/AH Plus may be attributable to incomplete infiltration of hydrophobic AH Plus into the thick zone of demineralized dentin. Similarly, Hashem et al.³⁵ demonstrated that dentin treatment with MTAD as a final rinse and obturation with gutta-percha/AH Plus resulted in a significant decrease in the bond

strength compared with gutta-percha/AH Plus following irrigation with EDTA.

The altered characteristics of dentin treated with EDTA may be a potential contributing factor to the increased resistance to bacterial leakage of the samples treated with EDTA/gutta-percha/AH Plus compared with MTAD/gutta-percha/AH Plus seen in the present study. It has been demonstrated that EDTA decreased the wetting ability of dentin,³⁶ although produced a suitable dentin surface for the adhesion of hydrophobic materials such as AH Plus.³⁵ However, the results of the present study showed a similar incidence of bacterial leakage for samples treated with EDTA/Resilon/hydrophilic Epiphany SE compared with those treated with EDTA/gutta-percha/AH Plus, which is not in alignment with the research discussed.

The results of this study are in contrast to those of Ghoddsi et al.,³⁷ who found no significant difference in leakage between EDTA/gutta-percha/AH Plus and MTAD/gutta-percha/AH Plus. This conflicting finding of Ghoddsi et al.³⁷ may be because of the method chosen of 5.25% NaOCl application following the use of EDTA, in addition to the diversity of methodologies used to assess leakage.

Within the limitations of this study, it could be concluded that (1) there was no significant difference between the sealing ability of gutta-percha/AH Plus and that of Resilon/Epiphany SE; (2) no significant difference was found in the sealing ability of Resilon/Epiphany SE when either MTAD or EDTA was used for removal of smear layer; and (3) EDTA can be a better conditioner for root canal dentin before the use of gutta-percha/AH Plus as the root filling and thereby improving the sealing ability of root canals obturated by this system. However, further investigations should be conducted to confirm the findings of this study.

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