Comparative Assessment of ActiV GP/Glass Ionomer Sealer, Resilon/Epiphany, and Gutta-Percha/AH Plus Obturation: A Bacterial Leakage Study

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Abstract

The objective of this study was to compare the sealing ability of ActiV GP/glass ionomer (GI) sealer (Brasseler USA, Savannah, GA), Resilon/Epiphany (Pentron Clinical Technologies, Wallingford, CT), and gutta-percha (GP)/AH Plus (Dentsply Maillefer, Tulsa, OK). Seventy-three human single-rooted teeth were randomly divided into three test groups (20 canals each) and two control groups (5 positive and 8 negative). Using *Enterococcus faecalis*, a split-chamber bacterial leakage model was developed to evaluate the sealing ability of the three obturation systems. Samples were monitored every 24 hours for 65 days. Thirteen teeth leaked in both the Resilon/Epiphany and GP/AH Plus groups, whereas 17 teeth leaked in the ActiV GP/GI group at the end of the observation period. There were no statistically significant differences in the resistance to leakage between the three obturation systems ($p > 0.05$). *(J Endod 2008; 34:725–727)*

Key Words

Bacteria, glass ionomer, leakage, obturation, resin

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Microorganisms and their byproducts are primary causes of periradicular periodontitis (1). Proper endodontic treatment significantly reduces the number of microorganisms in the root canal system (2). However, continued ingress of oral fluids can negate the success of root-filled teeth, especially when there is an inadequate coronal seal (3). The incorporation of restorative dentin-bonding principles may enhance the resistance of obturation materials to leakage (4). Used with gutta-percha (GP) core materials, the AH series (Dentsply Maillefer, Tulsa, OK) is the most widely used resin-based sealer system (5), with AH Plus being the latest of the series. Resilon/Epiphany (Pentron Clinical Technologies, Wallingford, CT) is the first obturation system to claim the ability to form a "monoblock" between the canal walls and obturation material (6). Resilon is a polycaprolactone polymer which contains bioactive glass and radiopaque fillers. Epiphany is a dual-cure resin sealer and primer, which bonds to both the dentinal wall and the Resilon cone. Its radiopacity, solubility with solvents, and handling characteristics are similar to those of GP/AH Plus (6)

Pitt Ford (7) introduced a glass-ionomer (GI) sealer in 1979 in a single-cone technique. In 1991, Ketac-Endo (ESPE, Seefeld, Germany) was released as the first commercially available GI sealer (8). Dental applications of GI sealers take advantage of their bond to dentin, fluoride release, antimicrobial activity, and biocompatibility (8). However, some in vitro tests have indicated a propensity for leakage and disintegration (9, 10).

ActiV GP Precision Obturation System (Brasseler USA, Savannah, GA) is a new GI-based obturation system. The manufacturer claims the product to be superior to previous GI-based systems in terms of handling characteristics, working time, and radiopacity (11). Inadequate bonding between GI and GP is a drawback with GI-based sealers (11). To enhance the GP-GI bonding, ActiV GP has a 2-μm coating of GI particles on its surface; these particles are also incorporated into the body of the cone. As with Resilon/Epiphany, the bond to both the dentin and core via the sealer is referred to as a "monoblock."

The advent of greater taper master cones that closely match the size and taper of nickel-titanium (NiTi) rotary files has rejuvenated interest in single-cone obturation techniques (12, 13). ActiV GP cones are designed to match Sequence NiTi rotary files (Brasseler USA); in turn, a single-cone obturation technique is recommended for ActiV GP. Recent investigations have evaluated its sealing ability via a fluid filtration model (14), its resistance to leakage to *Streptococcus mutans* (15), and bond strength using a push-out test (16). Currently, no literature has compared the leakage resistance of a single-cone GI system with that of warm vertical compaction with Resilon/Epiphany. The purpose of this investigation was to compare the sealing ability of a GI-based, a synthetic polymer-based, and a GP/epoxide–amine resin–based obturation system using a split-chamber bacterial leakage model. *Enterococcus faecalis* was selected for use in this study because it is implicated in the etiology of secondary endodontic infections (17).

Materials and Methods

Seventy-three freshly extracted human single-rooted teeth with straight canals and mature apices were randomly divided into three test groups (20 canals each) and two control groups (5 positive and 8 negative). Teeth were decoronated, leaving approximately 16 mm of root. They were subsequently immersed in 6% NaOCl for 6 hours and

stored in distilled water. Working length (WL) was determined by subtracting 1 mm from the length at which a #10 K-file was visible at the foramen.

Each canal was instrumented to a size 50/06 using a crown-down technique with Sequence 0.06 taper NiTi rotary instruments (Brasseler USA). After each file use, each canal was irrigated with 1 mL of 6% NaOCl followed by 1 mL of 17% EDTA (Patterson Dental Supply, Dallas, TX). The final rinse consisted of 1 mL of 17% EDTA followed by 2 mL of sterile distilled water; canals were dried with sterile paper points (Dentsply Tulsa Dental, Johnson City, TN).

As per the manufacturer's recommendations, a single-cone technique was used for the ActiV GP group. The master cone (50/06) was coated with ActiV GP sealer and inserted to WL. After setting, the master cone was seared off with a System B (SybronEndo, Orange, CA) 5 mm beneath the canal orifice. A 2-mm layer of ActiV GP sealer was deposited on top of the master cone using a syringe to create a coronal seal. This left an unfilled 3-mm trough coronal to the sealer. A continuous-wave warm vertical compaction technique was used for both the Resilon/Epiphany and the GP/AH Plus groups according to manufacturer's instructions. A System B (Analytic, Sybron Endo, Orange, CA) was used for the initial down pack to 3 mm from the WL followed by incremental backfill using the Obtura (Obtura II; Sparta, Fenton MO) and vertical compaction with pluggers. A 3-mm coronal trough was created for each tooth.

Positive controls were not obturated. Except for the apical 2 mm and the occlusal table, all teeth in the experimental and positive control groups received three coats of clear nail polish. Negative control teeth were cleaned, shaped, and obturated with GP/AH plus using a continuous-wave warm vertical compaction technique. Three coats of clear nail polish covered 100% of the root surface. Teeth were incubated in 100% humidity at 37°C for 3 weeks before the introduction of *E. faecalis*.

The bacterial leakage model used was adapted from Khayat et al. (18). The tapered ends of 2-mL Eppendorf plastic tubes (Eppendorf-Elkay, Shrewsbury, MA) were resected and the teeth inserted with the apex pointing down (Fig. 1). The junction between the tube and the extruded root was sealed with hot glue. Three coats of clear nail polish were placed over the set glue. The tooth and plastic tube assembly was

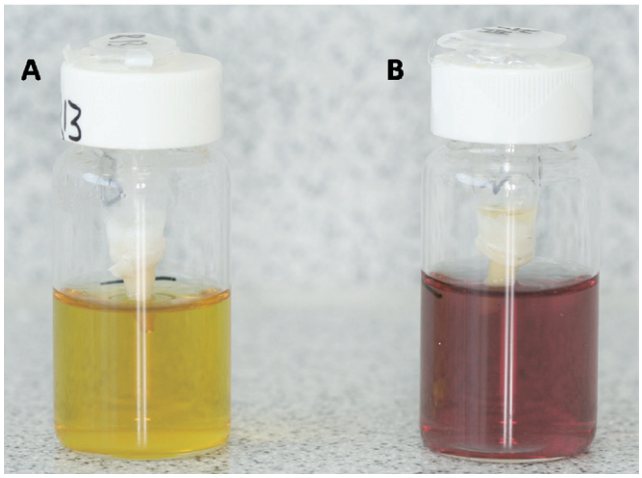

Figure 1. The bacterial leakage model used in the study. The upper chamber consists of a resected Eppendorf tube containing the obturated root and bacterial suspension. A scintillation vial forms the lower chamber, which contains 10 mL of BHI broth with the apical 2 mm of the root tip suspended in the broth. (*A*) A Resilon/Epiphany obturated sample showing bacterial leakage indicated by the yellow color change in the BHI broth. (*B*) A negative control sample showing no bacterial leakage indicated by the purple color of the BHI broth.

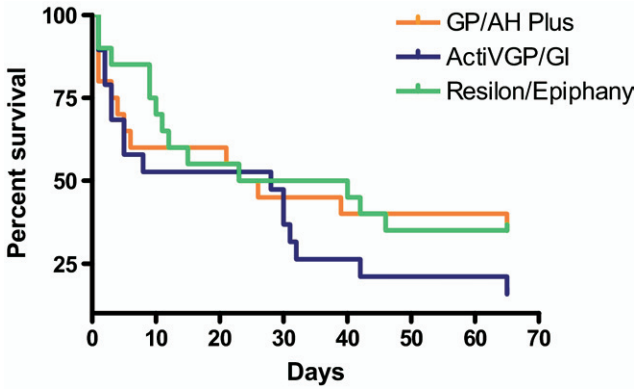

Figure 2. Survival rates (teeth without bacterial leakage) as a percentage of samples obturated in each of three groups: 1, GP/AH Plus; 2, Resilon/Epiphany; and 3, ActiV GP/GI sealer.

snugly fit into a hole in the cap of a scintillation vial (Fischer Scientific, Pittsburgh, PA), and the junction was sealed with hot glue and a coat of nail polish. All tooth-tube-cap assemblies were sterilized with ethylene oxide gas; the 20-mL glass scintillation vials were autoclaved. The root of each tooth was immersed approximately 2 mm into the Difco Purple Broth Base (Beckton Dickinson, Sparks, MD) contained in the scintillation vials. The indicator changes color from purple to yellow when the pH drops below 6.8. The sterile broth and mounted teeth were observed for 5 days to ensure no contamination occurred before inoculation. The inoculation consisted of 0.1 mL of a 20-hour culture of *E. faecalis* OG1X at 10^7 colony -forming units/mL grown in brain heart infusion (BHI). *E. faecalis* OG1X is a derivative of an oral isolate that has cariogenic potential (19). A standard curve of *E. faecalis* cell numbers versus optical density was formed and used to determine the culture dosage necessary for inoculation. The top chambers were reinoculated every 7 days.

Gram staining was performed when the broth changed color, and light microscopy was used to confirm the presence of *E. faecalis*. Survival analysis and log-rank testing compared the survival curve patterns of the three groups ($p < 0.05$). The Fisher exact test was used to compare leakage between all groups ($p < 0.05$).

Results

The survival curves are shown in Figure 2. All positive controls leaked within 24 hours; none of the negative controls leaked. Within the first 24 hours, 2 ActiV GP/GI sealer teeth, 2 Resilon/Epiphany teeth, and 4 GP/AH Plus teeth leaked. At the end of week 1, 8 ActiV GP/GI sealer, 8 GP/AH Plus teeth, and 3 Resilon/Epiphany teeth leaked. After 65 days, 17 ActiV GP/GI sealer teeth, 13 Resilon/Epiphany teeth, and 13 GP/AH Plus teeth leaked. Survival analysis and log-rank test showed no statistically significant differences between the groups with respect to leakage over time ($p = 0.509$). The Fisher exact test also showed no significant difference in the number of teeth that leaked at the end of the observational period between different groups ($p = 0.169$).

Discussion

Numerous in vitro studies have shown that GP obturated teeth leak at high rates. There has been an effort to develop new obturation materials such as Resilon and ActivGP that may provide a better seal of the root canal by providing a "monoblock" (a solid mass of obturation material) that adheres and bonds to the dentinal wall. Within the parameters of this study, it did not appear that a complete seal occurred for any of the systems tested. The inability for the Resilon and ActivGP to

form a "monoblock" may be because of the unfavorable geometry of canals for bonding as well as the potential for gapping along the sealer/dentin interface (20).

There has been conflicting data regarding the sealing ability of ActiV GP. Monticelli et al. (14) found that there was no difference in leakage between teeth obturated with GP/AH Plus and ActiV GP/GI sealer using a fluid filtration system. However, when *S. mutans* was used in a bacterial leakage model, it was found that single-cone obturation with ActiV GP/GI sealer resulted in significantly more leakage compared with GP/AH Plus (15).

Using an *E. faecalis* bacterial leakage model, although not significantly different, both GP/AH Plus and Resilon/Epiphany showed less leakage than ActiV GP/GI sealer (Fig. 2). This may be caused, in part, by the longer setting time and low viscosity of AH Plus and Epiphany sealers (21). Enhanced flow may result in less cracking and separation from the dentinal walls upon setting as well as allow for better flow into accessory canals and other irregularities. In addition, it is possible that the two warm vertical techniques attained a thinner sealer interface in the coronal and middle thirds of the canals (22, 23). The ActiV GP/GI sealer system uses a single-cone technique that relies on the ability to create a standardized tapered preparation in canals with round cross-sectional geometry. Thus, maximizing the space occupied by the obturation material would reduce the potential for gaps that could occur during sealer contraction. Despite the advent of master cones that closely resemble the geometry of NiTi rotary instruments, teeth obturated with a single-cone technique may still have a thicker sealer interface (23, 24). It has been reported that the coating of GI filler on the surface of ActiV GP/GI sealer cones is nonhomogeneous, which may also contribute to less favorable bonding (14). In addition, there has not been an independent confirmation of the lack of shrinkage upon setting of ActiV GP/GI sealer (15).

The lack of statistical significance may be partially because of the leakage model used. A bacterial model system was chosen in this study because it is more clinically relevant. However, it does not allow quantitative measurement of the amount of the bacteria that penetrated through the canal. In addition, the amount of leakage that could potentially lead to clinical failure is not known. Therefore, it is difficult to determine whether the lack of statistical significance observed in this study translates into any clinical significance (25).

Future studies should include obtaining a larger sample size for a better discriminative power involving longer periods of evaluation. In addition, a quantitative analysis of microleakage and investigations into other characteristics of ActiV GP/GI sealer such as its ability to adapt to canal irregularities, solubility, dimensional stability, and antimicrobial properties would improve assessment of the value of ActiV GP/GI sealer as an obturation material.

In summary, there were no statistically significant differences for any of the parameters tested between the three obturation systems tested. Based on these results, the single-cone ActiV GP/GI sealer system has potential as an obturation system to provide a seal comparable to that achieved with other popular obturation systems.

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