Methacrylate Based Resin Endodontic Sealers: A Paradigm Shift in Endodontics?

A Peer-Reviewed Publication
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Educational Objectives
Upon completion of this course, the clinician will be able to do the following:
1. Be knowledgeable concerning the introduction of methacrylate based resin sealers
2. Be knowledgeable about leakage studies conducted on methacrylate based resin sealers and the factors that influence the outcomes of these tests
3. Understand the advantages that methacrylate based resin sealers may offer over other endodontic obturation materials
4. Be knowledgeable about the clinical technique used to place methacrylate based resin sealers

Abstract
Bonding materials and techniques have completely changed the way dentistry is practiced. Since their introduction, techniques have evolved such that it is now possible to bond materials to dentin, and hydrophobic resins have been replaced by hydrophilic resins. In recent years several methacrylate resin-based root canal sealers (MBRSs) have been introduced as an alternative to conventional gutta-percha and zinc oxide-eugenol-based techniques. Efforts to introduce a simplified obturation technique based on dentin bonding principles coupled with favorable physical properties have contributed to an increase in interest in using this approach. It is the intent of the authors to critically review the published literature and to arrive at an opinion as to the current status and future of methacrylate based resin sealers. This will be followed by presentations of cases in which methacrylate based resin sealers were used.

Introduction
The acid etch bonding technique was introduced to dentistry in the mid-1950s by Buonocore and was based on resin technology developed by Hagger. Bonding materials and techniques have completely changed the way dentistry is practiced. Hydrophobic resins were replaced by hydrophilic materials, and about 30 years of research resulted in a change from using 85% phosphoric acid liquid for 60 seconds to etch enamel to using 35% phosphoric acid gels for 15 seconds for both dentin and enamel. Later, resin-based sealers and different obturation materials were introduced into endodontics.

Before a newly developed material should be used clinically, a series of tests needs to be performed to determine its biocompatibility. The currently used methacrylate based resin sealers that will be discussed have been tested rigorously, with the exception of clinical prospective studies. They did, however, undergo user evaluation tests. There is a legitimate concern on the part of manufacturers that if a prospective study were to be done — and in endodontics ideally with at least a 5-year postoperative follow-up — the time elapsed from initiation of the project until the final results are obtained would be excessive and counterproductive. Frequently, improvements in materials and changes in techniques are introduced after materials are on the market and are based on clinical feedback from practitioners and data from researchers. The ultimate success can only be determined when a material or technique is used successfully in clinical practice. Based on their long track record, gutta-percha and zinc oxide-eugenol and other conventional sealers should serve as the “gold standard” for a meaningful comparison.

Methacrylate based resin sealers
Methacrylate based resin sealers are based on polymer chemistry technology, initially developed for adhesive restorative dentistry. Attention will be focused on two systems:
1. EndoREZ (Ultradent Products Inc. South Jordan, UT)
2. Epiphany (Pentron Clinical, Wallingford, CT)/ Resilon

EndoREZ is a hydrophilic, two-component, chemical or dual-curing sealer and contains zinc oxide, barium sulfate, resins, and pigments in a matrix of urethane dimethacrylate. The sealer can be used with gutta-percha or with resin-coated gutta-percha, the latter with the objective of forming a monoblock (Figure 1).

Early publications, including those of Becce and Pameijer, reported on the biocompatibility and adhesive-ness of EndoREZ, the latter based on its hydrophilic properties. Subsequently, publications appeared testing the different MBRSs using a variety of techniques, which to a large extent have caused more controversy than that they solved concerns regarding safety and efficacy, and whether they are long-lasting and will ultimately replace gutta-percha and conventional sealers.

Products such as RealSeal (Sybron Dental Specialties, Orange, CA), SimpliFill (LightSpeed Technology Inc., San Antonio, TX) and Resinate (Obtura Spartan, Fenton, MO) are all categorized under Epiphany/Resilon.

Resilon is composed of polymer-based resin (polycaprolactone), bioactive glass, bismuth oxide, barium sulfate, and coloring agents. Epiphany contains a dual cure sealer, UDMA, PEGDMA, EBPADMA and BISGMA, barium-borosilicate, BaSO₄, bi oxychloride, calcium...
hydroxide, photo initiators, and a thinning resin. In addition, the system comes with a self-etching primer. The premise behind the material is the formation of a “monoblock” (the primer forms a hybrid layer that bonds to the sealer, which in turn bonds to the Resilon core).

Methacrylate based resins sealers enable obturation in a slightly moist root canal because they are hydrophilic. This hydrophilicity, combined with advanced bonding techniques and a user-friendly methodology (EndoREZ), encourages the formation of deep resin tags extending into the dentinal tubules from the root canals. Deep resin tags help enhance bonding and the clinical success of obturation.

Figure 2. Epiphany/Resilon

Leakage studies
It is well established that selection of an appropriate sealer will influence the outcome of endodontic therapy. For that reason many investigators have focused on this important aspect, using techniques such as fluid filtration, dye penetration, and bacterial leakage to test coronal and apical leakage of MBRS. Frequently, AH Plus or AH 26 are used as control materials.

In one of the first published leakage tests using India ink, Zmener and Banegas in 2004 reported no statistically significant difference between EndoREZ and AH Plus. Orucoglu et al., using the fluid filtration method, reported that Diaket with cold lateral condensation leaked less apically than EndoREZ and AH Plus did. Neto et al. reported that AH Plus leaked less than EndoREZ and AH 26 when using a single cone technique. Adanir et al. found that resin-based sealers were more effective than zinc oxide-eugenol in sealing root canals, again using the fluid filtration method. Using similar techniques, Onay et al. found that the apical seal of Epiphany and Resilon was not different from those of AH Plus and gutta-percha, AH Plus and Resilon, or Epiphany and gutta-percha. In contrast, Tunga and Bodrumlu concluded by means of a fluid-transport method that Epiphany and Resilon leaked significantly less (p<0.05) than gutta-percha and AH 26 did. Stratton et al. reached a similar conclusion comparing Resilon with gutta-percha and AH Plus. Shipper et al. and Maltezos et al. drew similar conclusions using a bacterial leakage test and found that Epiphany and Resilon were superior to gutta-percha and various other sealers. On the other hand, Pitout et al. using bacterial leakage tests as well as a dye penetration method, and Biggs et al. did not observe a difference between Resilon and gutta-percha. In summary, there has been no general agreement as to whether or not there is reduced leakage when using MBRSs.

Several authors have used dye penetration to determine whether MBRSs are superior to conventional materials. Gernhard et al. and Sevimay and Kalayci established more dye leakage for EndoREZ than for AH Plus and gutta-percha. Resilon as the main obturation material consistently resulted in less microleakage than gutta-percha at all 3 time intervals — 10 days and 1 and 3 months. An explanation for this difference between the two materials will follow later.

Toxicology studies
Dental materials must be biocompatible. Cytotoxicity studies have been conducted by numerous investigators. As in the leakage studies, the results of in vitro studies vary among investigators. Huang et al. showed that the elution compounds from MBRS, zinc oxide-eugenol, and calcium hydroxide-based sealers were cytotoxic to primary human PDL cultures and V79 cells, with calcium hydroxide being the least toxic. Also, according to Huang and co-workers, the highest level of DNA damage was induced by MBRSs, in this case Topseal, AH 26, and AH Plus. Koulouzidou et al. demonstrated similar results — AH 26 had a severe cytotoxic effect, while Topseal and AH Plus had a markedly lower effect. This was further supported by Bouillaguet et al. who reported that “most materials pose significant cytotoxic risks and that cytotoxicity generally increased with time.”

At 72 hours, GuttaFlow became significantly less toxic than AH Plus, Epiphany sealer, and Resilon. Key et al. determined Epiphany to be less toxic than Grossman’s sealer, while Epiphany was more cytotoxic than Sealapex after 1 hour, but less after 24 hours. Epiphany was more cytotoxic than conventional materials were. Eldeniz et al. reported similar findings. Based on the findings of these authors, it appears that not one sealer is universally accepted as being non-toxic. Controversy regarding the reaction of materials exposed to certain test conditions is not new. With the introduction of glass ionomer cements, tissue culture tests reported toxicity when they were placed in direct contact with the medium. However, after elution of irritating chemicals, the reaction subsided over time.

The early toxicology studies of EndoREZ by Louw, Becce, and Pameijer reported that EndoREZ was mildly irritating, yet within acceptable standards. This has been
supported by more recent studies by Pameijer, Zmener, and Banegas.

Based on testing, EndoREZ was determined to be biocompatible and was introduced to the dental profession.

The role of moisture

The data from several of the leakage studies are most likely the result of the ingrained belief that after a final rinse root canals need to be dried thoroughly. Statements in materials and methods sections of papers such as “the canals were dried” get the stage for a hydrophobic environment while a hydrophilic material is being used.

For methacrylate based resin sealers, whether EndoREZ or to a lesser extent Epiphany, to establish a proper seal the dentin needs to be moist to allow for the penetration of resin tags in the opened dentinal tubules, thus taking advantage of the hydrophilicity of the bonding agent or sealer. In the case of EndoREZ, this allows for deep penetration of resin tags, up to 500 µm or more, and for Epiphany allows bonding of the adhesive by means of a hybrid layer to the dentin.

Zmener et al. studied four scenarios of dentin wetness/dryness for apical and coronal dye leakage using methylene blue. In Group 1, 95% ethanol was used followed by paper points to dry the canals. In Group 2, the canals were blot dried with several paper points. In Group 3, a luer vacuum adaptor with low vacuum for 5 seconds followed by one paper point for only 1–2 seconds was used. In Group 4, the root canal remained flooded, and no effort was made to remove excess distilled water. It was theorized that perhaps the hydrophilic properties of EndoREZ with the scenario in Group 4 would displace excess water. EndoREZ and Epiphany/Resilon in Groups 2 and 3 exhibited significantly less coronal and apical leakage (p<0.05) than was seen in Groups 1 and 4. The method with a low vacuum luer adaptor and 1–2 s paper point drying (Group 3) scored the lowest leakage. There was no statistically significant difference between EndoREZ and Epiphany/Resilon.

One of the reasons that Epiphany/Resilon has perhaps scored better results in leakage studies is based on the Epiphany/Resilon system’s use of a dentin bonding agent, which makes the moisture condition of root dentin less critical. This statement can be underscored by the study of Gillespie et al. They reported less leakage for EndoREZ when a dual-cured two-step self-etch adhesive was used, and statistically significant differences in filling techniques. EndoREZ alone exhibited significantly higher overall leakage, while no difference was found between AH Plus and the EndoREZ modified technique using a dentin bonding agent. Leakage studies that state in their materials and methods sections that “the canals were dried with paper points” have generated data with questionable validity, as the methodology is flawed. Field Emission Scanning Electron Microscopy (FESEM) and scanning electron microscopy (SEM) demonstrate the potential of EndoREZ when proper moist conditions are adhered to and the recommended insertion technique is followed, as well as what happens when the canal is dried according to well-established endodontic techniques using paper points.

Work by Lambrechts et al. in 2006 using FESEM showed convincingly the excellent hydrophilic penetration potential of EndoREZ when applied to moist dentin. They placed teeth in HCl for 30 hours followed by 2% NaOCl for 10 minutes and a distilled water rinse to dissolve the dentin. Resin tag bundles protruding from the root canal filling surface and extending from 400 to 600 µm or more were seen using FESEM (Figure 3). Due to their length and weight these bundles bent parallel to the root filling surface. In view of the ability to penetrate the dentinal tubules to the extent shown in this study, a bonding agent in conjunction with EndoREZ does not seem to offer any benefits. It may actually be detrimental, as the sealer can only bond to the resin of the bonding agent without resin tag bundle formations.

In contrast, inserting EndoREZ with a gutta-percha point into a dried root canal produces poor adaptation of the sealer to dentin with a lack of resin tag formation. The resin will simply not be able to penetrate the dentinal tubules, setting the stage for excessive leakage, which is solely operator induced. This explains the considerable leakage reported in leakage studies in which the dentin was dried before insertion of the sealer.

Oxygen inhibited layer

During biocompatibility studies, specimen preparation of methacrylate based resin sealers can result in the formation of an “oxygen inhibited layer.” Resin, whether chemical, light, or dual cured, does not polymerize when in contact with air. That is not to say that polymerized
sealers cannot cause irritation. Conversion of monomer in a typical polymerization reaction is at best less than 50–70%. Oxygen left behind from NaOCL inhibits polymerization. Therefore, it is of importance to thoroughly flush the root canal with EDTA after the use of NaOCL, followed by sterile saline or 2% chlorhexidine (Consepsis, Ultradent Products Inc.).

Clinical evidence
One long-term study on EndoREZ has been reported (Zmener and Pameijer35,36) and one intermediate clinical study on Epiphany/Resilon (Debelian37). In a retrospective study on 180 patients,35 a total of 295 root canals were treated with laterally condensed gutta-percha cones in conjunction with EndoREZ. Root canal therapy was carried out in one visit using standardized techniques. The results were assessed clinically and radiographically 14 to 24 months postoperatively and compared to baseline radiographs. Parameters for success were based on absence of clinical symptoms, a normal or slightly widened periodontal ligament, and reduction of periapical radiolucencies with an absence of pain in patients who had pre-existing lesions associated with pain. After 2 years, the overall success rate was 91.03%. In a subsequent 5-year follow-up,36 129 of the patients responded to a recall request. Root canals had been adequately filled to the working length in 92 teeth (76.66%) and short in 13 (10.83%). Fifteen cases (12.50%), filled flush at the initiation of the experiment, showed slight resorption of the filling material at the apex within the lumen of the root canal. Of the 10 roots with extrusion, none had radiographic evidence of sealer in the periradicular tissues after 5 years. All patients were free of clinical symptoms. A life table analysis revealed a cumulative probability of success of 86.3% at the 5-year recall with a 95% confidence interval of 79.7%–91.0%. This percentage compares well with what has been reported in the literature for other sealers.38,39

In a 2-year prospective study on Resilon/Epiphany reported by Debelian,37 a total of 67 vital teeth were treated in one visit and 53 necrotic pulps in 2 visits (n=120). After 2 years, 108 cases were evaluated. Using the mean of the Periapical Index Scores (PAI) of three evaluators, the results can be interpreted as follows. When the PAI 1 and 2 were combined (1=healed; 2=healing), success after 24 months was 91.6%. It is of interest to note that the results reported by Zmener and Pameijer35 after 24 months using EndoREZ were almost the same, 91.3%. It appears that after 2 years the materials performed similarly in spite of different clinical protocols and different operators. If we exclude all experiments that have a flawed specimen preparation technique, in particular the drying of dentin, then MBRSs appear to perform like conventional root canal sealers.

Do methacrylate based resin sealers reinforce roots?
A comparison of intraradicular dentin bond strength between Epiphany/Resilon and gutta-percha/Kerr Pulp Canal Sealer EWT, using a push-out test, demonstrated that the mean bond strength of the Epiphany/Resilon group was significantly higher (p<0.05) (Skidmore et al.40). Teixeira et al.41 also reported higher fracture loads for MBRS than gutta-percha; however, no statistical significance was established. The lack of reinforcement was further refuted by Ungor et al.42 by testing dentin root cylinders with AH Plus + gutta-percha, AH Plus + Resilon, Epiphany + Resilon, Epiphany + gutta-percha, and gutta-percha alone. They concluded that the Epiphany–Resilon combination was not superior to that of the AH Plus/gutta-percha. Using a similar dentin cylinder protocol to optimize standardization, Grande et al.43 arrived at a similar conclusion. The flexural properties of Resilon and gutta-percha are too low to reinforce roots. Although supportive of the results of Grande et al.,43 the data of Gesi et al.44 cannot be accepted as valid since these researchers dripped the debrided root canals with multiple paper points. Also, for Epiphany/Resilon the manufacturer’s instructions for use clearly recommend the dentin be moist. Additional criticism has been leveled at the choice of the push-through test, variation in specimen thickness, analysis of the data, etc. (Leinfelder45).

Retreatment of methacrylate based resin sealers
The ability to retreat endodontically treated teeth is one of the requirements of a root canal sealer. According to de Oliveira et al.46 and Ezzie and co-workers,47 compared to gutta-percha and AH Plus, Epiphany/Resilon could be removed faster and demonstrated less residual filling material when K3 files48 or ProFile 0.06 combined with heat and chloroform47 were used.

Methacrylate based resin sealers: Clinical technique
Several methacrylate based resin sealers available to the dental profession. The product used for the technique in the cases that are presented is EndoREZ, which is one of these. EndoREZ is a suitable endodontic sealer for most obturation techniques.

After canal instrumentation and disinfection, all anti-microbial rinses and agents should be thoroughly removed and rinsed from the canal. Do not desiccate the canal with multiple paper points. The hydrophilic nature of EndoREZ allows the clinician to use just 1–2 paper points, which leaves a small amount of moisture inside the canal. This small amount of moisture is actually beneficial when using EndoREZ since the material actively seeks the moisture deep into dentinal tubules and lateral
canals (Figure 3). It is important to note that if lubricants and/or rinses containing hydrogen peroxide are used (such as Glyde, RC Prep, ProLube, etc.), that the polymerization of EndoREZ and other methacrylate based resin sealers will be inhibited and the material may never set in the canal. When using methacrylate based resin sealers, take care to use lubricants that contain no hydrogen peroxide. Once the canal has been dried slightly using 1–2 paper points, trial fit a resin-coated gutta-percha cone (or standard gutta-percha cone). Verify the fit radiographically and re-fit if necessary. Once fit has been verified, remove the cone from the canal.

Remove the cap and collar from the EndoREZ syringe and replace with a mixing tip. (When using a new syringe bleed a small amount from the barrels to ensure even extrusion of the materials.) Then place the collar back onto the syringe. Once the mixing tip and collar assembly are in place, verify flow of the two components (a base and catalyst) by injecting a small portion onto a mixing pad. Once flow has been verified, remove the plunger from a Skini syringe, and back-fill through the mixing tip directly into a Skini syringe (Figure 4).

Inject a small amount of the resin into the Skini syringe and replace the plunger, taking care to slowly insert the plunger to avoid trapping any air bubbles in the Skini syringe. Attach an appropriate length NaviTip (30-gauge tip) to the Skini syringe. Verify flow from the NaviTip (Figure 5).

Once flow has been verified, place the NaviTip into the canal to be obturated. The tip of the NaviTip should not approach any closer than 2–3 mm from the apical terminus of the canal. Once the NaviTip is in place in the canal, slowly inject EndoREZ into the canal, taking care to keep the tip of the NaviTip buried in the material as the canal fills. As EndoREZ is hydrophilic in nature, the material will flow into lateral canals and accessory canals, along with penetrating deep into dentinal tubules (Figure 6).

Once the canal is filled to the coronal orifice, remove the NaviTip from the canal, and place the resin-coated gutta-percha cone into the canal (Figure 7). Passively place additional cones into the canal as necessary to fill the space (Figure 8).

Recently, EndoREZ accelerator has become available that facilitates rapid cure of EndoREZ in the canal in 4–5 minutes, as compared to 20 to 30 minutes. Delivery is accomplished by dipping either accessory gutta-percha or resin coated gutta-percha cones into the accelerator, followed by harpooning these cones in to the as yet unpolymerized EndoREZ, thus accelerating polymerization. Furthermore, a reduced volume of EndoREZ is subjected to less polymerization shrinkage, which will benefit the seal. This technique allows the clinician to move to definitive, restorative steps almost immediately.

EndoREZ can be used with most obturation techniques, including lateral compaction, vertical compaction, warm vertical, and thermal techniques. Rather than filling the canal with EndoREZ, however, a thin coat of sealer should be applied to the walls of the canal first, relying on the physical force, pressure or heat of traditional obturation methods to accomplish the goals of traditional obturation.

According to the manufacturer’s instructions, a “passive” approach to obturating the canal results in a fill that spans and binds the intricate architecture of dentinal tubules and lateral canals to the resin-coated gutta-percha.
Figure 7. Placing the resin-coated gutta-percha cone into the canal

Figure 8. Placement of accessory gutta-percha cones

Case 1. Pre-operative view

Case 1. Immediate post-operative view

Case 2. Pre-operative view

Case 2. Immediate post-operative view

Case 3. Pre-operative view

Case 3. Immediate post-operative view

Case 1 images courtesy of Dr. D. Kendel Garretson.
After the gutta-percha cones have been placed, use a heat element to sear off any loose ends.

Successful obturation is obtained using the above technique, as demonstrated by the cases.

**Discussion and future expectations**

The clinical success rates that have been reported for both EndoREZ and Epiphany/Resilon are in agreement with success rates in previous studies using conventional sealers and gutta-percha (Ørstavik et al.98, Ausburger and Peters98; Friedman et al.98).

In addition, EndoREZ and Epiphany are well tolerated and can be considered biocompatible. Extensive use by the dental profession has proven this to be true.

Technique modifications and new techniques will continue to be developed, and new sealers, currently under development, will appear on the market within a few years. It can be anticipated that methacrylate based resin sealers will continue to improve their appeal to the dental profession.

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Author Profiles

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Dr. Pameijer earned his dental degrees from the University of Utrecht in The Netherlands and Boston University, Boston, MA. In addition, he holds a PhD from the University of Lund in Sweden, as well as an MScD, DSc, and Certificate of Advanced Graduate studies in Prosthodontics, from Boston University. Dr. Pameijer is currently Professor Emeritus at the University of Connecticut, Farmington, CT. Dr. Pameijer has published over 200 publications in mostly peer reviewed journals and is on the editorial board of many scientific journals. He has lectured extensively nationally and internationally in Europe, Asia, North and South America and Africa. Dr. Pameijer is currently a consultant for several American and European companies and spends his time doing research, writing publications, lecturing and one day private practice.

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The acid-etch bonding technique was based on resin technology developed by ______.

- Hagger
- Black
- Simonsen
- none of the above

Hydrophobic resins have been replaced by hydrophilic materials.

- True
- False

When acid-etch bonding techniques were first used in dentistry, they used for _____ to etch _____.

- 35% phosphoric acid; 60 seconds; enamel and dentin
- 35% phosphoric acid; 60 seconds; enamel
- 85% phosphoric acid; 60 seconds; enamel
- none of the above

Frequently, improvements in materials and changes in techniques are introduced after materials are on the market and are based on clinical feedback from practitioners and data from researchers.

- True
- False

The primer used with Epiphany _____.

- is self-etching
- forms a hybrid layer that bonds to the sealer
- is a pure white color upon visual examination
- a and b

EndoREZ _____.

- is hydrophilic
- contains zinc oxide
- can be used with gutta-percha or resin-coated gutta-percha
- all of the above

Resilon's composition includes _____.

- barium sulfate
- polymer-based resin
- calcium hydroxide
- all of the above

Many investigators have focused on the selection of a sealer because _____.

- this is an easy thing to study
- manufacturers of gutta-percha have mandated this
- selection of an appropriate sealer will influence the outcome of endodontic therapy
- all of the above

Techniques used to investigate sealers, and addressed in this paper, have included iontophoresis.

- True
- False

Using fluid filtration methods, Ocruoglu et al. as well as Adanir et al. reported that EndoREZ leaked more than zinc oxide–eugenol did.

- True
- False

Huang et al. found in cytotoxicity tests that _____ was the least toxic.

- calcium hydroxide
- calcium sulfite
- sodium perborate
- none of the above

Early toxicity studies by Louw, Beec, and Pameijer and later studies by Pameijer, Zmener, and Banegas have found EndoREZ to be mildly irritating and within acceptable standards.

- True
- False

The data from several of the leakage studies discussed in this article are most likely the result of the ingrained belief that _____.

- after a final rinse, root canals must be treated with EDTA
- after a final rinse, root canals need to be dried thoroughly
- before a final rinse, root canals need to be etched
- a and c

For methacrylate-based resin sealers, to establish a proper seal the dentin needs to be _____ to allow for the _____.

- dry; penetration of resin tags in the closed dentinal tubules
- moist; penetration of resin tags in the closed dentinal tubules
- moist; penetration of resin tags in the opened dentinal tubules
- none of the above

Leaving dentin moist prior to using EndoREZ sealer _____.

- allows for permeation of resin tags
- enables deep penetration of resin tags up to 50 μm
- enables deep penetration of resin tags up to 300 μm
- a and c

Leaving dentin moist prior to using Epiphany _____.

- enables deep penetration of resin tags into the cementum
- enables bonding of the adhesive by means of a hybrid layer to the dentin
- enables bonding of the adhesive by means of a hybrid layer to the cementum
- a and c

EndoREZ and Epiphany both use a dentin bonding agent.

- True
- False

According to the article, the methodology of leakage studies that state in their materials and methods sections that “the canals were dried with paper points” is _____.

- appropriate
- correct
- flawed
- a and b

Using FESEM, Lambrechts et al. showed resin tag bundles protruding from the root canal filling surface and extending _____ after EndoREZ was used as a sealer.

- from 200 to 400 μm
- from 400 to 600 μm
- from 500 to 700 μm
- none of the above

Resin does not polymerize when in contact with air.

- True
- False

It is important to thoroughly flush the root canal with EDTA after the use of NaOCl, followed by sterile saline or 2% chlorhexidine because _____.

- this helps EDTA form a bond with the resin
- oxygen left behind from NaOCl promotes polymerization, thus forming an oxygen-inhibited layer
- oxygen left behind from NaOCl inhibits polymerization, thus forming an oxygen-inhibited layer
- a and b

In a retrospective study on 180 patients, where EndoREZ was used as the root canal sealer, _____.

- after 2 years, the overall success rate was 91.03%
- after 5 years, all patients evaluated were free of clinical symptoms
- a and b
- none of the above

The ability to re-treat endodontically treated teeth is one of the requirements of a root canal sealer.

- True
- False

Compared to gutta-percha and AH Plus, one study found that a methacrylate-based resin sealer (Epiphany/Resilon) could be removed faster and with less residual filling material.

- True
- False

Leaving a small amount of moisture in root canals after final rinsing is beneficial for methacrylate resin–based sealers _____.

- due to the hydrophilic nature of the sealer
- due to the hydrophilic nature of the sealer
- due to the poor porosity of dentin
- none of the above

Use of lubricants and/or rinses containing hydrogen peroxide will _____.

- promote demineralization
- promote polymerization of methacrylate-based resin sealers
- inhibit polymerization of methacrylate-based resin sealers
- a and c

EndoREZ will flow into lateral canals and accessory canals because it is _____.

- hydrophilic
- hydrophobic
- thinner in viscosity than water
- a and c

A resin-coated gutta-percha point should be placed in the root canal prior to placing any methacrylate-based resin sealer in the canal.

- True
- False

An accelerator is available and _____.

- should be placed in the canal prior to placing sealer
- can be used with gutta-percha or resin-coated gutta-percha
- after 5 years, all patients evaluated were free of clinical symptoms
- a and c

An accelerator is available and _____.

- speeds up setting of EndoREZ
- should be placed in the canal prior to placing sealer
- can be used with gutta-percha or resin-coated gutta-percha
- a and c

Both EndoREZ and Epiphany/Resilon _____.

- are well-tolerated and biocompatible
- have been extensively used by the dental profession
- have been studied and found to have clinical success rates in agreement with success rates using conventional sealers and gutta-percha
- all of the above
Methacrylate Based Resin Endodontic Sealers: A Paradigm Shift in Endodontics?

Educational Objectives

1. Be knowledgeable concerning the introduction of resin-based sealers
2. Be knowledgeable about leakage studies conducted on resin-based sealers and the factors that influence the outcomes of these tests
3. Understand the advantages that resin-based sealers may offer over other endodontic obturation materials
4. Be knowledgeable about the clinical technique used to place resin-based sealers

Course Evaluation

Please evaluate this course by responding to the following statements, using a scale of Excellent = 5 to Poor = 0.

1. Were the individual course objectives met?  
   Objective #1: Yes No  
   Objective #2: Yes No  
   Objective #3: Yes No

2. To what extent were the course objectives accomplished overall?  
   5 4 3 2 1 0

3. Please rate your personal mastery of the course objectives.  
   5 4 3 2 1 0

4. Be knowledgeable about the clinical technique used to place resin-based sealers
5. How do you rate the author’s grasp of the topic?   5 4 3 2 1 0
6. Please rate the instructor’s effectiveness.    5 4 3 2 1 0
7. Was the overall administration of the course effective?  5 4 3 2 1 0
8. Do you feel that the references were adequate?    Yes No
9. Would you participate in a similar program on a different topic?  Yes No
10. If any of the continuing education questions were unclear or ambiguous, please list them.
11. Was there any subject matter you found confusing? Please describe.
12. What additional continuing dental education topics would you like to see?

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