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Reduced Long-Term Sealing Ability of Adhesive Root Fillings After Water-Storage Stress

Gustavo De-Deus, DDS, MS, Fátima Namen, DDS, MS, PhD, and João Galan Jr, DDS, MS, PhD

Abstract

This study was designed to compare in vitro the short-term and long-term ability to prevent through-and-through fluid movement along Resilon/Epiphany root fillings. A sample of 40 human upper incisors were prepared and assigned to experimental groups of 20 teeth each, designated as G1, Resilon/Epiphany, and G2, gutta-percha/AH Plus. Additional 10 teeth were used as controls. Each tooth was assembled in a hermetic cell to allow the evaluation of fluid filtration. After the root filling procedures, the filled roots were stored at 37°C and 100% humidity for 7 days to allow setting of the sealer. Forthwith, the teeth were submitted to the first fluid flow measurement. Leakage was measured by the movement of an air bubble traveling within a pipette connected to the teeth. Shortly after the measurements, the teeth were detached from the hermetic cell and then stored in water for 14 months at 37°C. At this moment, fluid filtration was re-measured. Both Kruskal-Wallis and Wilcoxon signed rank tests were applied to detect differences between the experimental groups. No differences were found between the experimental groups during the immediate measure ($P > .05$), whereas Resilon/Epiphany group displayed significantly more fluid movement than the gutta-percha/AH Plus group after 14 months of water storage ($P < .05$). The water-storage stress had no significant effect on the sealing ability of the gutta-percha/AH Plus root fillings ($P > .05$). The main point of our study is the fact that long-term sealing was compromised in the Resilon/Epiphany samples, when exposed to long-term water storage. *(J Endod 2008;xx:xxx)*

Key Words

Epiphany, fluid movement, long-term sealing ability, Resilon, root-filling, water storage

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0099-2399/$0 - see front matter

doi:10.1016/j.joen.2007.12.014

Preliminary studies of the Resilon/Epiphany adhesive root-filling materials have shown remarkable promise, such as a decrease in the amount of leakage when compared with conventional gutta-percha fillings (1–3) and an improvement on the root fracture resistance (4). As a consequence, the Resilon core filling with Epiphany sealer was initially considered as a single entity in the so-called Resilon "Monoblock" System (RMS). Nevertheless, recent independent studies have shown negative results, and as a consequence, the initial position of the success of the Resilon/Epiphany adhesive root-filling materials is questionable (5, 6). A well-controlled study concluded that Resilon allowed more glucose penetration than gutta-percha root fillings, whereas a fresh bacterial leakage study stated that Resilon/Epiphany was no better than gutta-percha/AH Plus at sealing root canals (5, 6). In an elucidative manner, a transmission electron microscopy– ultrastructural evaluation showed that a weak link in Resilon-filled root canals was located along the sealer-dentin interface, probably a result of the rapid polymerization stresses created by resin materials inside the root canal system (7). AQ: 1

Furthermore, in light of current adhesive dentistry studies, it is very desirable that the Resilon/Epiphany system be evaluated regarding its ability to preserve its bonding ability over time. This is necessary because Resilon is biodegradable through enzymatic and alkaline hydrolysis (8, 9).

The short-term sealing ability of Resilon/Epiphany has been well-documented and addressed by recent studies (5–7, 10–12). However, the long-term sealing ability still remains poorly evaluated. To date (November 2007), an English PubMed Database search on "Resilon" and "sealing ability" produced more than 20 articles published since 2004. On the other hand, when "long-term" was included as a key word, an English PubMed Database search displayed just 1 study (13).

The present study was designed to compare the short-term and long-term ability to prevent through-and-through fluid movement along Resilon/Epiphany root fillings. The artificial aging technique used was water storage of the samples for 14 months. Conventional, nonbonding gutta-percha/AH Plus root fillings were used as reference, and a fluid transport model was used for leakage assessment. The tested null hypotheses were (1) that there is no difference in the short-term ability to prevent fluid movement along Resilon/Epiphany and gutta-percha/AH Plus root-fillings, and (2) that there is no difference in the long-term ability to prevent fluid movement along Resilon/Epiphany and gutta-percha/AH Plus root fillings.

Materials and Methods

Specimen Preparation

A sample of 50 well-preserved extracted human upper central incisors that were 20 ± 1 mm in length and had straight roots were selected for the present study. Standard access cavities were made, and all the canal orifices were located. The patency of each canal was confirmed, and the working length was established by deducting 1 mm from the canal length. The root canal was prepared with K3 NiTi rotary instruments (SybronEndo, West Collins, CA) at 250 rpm. The final preparation had a 0.06 taper with a diameter of 0.35 mm at the apex. All canals were irrigated between each file with 0.5 mL of freshly prepared 5.25% NaOCl, and the smear layer was removed with 3 mL of 17% ethylenediaminetetraacetic acid (pH 7.7) for 3 minutes. A solution of 3 mL of bi-distilled water was used as final flush. All canals were dried with paper points (Dentsply-Maillefer, Ballaigues, Switzerland).

The use of different root-filling materials resulted in 2 experimental groups with 20 specimens each (G1 and G2). Five teeth with intact crowns were also used as a negative control, and 5 teeth that were not obturated served as a positive control. The experimental and control groups were randomly distributed with the aid of a computer algorithm (http://www.random.org).

Canal Filling

The prepared teeth were filled by using the single-cone technique to control the methodologic variables associated with the filling technique. For all specimens, an ISO size 40 file was used to place a measured volume of sealer (20 μL) into the canal while using a counterclockwise rotation.

In G1, a prefitted size 45 0.06-taper gutta-percha cone (Diadent Group International, Chongchong Buk Do, Korea) was used with AH Plus sealer (Dentsply-Maillefer). A firm apical pressure was used to insert the gutta-percha cone into the full working length. A heated instrument was used to remove the coronal surplus of gutta-percha, and then the filling was compacted.

Following the manufacturer's directions, Epiphany primer was introduced into the canals of G2 by using a microbrush, and a prefitted size 45 0.06-taper Resilon cone (Resilon Research LLC, Madison, CT) was used in the same manner described for G1. To create the immediate coronal seal of Reslion/Epiphany, the teeth were light-cured for 40 seconds with a Coltolux LED curing light (Coltene Whaledent Product, Cuyahoga Falls, OH).

The crowns of all specimens were removed, leaving roots that were 10 mm in length.

Hermetic Cell and Flow Rate Measuring

The teeth were placed into a device designed to measure leakage by fluid filtration, described in earlier studies (14–16). Compressed air was used to generate a constant pressure of 2.5 atm (Fig. 1*A* and *B*). A small air bubble was then introduced into the system with a microsyringe, and the fluid flow through the root fillings was measured by the movement of the bubble within a pipette. Measurements of the air bubble movement were made after 2 hours under pressure.

After the root filling procedures, the filled roots were stored at 37°C and 100% humidity for 7 days to allow setting of the sealer. Forthwith, the teeth were submitted to the first fluid flow measurement (immediate measurement). After that, the teeth were detached from the hermetic cell and then stored in water for 14 months at 37°C. After this artificial aging, the teeth were remounted in the hermetic cell, and fluid filtration was re-measured in a similar manner as described above.

Data Presentation and Statistical Analysis

Data are presented as μL/h (17). Comparisons were made between the leakage data of the different filling materials at 7 days and 14 months by using Kruskal-Wallis tests; two by two analyses were performed with Dunn tests. Comparisons between leakage data for the same group over time were performed with Wilcoxon signed rank tests with Bonferroni correction. The fluid flow was used as a factor, and the level of significance was set at $P < .05$.

Results

The results from the control groups confirmed the consistency of the experimental model. Overall, fluid flow was variable in the experimental groups, as observed with the box plots in Fig. 2*d*. Moreover, histograms for each group were plotted in Fig. 2*a* to show the intrinsic dispersion of the data at the initial measurement and 14 months later. The loss of the long-term sealing ability of the Resilon/Epiphany samples is demonstrated by the increase of fluid flow displayed in Fig. 2*b*, and likewise, the number of specimens that show detectable leakage is illustrated in Fig. 2*c*.

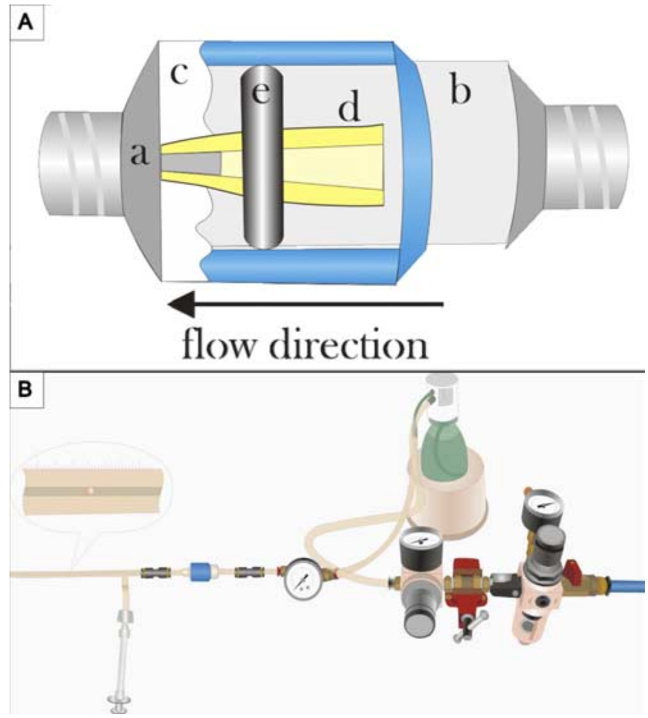

Figure 1. (*A*) Schematic illustrating the modified hermetic cell (assembled double-chamber). Each root (d) was placed inside an o-ring (Ø 2.5 cm) (e) and then embedded in a 2-component paste/paste epoxy resin cylinder (c), formed in a mold consisting of the end part of a 20-mL Luer-type disposable syringe (a). Cervical and apical openings of the embedded root were kept free of the epoxy resin. A second hollow cylinder, cut from a 5-mL Luer-type disposable syringe, was adapted to the first cylinder before setting of the epoxy resin (b). Subsequently, the margins adjoining the 2 disposable syringes were filled with a blue-fluid epoxy resin (Arazyn 1.0; Ara Química, São Paulo, SP, Brazil). This assembly produced a sealed assembled hermetic cell (a double-chamber) made with 2 partial disposable Luer-type syringes. (*B*) General view of the flow rate measuring system setup.

The following observations were made on the basis of the statistical comparisons of the present data:

- No significant differences were found between the fluid flow data of the experimental groups during the immediate measure ($P > .05$).
- The Resilon/Epiphany group displayed significantly more fluid movement than the gutta-percha/AH Plus group after 14 months of water storage ($P < .05$).
- The water-storage stress has no significant effect on the sealing ability of the gutta-percha/AH Plus root fillings ($P > .05$).

Discussion

The current results showed a similar short-term leakage pattern between Resilon/Epiphany and gutta-percha/AH Plus. Consequently, the first null hypothesis was accepted. Preliminary studies of Resilon have shown remarkable promise, such as a decrease in the amount of leakage when compared with conventional nonbonded gutta-percha fillings. On the other hand, several earlier studies had shown similar or inferior results in bonded root-fillings (5, 6, 10, 12). These similar sealing results might be because of the well-documented limitations of root dentin bonding (17–19). The root canal system has an unfavorable geometry for resin bonding (18); therefore, it is not possible to achieve

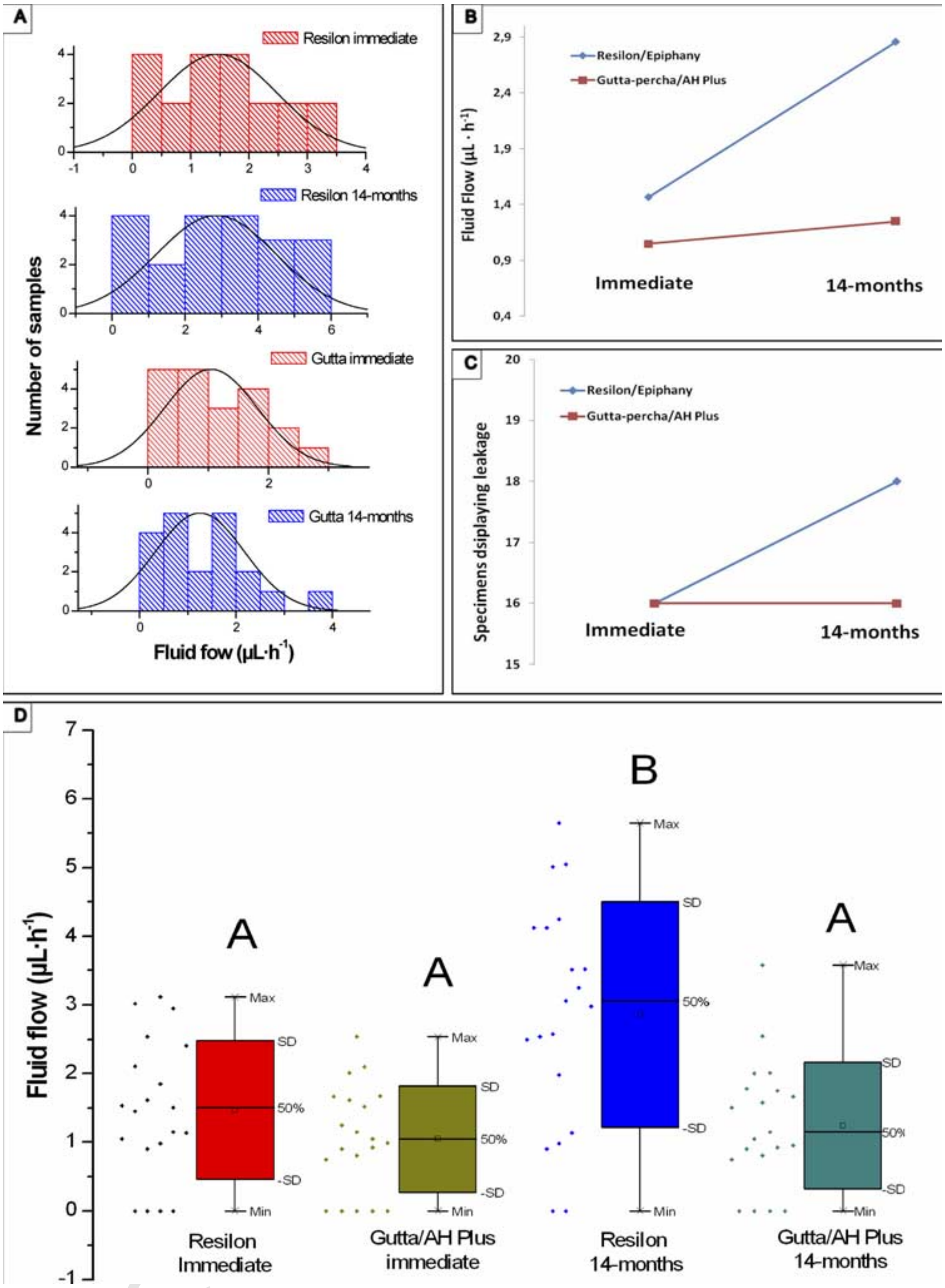

Figure 2. (*A*) Histograms for each group to show the intrinsic dispersion of the data at the initial measurement and 14 months later. (*B*) Fluid flown measures and (*C*) the number of specimens that show detectable leakage. (*D*) Box plots of the fluid flown data at the initial measurement and 14 months later; letters indicate significant differences between groups; $P < .05$.

the desirable gap-free monoblock root-filling. The complete infiltration of resin into the demineralized dentin is another limitation, as a result of the difficulty in achieving the ideal ratio between the degree of the dentin demineralization and the ability of resin infiltration (20) into the root canal system. Furthermore, the chemical link between the methacrylate-based root canal sealer and Resilon is very weak (21).

The results attained by Onay et al (10) are in line with the present work. Those authors demonstrated no significant differences between Resilon/Epiphany and the combination of AH Plus sealer and gutta-percha. Moreover, a recent bacterial leakage study by De-Deus et al (6) demonstrated that the sealing ability of Resilon/Epiphany was equivalent to gutta-percha/sealer when warm vertical condensation was used. However, Shemesh et al (5) concluded that Resilon allowed more glucose penetration than gutta-percha root fillings.

The long-term results of the current study showed a considerable decrease of the sealing ability for the bonded root-fillings. In addition, more specimens displayed detectable leakage after 14 months of water storage for both groups; however, this effect was significant specifically for the Resilon/Epiphany samples. Therefore, the second null hypothesis was rejected. As Schwartz (19) recently stated, ‘‘Another limitation of dentin bonding is deterioration of the resin bond with time.’’ The current long-term results are in agreement with several adhesive dentistry studies that have shown significant decreases in bond strengths, even after relatively short storage periods (19).

Bond deterioration has been well-documented in vitro (22, 23) and in vivo (23–25). As De Munck et al (22) described, the decrease in bonding effectiveness is partially caused by the hydrolysis degradation of the interface components. However, the reasons for the loss of sealing capacity over time cannot be explained by the current evaluation. A study by Biggs et al (12) with a fluid filtration method indicated that Resilon/Epiphany was equivalent but not superior to gutta-percha sealed with AH Plus or Roth's sealers when compared during a period of 90 days. Moreover, it has been reported that AH Plus is more resistant to the solubility process than Epiphany (26), and that AH Plus sealer, in itself, has a superior sealing ability when compared with other sealers (27).

It is worth mentioning that the current results are confirmed by the recently published data of Paqué and Sirtes (13), in which "a somewhat unsuspected dramatic increase in fluid movement occurred with specimens filled with Resilon/Epiphany over time." However, gutta-percha/AH Plus fillings retained their sealing ability after 16 months of storage. The current study was set up similarly to the one by Paqué and Sirtes, aiding in the ability to compare data concerning the fragility of the current dentin bonding technology for root fillings. Although the 2 studies used different storage media, the final conclusions of both are similar. We used the most common artificial aging technique to simulate in vivo aging, water storage (28, 29), whereas Paqué and Sirtes used sterile NaCl solution.

The RMS was developed with the purpose of improving root canal seal and to replace gutta-percha as a material, providing a superior root canal filling. However, under the experimental conditions of the current in vitro evaluation, no advantage was found in using Resilon/Epiphany. The bonded root-fillings displayed similar short-term sealing ability to the conventional unbonded gutta-percha root-fillings. More important is the fact that long-term sealing was compromised in the Resilon/Epiphany samples. As an in vitro study, our results must be interpreted with caution. On the other hand, from the adhesive restorative literature some clear associations were apparent when in vitro and in vivo bonding effectiveness data were correlated. Adhesives that performed less well in several independent laboratory studies also appeared to be less clinically effective. So, in contrast to common belief, clinical effectiveness of adhesives can be in part predicted by in vitro findings (22). Therefore, in a general balance of things, the loss of sealing ability over time might represent a critical fact because the stability of the resin/dentin bond is essential to assure a predictable clinical result.

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AUTHOR QUERIES

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AQ1— Correct spell out of “TEM”?