A comparative evaluation of 3 root canal filling systems

Ruchika Roongta Nawal, MDS, a Mahantesh Parande, MD, b Ritu Sehgal, c Nageswar R. Rao, MDS, d and Aisha Naik, b New Delhi, India
MAULANA AZAD INSTITUTE OF DENTAL SCIENCES, BELGAUM INSTITUTE OF MEDICAL SCIENCES, AND S.D.M. INSTITUTE OF DENTAL SCIENCES

Objective. This in vitro study was conducted to evaluate and compare the microbial leakage of a new obturation system: Guttaflow with resin-based Resilon cones and Epiphany sealer, keeping gutta-percha with AH plus sealer as the standard.

Study design. The microbial leakage was tested using Enterococcus faecalis ATCC 29,212 as the bacterial marker in the microbial leakage test. These results were supplemented with scanning electron microscopy (SEM).

Results and conclusion. The microbial leakage test indicated good sealing abilities for Resilon and Guttaflow, with the latter resisting microbial leakage for a longer period. AH plus with gutta-percha showed poor sealing ability. Results of the scanning electron microscopy correlated with the microbial leakage test. This study indicates that newer obturation systems like Guttaflow and Resilon cones with Epiphany provide better seal against microbial leakage than the standard obturation material, gutta-percha used with AH plus sealer. (Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111:387-393)

Invasion of microorganisms or the leakage of their by-products into the periapical tissues is believed to be the predominant cause of periapical pathology. 1-5 Healing of periapical disease involves a combination of bacterial eradication during treatment through chemomechanical means, 6,7 along with sealing of both the root canal and access cavity with materials that will prevent bacterial reentry. 8,9

To achieve complete healing, proper disinfection, 3-dimensional obturation, and adequate coronal sealing are essential. However, obturation materials and methods have failed to show a long-lasting perfect seal with the cavity wall. 10,11 Eventually, a microscopic gap is formed at the material and tooth interface, which allows leakage of oral fluids and percolation followed by bacterial penetration and growth. 2,12

To minimize the microbial leakage, many alterations are now being proposed to the “gold standard” technique of filling root canals with gutta-percha and sealer.

Among them, Guttaflow (Coltene Whaledent, DPI, Mumbai, India), a new flowable root canal filling paste, is a nonheated flowable obturation system that combines both the sealer and the gutta-percha in 1 injectable system. The sealer is silicone based with polymethyl hydrogen siloxane as its main component and the powder consists of finely ground gutta-percha (0.9 μm). It is available in capsule, which is triturated for about 30 seconds and then inserted in the canal in combination with a single master gutta-percha cone. This material has shown good homogeneity and adaptation to the root canal walls owing to its better flow properties 13 and is believed to flow into lateral grooves and depressions. 14

Another group of root canal filling materials that has gained popularity are the resin-based filling materials. These materials have exhibited improved resistance to bacterial penetration through their strong bonding to the root canal dentin. 15 Resilon, a thermoplastic synthetic polymer–based root canal filling material, is based on polymers of polyester and also contains bioactive glass, bismuth oxychloride, and barium sulfate. The overall filler content is 65% by weight. Epiphany sealer is a dual curable dental resin composite sealer. The resin matrix is a mixture of BisGMA, ethoxylated BisGMA, UDMA, and hydrophilic difunctional methacrylates. It contains fillers of calcium hydroxide, barium sulfate, barium glass, and silica. The total filler content of the sealer is 70% by weight.

This study was conducted to test the resistance to leakage through a microbial leakage model of conventional root canal filling materials: AH plus with gutta-percha with the newer materials Resilon-
Epiphany and Guttaflow. The microbial leakage was tested using *Enterococcus faecalis* ATCC 29,212 as the bacterial marker in the microbial leakage test, which was supplemented with scanning electron microscopy (SEM).

**MATERIALS AND METHODS**

**Test for bacterial microleakage**

Forty caries-free, human maxillary incisors with straight roots, extracted for periodontal reasons, were used for the purpose of this study. The teeth were immersed in 5% sodium hypochlorite (NaOCl) for 15 minutes to remove organic material from the root surfaces. Any remaining tissue was mechanically removed using a curette, being careful not to damage the root surface. The teeth were then stored in sterile distilled water and kept moist throughout the course of this study.

**Preparation of the specimen.** The test teeth were de-coronated near the cementoenamel junction in such a way that the root length for all specimens was standardized at 15 mm. Access to the root canals was gained from the coronal orifice of the roots using size # 4 and # 6 round burs in a high-speed hand-piece under copious water spray. Patency of the canals was verified by placing a # 15 K-file (0.02 taper) (Dentsply Maillefer, Mumbai, India). Working lengths were designated as 1 mm short of the point at which the # 15 K-file exited the apical foramen.

Coronal flaring of all the canals was accomplished with # 1 to 3 Gates-Glidden drills (Mani, Mumbai, India). All the teeth were then instrumented with # 45 K-files (0.02 taper) apically to obtain a standardized diameter of the apical end of the canals. Approximately 2 mL of 2.5% NaOCl, delivered in a disposable syringe fitted with a 27-gauge needle, was used to flush the canal between each file size.

For rinsing after instrumentation, 5 mL of 17% EDTA was used followed by 5 mL of 2.5% NaOCl rinse to remove the smear layer. The final rinse in all the canals was done with 5 mL of saline to remove any remnants of NaOCl. This ensured noninterference of NaOCl with the bonding of resin-based obturation system to the canal walls. After completing the preparation, # 15 K-file was passed through the apical foramen to ensure the patency in all the canals.

**Sterilization protocol.** After biomechanical preparation, all the teeth were sterilized in an autoclave at 6.8 kg pressure for 20 minutes at 121°C. The teeth were then randomly divided into 5 groups. Obturation of the autoclaved teeth was carried out in a laminar airflow hood (Kartos, India) under aseptic conditions.

**Group 1 (10 teeth): lateral condensation of gutta-percha with AH plus sealer.** These samples were obturated with gutta-percha and AH plus sealer (Dentsply, India) using cold lateral condensation as described by Ingle et al. A 0.02-taper gutta-percha master point of # 45 size was fitted in the root canal at the working length and checked for tug-back criteria. AH plus sealer was applied to the root canal using a # 45 file size with counter-clockwise rotation. The apical part of the master point was coated with sealer and introduced slowly into the root canal until the working length was reached. Lateral condensation was done using standardized finger spreaders and corresponding cones (0.02 taper). Obturation was considered complete when the spreader could no longer penetrate the filling mass beyond the cervical part.

**Group 2 (10 teeth): lateral condensation of teeth using Resilon cones and Epiphany sealer.** These samples were obturated using Resilon cones and Epiphany sealer using cold lateral condensation technique. A 0.02-taper Resilon master point of # 45 size was selected and checked for tug-back criteria. The canal was conditioned with 2 to 3 drops of self-etch primer dispensed with a pipette on orifice and applied evenly on the canal wall with the brush provided by the manufacturer. Any excess primer was removed with paper points. The sealer was then mixed and applied with a file size # 45 in a counter-clockwise direction. The apical part of the master point was coated with sealer and introduced in the canal until the working length was reached. Lateral condensation was done using standardized spreaders and corresponding Resilon cones (0.02 taper). Obturation was considered complete when the spreader could no longer penetrate the filling mass beyond the cervical part. Once the obturation was complete, the coronal surface was light-cured in the chamber for 40 seconds.

**Group 3: Guttaflow obturation system (10 teeth): teeth were obturated using the Guttaflow system as per the manufacturer’s instructions.** Teeth were obturated using the Guttaflow system as per the manufacturer’s instructions. A # 45 size (0.02 taper) master cone was selected and checked for tug-back criteria. Guttaflow provided in single-use special capsules was mixed in the triturator for 30 seconds. The capsule was then loaded on the dispenser with attached canal tip. Guttaflow was layered slowly from the fine canal tip into the apical part. The selected master point was coated with Guttaflow paste in the apical third and placed in the canal. The canal tip was then inserted lateral to the master cone and the remaining canal was back-filled with Guttaflow paste.

**Group 4 (5 teeth): negative control.** Following obturation by lateral condensation with gutta-percha and
AH plus sealer, the entire length of the root was sealed with nail enamel.

**Group 5 (5 teeth): positive control.** The group 5 teeth were those in which no obturation was done.

**Preparation of leakage apparatus.** Bacterial leakage model was prepared according to previous experiments. It comprised 3 main parts, i.e., an upper chamber, the prepared tooth, and the lower chamber. After obturation, the outer surfaces of the teeth were coated with 2 layers of nail enamel except the apical 2 mm.

Foley’s catheter tubes (20 no.) were cut into approximately 8-mm sections. Orthodontic ligature wires were passed through the upper part of each tube and attached to the rubber-stopper of the glass vials. These were then sterilized in an autoclave.

The roots were then passed through the sterile tubes under laminar airflow. An excess 3 mm of each tube was left above the coronal portions of the teeth, which formed the upper chamber of the apparatus. The junction between the tube and the tooth was sealed with sterile cyanoacrylate. The cyanoacrylate was repeatedly tested and confirmed for sterile condition. The rubber stoppers with the attached teeth and tubings were placed in the sterile glass vials, creating 2 separate reservoirs. The glass vials were filled with 2 mL of sterile Brain Heart Infusion (BHI) broth, which formed the lower chamber of the apparatus (Fig. 1).

These sterilized set-ups, along with the obturated teeth, were incubated at 37°C for 48 hours to allow the sealer to set and to ensure sterilization. Turbidity if observed in the lower chambers of any of these samples was considered as contamination. None of the apparatuses showed any contamination.

**Bacterial leakage test**

*E. faecalis* was used as an indicator of microbial leakage in this study. The strains used were obtained as clinical isolates from infected root canal cases, as in previous studies. The isolates were incubated in BHI broth for 4 hours. The upper chambers of the apparatuses were filled with the 4-hour broth culture of *E. faecalis*, whereas the lower chambers contained the sterile BHI broth.

The upper chambers of the apparatuses with the attached teeth were suspended such that the apical 2 mm of the tooth was immersed in the broth. The entire assembly was then incubated at 37°C and observed each day for turbidity in the lower chamber, for 30 days. The strain of *E. faecalis* was replenished every week to ensure the viability of the bacterial marker. Utmost care was taken to avoid spillage and accidental contamination of the lower chambers.

Any turbidity in the sterile BHI broth of the lower chamber was considered as an indication of bacterial leakage from the upper to the lower chamber through obturation (Fig. 2). Turbidity in the lower chamber, if any, was tested for the presence of *E. faecalis* by standard microbiological techniques.

**Table I. Number of days from inoculation to bacterial leakage**

<table>
<thead>
<tr>
<th>Specimen no.</th>
<th>GP + AH</th>
<th>Resilon + Epiphany</th>
<th>GP + Guttaflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+30</td>
<td>17</td>
<td>+30</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>+30</td>
<td>+30</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>+30</td>
<td>+30</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>10</td>
<td>+30</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>+30</td>
<td>+30</td>
</tr>
<tr>
<td>6</td>
<td>+30</td>
<td>+30</td>
<td>15</td>
</tr>
<tr>
<td>7</td>
<td>+30</td>
<td>+30</td>
<td>+30</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>18</td>
<td>+30</td>
</tr>
<tr>
<td>9</td>
<td>17</td>
<td>+30</td>
<td>18</td>
</tr>
<tr>
<td>10</td>
<td>21</td>
<td>+30</td>
<td>21</td>
</tr>
</tbody>
</table>

Samples that did not leak at all during the 30-day observation period are indicated as +30.
The investigators examining leakage during the 30 days were blinded to all the groups. Statistical analysis was performed using Kruskal-Wallis test for nonparametric data to determine any significant differences between groups. Pairs of groups were compared using Mann Whitney U test ($P < 0.05$).

**Scanning electron microscopy preparation**

On completion of the leakage test, 1 sample each from gutta-percha, Resilon, and Guttaflow groups was randomly chosen. Each specimen was longitudinally sectioned to obtain the dentin-filling interface. The entire root surface of both the split sections for each group was carefully studied by for scanning electron microscopy. This was used to detect the presence of any gap between the tooth surface and obturation throughout the length of the obturated root.

**RESULTS**

No growth was observed while checking for sterilization of the whole apparatus. The results obtained during the bacterial microleakage test for a period of 30 days are summarized in Table I. The positive control specimens leaked within 24 hours and none of the negative control specimens leaked during the 30 days. Group 1 showed leakage in 7 (70%) of 10, whereas both groups 2 and 3 showed leakage in 3 (30%) of 10 samples. According to the number of days at which the first leakage occurred, the AH plus group showed first leakage on the 7th day of observation, whereas the Resilon group leaked on the 10th day. The Guttaflow group showed first leakage on the 15th day.

The median, mean, and maximum days of leakage and the mean rank for each leakage group are shown in Table II. Statistical analysis using the Kruskal-Wallis test revealed significant differences between groups 2 and 3 in relation to group 1. The difference between groups 2 and 3 was insignificant. The Mann-Whitney U test was used to compare the results, and both the Resilon and Guttaflow groups were found to be superior to the gutta-percha group with respect to the number and rate at which the samples leaked (Table III).

There was no statistical difference between Resilon and Guttaflow groups; however, the former showed leakage earlier than latter group.

The dentin-filling interface of the longitudinal sections showed a uniform 12-μm gap in the gutta-percha specimens (Fig. 3, A). This gap was observed between the resin sealer that penetrated the dentin and the gutta-percha filling.

There was no gap at low- and high-power scanning electron microscopy for Resilon and Guttaflow groups (Fig. 3, B, C). The high-power scanning electron microscopy clearly showed excellent adaptation of the Guttaflow material to the canal walls (Fig. 3, C). This test further supplements the results of our microbial leakage test.

**DISCUSSION**

This study was conducted to test the resistance to microbial leakage of root canal filling materials: AH plus with gutta-percha, Resilon-Epiphany, and Guttaflow. The microbial leakage of the 3 root canal filling systems was evaluated by bacterial leakage method using *Enterococcus faecalis* ATCC 29,212 as the bacterial marker. Using bacteria itself as a marker is a clinically relevant demonstration of microbial leakage associated with root canal system. The gram-positive facultative bacteria *E. faecalis* used in this study is a common isolate from infected root canals. It is most often isolated in retreatment cases of apical periodontitis. Its prevalence ranges from 24% to 77%. This finding can be explained by its various virulence factors, including its ability to compete with other microorganisms, invade dentinal tubules, and resist nutritional deprivation. Thus, these bacteria seem relevant to clinical practice. For the purpose of the study, a clinical isolate of *E. faecalis* was used.

To avoid anatomical variations and to standardize the leakage measurements in this study, the length and type of specimens was kept constant. For testing the microbial leakage in the experimental setup, the canals were cleaned with 17% EDTA and NaOCl to remove the
smear layer. Smear layer may act as a barrier between obturating materials and the canal wall, which may make it difficult to create a seal and prevent coronal-to-apical leakage. Hence, its removal facilitates adherence of the sealer to the canal walls and its penetration in dentinal tubules, ensuring good bond strength.

On completion of an evaluation period of 30 days, our results showed that 70% of samples leaked in the gutta-percha group (lateral condensation with AH plus sealer). This high percentage is comparable with that of the previous studies’ results. On the other hand, the Resilon groups with resin sealer and the silicone-based Guttaflow group showed leakage in 30% of cases, i.e., less than half of that in the gutta-percha group. When evaluated on the basis of the number of days at which the leakage occurred, the gutta-percha group was the first to show leakage, on the 7th day of obturation; the Resilon group showed the first sample leakage on the 10th day of obturation; whereas in the Guttaflow group the first sample leaked on the 15th day. Almost 70% of samples in both the Resilon and Guttaflow groups remained leakage free until the end of the 30-day observation period. Although the Resilon and Guttaflow groups showed similar results regarding the number of samples leaked, the samples of the Resilon group leaked earlier than the Guttaflow group.

The positive controls (no obturation) leaked on the first day, whereas the negative controls did not leak at all until the end of the observation period. The results of the microbial leakage test, further confirmed by scanning electron microscopic analysis of the 3 groups, revealed that the gutta-percha group showed a clear gap at the dentin-filling interface, whereas both the Resilon and Guttaflow groups showed excellent adaptation to the canal wall.

The better sealing ability exhibited by the Guttaflow root-canal filling material could be attributed to its ability to flow into the canal. The material has been shown to flow into lateral canals or any grooves in the canal wall and hence could fill the space between the master cone and canal wall. In a study by Leski et al., it also showed good penetration into the dentinal tubules, which will also help in preventing leakage. Both gutta-percha with AH plus sealer and Resilon cones with Epiphany sealer, show a setting shrinkage following obturation. On the other hand, manufacturers claim that the Guttaflow obturation system exhibits a setting expansion of 0.2% following obturation in the canal. This property has been demonstrated by Hammad et al. These physical properties could contribute toward it, providing a good seal at the dentin interface and hence prevent leakage.

Previous studies by Elayouti et al. and De Dues et al. demonstrated good adaptability to root canal walls with Guttaflow in accordance with this study. Brackett et al. found no significant difference in sealing ability between Guttaflow and vertically compacted, thermoplasticized gutta-percha and AH plus sealer when using a fluid filtration study. Kontakiotis et al. also found no difference at a short-term evaluation period. However, Guttaflow showed significantly better coronal seal at a long 12-month follow-up. Monticelli et al. however, showed that teeth obturated with Guttaflow showed an equally good apical seal as compared with other groups, but its seal at a more coronal level was inferior as compared with teeth obturated with gutta-percha and AH plus by using a warm vertical technique. The difference in results of some studies could also be attributed to differences in methodologies used for testing coronal leakage.

The mechanism of the sealing ability of Resilon cones with Epiphany sealer can be attributed to the mono-block created by the Resilon filling closely adapting to the Epiphany sealer, and in turn the Epiphany sealer adapting to the dentinal walls. This is facilitated by removal of the smear layer and application of the Epiphany primer. Epiphany primer is a self-etch primer that contains sulfonic acid terminated functional monomer, Hema, water, and polymerization initiator. The preparation of the dentin through these chemical agents prevents shrinkage of the resin filling away from the dentinal wall and aids in sealing the roots filled with Resilon. Epiphany sealer has also shown very good ability to flow into the canal, which may also help in providing a good seal. The coronal leakage results for Resilon and Epiphany in this study are consistent with previous studies by Shipper et al. and Bodrumlu. Their studies showed that the gutta-percha group allowed bacterial penetration in a high proportion of cases, whereas the Resilon group resisted bacterial penetration. Stratton et al., using fluid filtration test, also showed similar results. However, in a study by Tay et al. there was no difference in apical leakage by silver-tracer technique between gutta-percha with AH plus sealer and the Resilon group. Paque and Sirtes showed that Resilon, when used with a composite sealer (Epiphany), seals the apical root canal, as well as gutta-percha and AH plus in the short-term observation period. After 16 months, however, the Resilon/Epiphany groups leaked significantly more than the gutta-percha/AH plus groups. This is an interesting observation and further studies with extended observation times are required for testing of these newer materials.

Further comparison between the 2 newer materials: Epiphany and Guttaflow against each other, was also done. Previous studies comparing these 2 materials
have given contradictory results. A microbial leakage study by Roggendorf et al. showed that Guttaflow had significantly better sealing properties as compared with Epiphany. This study, however, demonstrated the AH plus group to show minimum leakage, which was significantly superior to both Epiphany and Guttaflow groups. This is in contradiction with our study and many other studies previously mentioned that have clearly shown both Guttaflow and Epiphany to perform better than standard gutta-percha with AH plus sealer. Another dye penetration study by Taranu et al. also showed Guttaflow to be significantly superior to the Epiphany group in terms of leakage. Bouillaquet et al. compared AH plus, Epiphany, and Guttaflow sealer. They tested the leakage for an initial 24 hours and then long-term follow-up at 1 year by fluid filtration method. Their results indicated that AH plus showed more leakage in the initial 24 hours; however, no significant difference was found in leakage at 1-year follow-up among the 3 groups. In our study, the bacterial leakage model using *E. faecalis* as a marker was used to evaluate coronal leakage of both the newer materials. This method is considered to have more biological and clinical relevance than the dye leakage studies. The leakage was monitored continuously for 30 days, ensuring that any significant difference beyond the 24-hour time frame is captured for analysis of the superior sealer.

The results of this study showed that both Epiphany and Guttaflow groups have good sealing ability, wherein Guttaflow showed superior sealing ability, as it resisted leakage for a longer period. This difference in the sealing ability of Epiphany can be attributed to the polymerization contraction of methacrylate-based resin sealer. Root canals have high cavity configuration factors that contribute to polymerization stresses created by resin-based sealers. Guttaflow paste, on the other hand, has exhibited expansion on setting, which could lead to better coronal sealing ability. However, it is important to note that Guttaflow, being a root canal paste, has a high risk of overfilling, as shown by some previous studies. Further studies are required to test the quality of seal of Guttaflow throughout the length of the canal especially at coronal levels. Similarly, Epiphany also warrants further support studies for long-term evaluation of its coronal seal. Any future studies to explore these properties of the 2 materials will be useful.

CONCLUSIONS

This study has attempted to evaluate clinically significant properties of obturation materials: AH plus with gutta-percha, Resilon cones with Epiphany sealer, and Guttaflow. The microbial leakage test indicated good sealing abilities for Guttaflow and Resilon groups, with Guttaflow resisting bacterial leakage for a longer period.

In the future, if its setting shrinkage could be compensated for, the Resilon group may show improvement in sealing ability.

REFERENCES


Reprint requests:
Ruchika Roongta Nawal, MDS
Senior Lecturer
Department of Conservative Dentistry and Endodontics
Maulana Azad Institute of Dental Sciences
New Delhi 110002, India
r_roongta@yahoo.com